The City of Winnipeg

Water & Waste Department

HMI Layout and Animation Plan

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1 INTRODUCTION

This Wastewater Department HMI Layout and Animation Plan is intended to serve as a reference for consistent implementation of new HMI software applications for City of Winnipeg owned wastewater facilities. This document provides guidance to department personnel, as well as external consultants and external contractors, in the implementation of HMI systems for the Winnipeg Sewage Treatment Program (WSTP).

1.1 Scope of the Document

These implementation requirements apply to HMI systems at the following facilities:

- North End Sewage Treatment Plant (NEWPCC),
- South End Sewage Treatment Plant (SEWPCC),
- West End Sewage Treatment Plant (WEWPCC).

These requirements will also be applied to the Collection system where relevant and useful.

1.2 Application

The scope and intent of this document is to convey guidance regarding implementation of HMI applications. The standard shall apply to facility HMI systems as well as local touchscreen HMIs that are specific to a piece of equipment. The document will indicate where specific standards are applicable to facility HMI systems only.

The information is presented without knowledge of the specific process implementation. It is not within the scope of this document to provide detailed implementation direction, and it will be the responsibility of the respective system designers to fully develop the HMI application details with general conformance to the concepts presented herein. This document shall not be construed as comprehensive implementation requirements or negate the requirement for professional engineering involvement. Any design and implementation must be executed under the responsibility and seal of the respective engineer in each instance, and must be performed in conformance with all applicable codes and standards, as well as good engineering practice.

Where significant deviations from this guide are deemed to be appropriate by the design engineer, these shall be approved by the City.

As technology evolves and new application requirements are identified, it is recommended that this document is updated to ensure that it remains relevant and applicable.

Existing facilities do not necessarily comply with this guide. The expectations regarding application of this guide to new HMI systems at existing facilities must be assessed on a case-by-case basis, however general guidelines for application are presented as follows:

- All new implementations, not related to an existing facility, are expected to comply with this guide.
- All major upgrades to a facility, or a larger facility's process area, are expected to comply with this document, however in some cases compromise with the configuration of the existing facility implementation may be required.
- All minor upgrades should utilize this document as far as practical, however in some cases compromise with the implementation of the existing facility HMI system, which will be retained after an upgrade, will be required. Where these compromises are made they shall be kept to a minimum and agreed by the City.

1.3 Definitions

A	Amperes
CPU	Central Processing Unit
CV	Control Variable (PID control)
FRS	Functional Requirements Specification
HMI	Human-Machine Interface
HOA	Hand - Off - Auto (switch)
HOR	Hand - Off - Remote (switch)
HP, hp	Horsepower
HVAC	Heating, Ventilation, and Air Conditioning
kW	Kilo Watts
I/O	Input/ Output
MCC	Motor Control Centre
PDF	Portable Document Format
PLC	Programmable Logic Controller
PV	Process Variable (PID control)
SI	International System (of Units) (Système International (d'Unités))
SP	Setpoint Variable (PID control)
WSTP	Winnipeg Sewage Treatment Program
V	Volts
VFD	Variable Frequency Drive

1.4 References

The following City of Winnipeg standards and guides are applicable to HMI systems:

1. Electrical Design Guide, document code 510276-0000-47ER-0001.
2. Automation Design Guide, document code 612620-0013-40ER-0001.
3. Tag Naming Standard, document code 612620-0014-40ER-0001.
4. Historical Data Retention Standard, document code 612620-0016-40ER-0001.

2 GRAPHIC DISPLAYS

2.1 General Principles

Graphic displays shall be designed and implemented in a manner that promotes operator situational awareness. Operators shall be provided with an HMI system that allows them to quickly identify and react to abnormal conditions, thereby reducing equipment downtime and improving overall facility operation.

Use the following general principles when designing and implementing HMI applications for facility desktop HMI and touchscreen HMI systems:

1. Utilize a “shades-of-grey” approach to show all process and systems, other than those in an abnormal state as shown in section 2.2.
2. Design graphic displays around the tasks and goals of the operators, rather than the sensors and equipment that produce the data.
3. Organize information in a way that allows operators to make effective decisions. Group related information together, and make important information stand out.
4. Keep users aware of the state of the system. Avoid providing too much information on any one display, but ensure that enough information is provided that operators are not blind to the facility operation.
5. Illustrate equipment on graphic displays using a flat, 2-dimensional (2D) style to prevent visual distraction from the shades-of-grey style. Use of 3-dimensional (3D) style is only accepted for pushbuttons.
6. Do not use gradients, drop shadows, or other similar graphics techniques to enhance the visual appearance of graphic displays.
7. Use the minimum amount of detail to represent equipment. Excessive detail does not promote operator understanding, but rather acts as a visual distraction.
8. Do not incorporate unnecessary animation that is distracting to operators. Examples of unnecessary animation include rotating equipment, flowing water, and flickering flames.
9. Use colour to facilitate discrimination between important information and less-important information. Important information shall be shown in red, orange, yellow, and blue. Less important information is typically shown in a shade of grey. Further information is provided in Section 2.2.
10. Use different shapes, in addition to different colours, to facilitate discrimination between important information such as alarm icons.
11. Use different shades of grey to differentiate between running and stopped equipment, opened and closed valves, and energized/de-energized cables.
12. Do not depict instruments on Dashboard displays or process mimic displays. Only display the instrument reading, along with the units of measure.
13. Use toggle buttons to allow operators to show and hide details that are useful, but clutter the display. For example, a toggle could be used to show and hide minor equipment identifiers, process control loops, and process interlocks on the graphic displays.
14. Configure all operator setting/setpoint tags with proper engineering scales to ensure operators do not input an out-of-range value.
15. Minimize the amount of typing that is required by operators by providing selection lists, radio buttons, up/down arrows, or check boxes where possible. For setpoint, control output and any other analog value input fields up/down arrow buttons shall be provided to adjust the current value in increments of 5% of input field span.

16. Ensure that sufficient space is provided between selectable display objects, and that the objects are appropriately sized, to ensure compatibility with touchscreen HMI clients. Screens are to be scalable and tested on all sized displays approved for use in the facility.

2.2 Colour Scheme

Process graphics are to be implemented using the *Shades of Grey* colour scheme. Equipment and process lines are shown using a shade of grey, and abnormal conditions are shown in bright colours such as red, orange, yellow, and blue.

Refer to Table 2-1 for the standard colours used within City of Winnipeg HMI systems.

Table 2-1: RGB Colour Reference

Colour	Sample	RGB Value	Typical Purpose
White		255, 255, 255	Background of numeric displays, text displays, bar graphs, and gauges.
Grey 242		242, 242, 242	Active tab fill colour on the Header display.
Grey 230		230, 230, 230	Graphic Display Background, Stopped Equipment Fill.
Grey 208		208, 208, 208	Popup Window Inactive Background
Grey 192		192, 192, 192	Piping, fill colour of static equipment such as tanks and vessels, object outlines for equipment that are out of service and bar graph alarm ranges.
Grey 160		160, 160, 160	Border colour of static equipment such as tanks and vessels, Bar graph process variable.
Grey 154		154, 154, 154	Background colour of trend displays
Grey 128		128, 128, 128	Fill colour for Running Equipment, Bar graph alarm ranges.
Grey 96		96, 96, 96	Process Loops, Object outlines for equipment that is ready
Black		0, 0, 0	Text, Setpoint (SP) indicator arrows.
Red		255, 0, 0	Priority 1 Alarms (High Priority)
Orange		255, 128, 0	Priority 2 Alarms (Medium Priority)
Yellow		255, 255, 0	Priority 3 Alarms (Low Priority)
Light Blue		66, 186, 255	Abnormal States (e.g. Equipment in Manual Mode)
Blue		0, 0, 255	Hyperlinks

2.3 Standard Graphic Display Objects

Refer to Table 2-2 for standard graphic display objects. If additional objects are required, use the same style as that shown in this standard.

Table 2-2: Standard Graphic Display Objects

Object	State	Colour	Sample	Notes
Display Background	-	Grey 230		
Primary Titles	-	Black	**Primary Title**	Arial, 14 point, bold
Secondary Titles	-	Black	**Secondary Title**	Arial, 12 point, bold
General Text	-	Black	General Text	Arial 10 point, regular
Medium Text	-	Black	Medium Text	Arial 9 point, regular
Small Text	-	Black	Small Text	Arial 8 point, regular
Hyperlink	-	Blue	Hyperlink	Arial 10 point, underlined
Display Navigation Button	-	Grey 160, Grey 208		Located in the Header Display of a facility HMI application.
Back Button	-	Grey 160, Grey 208, White		Located in the Header Display of a facility HMI application.
Forward Button	-	Grey 160, Grey 208, White		Located in the Header Display of a facility HMI application.
Pushbutton	Enabled	System Default, Black Text	Button	Pushbuttons are to appear enabled or disabled as applicable. Do not change the text on a pushbutton. Disabled buttons are to appear flat.
	Disabled	Grey 230 Fill, Grey 160 Text, Grey 160 Border	Button	
Input Field	Enabled (read/write)	White Fill, Black Border	56 %	Use *General Text*
	Disabled (read only)	Grey 230 Fill, Grey 160 Text, Black Border	56 %	Use *General Text*

Object	State	Colour	Sample	Notes
Lock Icon	Locked	Grey 160		Show beside a secured object (e.g. an *Input Field*) that is locked.
Priority 1 Alarm Icon	Active	Red	1	Blink when unacknowledged, solid when acknowledged.
	Inactive	-	Invisible	
Priority 2 Alarm Icon	Active	Orange	2	Blink when unacknowledged, solid when acknowledged.
	Inactive	-	Invisible	
Priority 3 Alarm Icon	Active	Yellow	3	Blink when unacknowledged, solid when acknowledged.
	Inactive	-	Invisible	
Control Mode Icon (PLC)	Manual	Light Blue	M	Not blinking
	Auto	-	Invisible	
Control Mode Icon (Physical Switch)	Local	Light Blue	L	Not blinking. Local control mode should not have an icon (invisible) for vendor equipment that runs locally in normal operation.
	Hand	Light Blue	H	Not blinking
	Remote	-	Invisible	
Not Ready Icon	Not Ready	Light Blue	NR	Used if equipment is not ready to run (e.g. power is switched off). Not blinking
	Ready	-	Invisible	
Alarms Disabled Icon	Alarms Disabled	Light Blue	D	Show next to equipment that has one or more alarms disabled. Not blinking.
	No Alarms Disabled	-	Invisible	

Object	State	Colour	Sample	Notes
Override Icon	Override Active	Light Blue	O	Show next to an instrument or equipment that has one or more signals overridden. Not blinking.
	No Override Active	-	Invisible	
Static Tank / Vessel	-	Grey 160, Grey 192, Black text	TK-D415	May adjust shape to reflect actual tank or vessel shape. Do not show inner detail. Show equipment identifier inside object.
Non-Static Equipment	Running	Grey 96, Grey 128, White text	RDT-D415	Adjust the shape to reflect the shape of the equipment (typically as it is shown on the P&IDs). Do not show inner detail unless required to help clarify equipment type or operation. Show equipment identifier inside object.
	Stopped	Grey 96, Grey 230, Black text	RDT-D416	
Large Pipe (300+ mm) or Channel	-	Grey 192, Black text	FOA	11 Pixels in width/height. Indicate Fluid Commodity Code using *Small Text*.
Medium Pipe (90 - 250 mm)	-	Grey 192, Black text	MP	7 Pixels in width/height. Indicate Fluid Commodity Code using *Small Text*.
Small Pipe (3 - 80 mm)	-	Grey 192, Black text	PD	3 Pixels in width/height. Indicate Fluid Commodity Code using *Small Text*.
Process Loops	-	Grey 96		1 Pixel

Object	State	Colour	Sample	Notes
Process/Signal Continuation	-	Grey 192		Provide touch link to the referenced display. Use *Medium Text* (9 point).
Pump / Fan	Running	Grey 96, Grey 128		For variable speed pumps/fans, indicate the speed in units of percent using an *Indicator* object.
	Stopped	Grey 96, Grey 230		
	Unknown State	Grey 192, Grey 230, Black text		Show an *Alarm Icon* and an appropriately coloured rectangle around the object as per Table 2-3.
Mixer	Running	Grey 96, Grey 128		For variable speed mixers, indicate the speed in units of percent using an *Indicator* object.
	Stopped	Grey 192, Grey 230		
	Unknown State	Grey 192, Grey 230, Black text		Show an *Alarm Icon* and an appropriately coloured rectangle around the object as per Table 2-3.

Object	State	Colour	Sample	Notes
Actuated Modulating Valve or Damper	Closed	Grey 96, Grey 128, Grey 230		The width of the bar graph inside the object reflects percentage open. Show the actual position in units of % open using an *Indicator* object. The actuator shown is a motor actuator. Other actuator symbols are provided below. The actuator may be colour animated to reflect the running state if known.
	Intermediary Position	Grey 96, Grey 128, Grey 230		
	Open	Grey 96, Grey 128, Grey 230		
	Unknown State or Position	Grey 192, Grey 230, Black text		Show an *Alarm Icon* and an appropriately coloured rectangle around the object as per Table 2-3.
Actuated On/Off Valve or Damper	Closed	Grey 96, Grey 230, Black text		The actuator shown is a motor actuator. Other actuator symbols are provided below. The actuator may be colour animated to reflect the running state if known.
	Intermediary Position	Grey 96, Grey 128, Grey 230, White text		
	Open	Grey 96, Grey 128, Grey 230, White text		
	Unknown State or Position	Grey 192, Grey 230, Black text		Show an *Alarm Icon* and an appropriately coloured rectangle around the object as per Table 2-3.

Object	State	Colour	Sample	Notes
Valve Actuator - Motor	Energized (Running)	Grey 96, Grey 128, White text		Use in combination with a valve symbol. See ISA 5.1 for additional actuator symbols.
	De-Energized (Stopped)	Grey 192, Grey 230, Black text		
	Out of Service	Grey 192, Grey 230, Black text		
Valve Actuator - Pneumatic Spring Return	Stopped or Unknown if Moving	Grey 96, Grey 128		Use in combination with a valve symbol. See ISA 5.1 for additional actuator symbols.
	Actuator Moving (if known)	Grey 96, Grey 230		
	Out of Service	Grey 192, Grey 230		
Valve Actuator - Solenoid	In Service (Energized or De-energized)	Grey 95, Grey 230, Black text		Use in combination with a valve symbol. See ISA 5.1 for additional actuator symbols.
	Out of Service	Grey 192, Grey 230, Black text		
Indicator	-	White, Black	103 kPa	Use *General Text.* Show the units outside the white box.
Gauge	-	Black, Grey 128, Grey 192, White		Setpoint or control limits indicated with dashed line(s) (as required). Process reading indicated with black arrow. Alarm limits indicated with darker shades of grey.

Object	State	Colour	Sample	Notes
Bar Graph, Vertical	All elements shown	Black, Grey 92, Grey 128, Grey 160, Grey 192, Grey 230, White		Process variable (PV) is shown inside the right-hand rectangle using Grey 160 vertical fill animation. Left-hand rectangle is filled with Grey 230, and has the alarm limits and control limits overlaid on it. Low-Low and Hi-Hi alarm ranges are shown using Grey 128. Low and Hi alarm ranges are shown using Grey 192. Control limits are indicated in the left-hand rectangle with black dashed lines. Setpoint (SP) indicated on the right with a black arrow (triangle). PV is indicated in text below the bar graph. SP indication in text is shown on the faceplate only. Min/max values indicated in text to the left of the alarm limits. Object outlines using Grey 92.
	Hi-Hi, Hi-, Low, Low-Low alarm ranges, control limits, PV, and SP are shown. Min/max values are not shown.	Black, Grey 92, Grey 128, Grey 160, Grey 192, Grey 230, White		Alarm ranges for Low-Low, Low, Hi, and Hi-Hi are shown. PV is indicated in text below the bar graph. SP indication in text is shown on a faceplate. Bar graphs should colourize when alarm thresholds are reached. Colours should be the same priority as the equipment.

Object	State	Colour	Sample	Notes
	Hi, Low alarm ranges, control limits, PV, and SP are shown. Hi-Hi, Low-Low alarm ranges, Min/max values are not shown.	Black, Grey 92, Grey 128, Grey 160, Grey 230, White		Alarm limits for Low and Hi are shown using Grey 128. Alarm limits for Low-Low and Hi-Hi are not applicable. PV is indicated in text below the bar graph. SP indication in text is shown on a faceplate.
	Alarm ranges and PV are shown. Min/max values, control limits, and SP are not shown.	Black, Grey 92, Grey 128, Grey 160, Grey 192, Grey 230, White		Show min/max values as required.
	PV and SP are shown. Min/max values, alarm ranges, and control limits not shown.	Black, Grey 92, Grey 160, White		Show min/max values as required.
	Only PV is shown. Min/max values, alarm ranges, control limits, and SP not shown.	Black, Grey 92, Grey 160, White		Show min/max values as required.
	-	White, Grey 160, Black		The vertical bar graph is animated to reflect the tank level. Typically used on process mimic displays.

Object	State	Colour	Sample	Notes
Bar Graph, Horizontal	All elements shown.	Black, Grey 92, Grey 128, Grey 160, Grey 192, Grey 230, White		Elements may be removed as required in a similar manner as the vertical bar graph. SP indication in text is only to be shown on an equipment faceplate.
Tank Level Indicator	Racked in and Closed	Grey 96, Grey 128		
Power Circuit Breaker	Racked in and Open	Grey 96, Grey 230		Also show an *Alarm Icon* and an appropriately coloured rectangle around the object as per Table 2-3.
	Racked Out, Out of Service	Grey 192		
	Unknown State	Grey 192, Black text		
	Closed	Grey 128		State feedback is not typically from the breaker itself. State may be inferred based on data from protection relays, power meters, or intelligent overloads, etc.
Moulded Case Circuit Breaker	Open	Grey 192		Also show an *Alarm Icon* and an appropriately coloured rectangle around the object as per Table 2-3 as required.
	Unknown State	Grey 192, Black text		
	Energized	Grey 128		State feedback is not from the fuse itself. State may be inferred based on data from protection relays, power meters, or intelligent overloads, etc.

Object	State	Colour	Sample	Notes
Fuse	De-Energized	Grey 192		Also show an *Alarm Icon* and an appropriately coloured rectangle around the object as per Table 2-3 as required.
	Unknown State	Grey 192, Black text		
	Energized	Grey 128		3 pixels. Energized state is inferred based on other data.
Bus or Cable	De-Energized	Grey 192		3 pixels. De-energized state is inferred based on other data.
	-	Grey 230		Refer to Section 2.7.7 for information on Equipment Faceplates.
Equipment Faceplate Active Tab Background	-	Grey 208		
Equipment Faceplate Inactive Tab Background	-	Grey 128		
Equipment Faceplate Tab Icon, Home		Grey 128		
Equipment Faceplate Tab Icon, Details	-	Grey 128		
Equipment Faceplate Tab Icon, Configuration	-	Grey 128		Overlay an alarm icon if an alarm is active.
Equipment Faceplate Tab Icon, Alarms	-	Grey 128		
Equipment Faceplate Tab Icon, Trends	-	Grey 128		
Equipment Faceplate Link, Webpage	-	Grey 128		Not normally provided. Provide only if required.

Object	State	Colour	Sample	Notes
Equipment Faceplate Link, Help				

2.4 Display of Text Values

Text values on graphic displays are shown using either the *Input Field* or *Indicator* graphic objects that are listed in Table 2-2. The *Input Field* graphic object has a black border to convey the fact that it is a field that accepts input by the operator. The *Indicator* field does not have a black border, which signifies that this field does not ever accept input by the operator.

Use the fill colour of an *Input Field* object to indicate whether the field is currently accepting input by the operator. When an *Input Field* is enabled it shall be filled with white colour. When an *Input Field* is disabled it shall be filled with grey colour.

The *Input Field* object may be linked to a discrete point or an expression to control whether it is enabled or disabled. For example, the manual speed setpoint field on an equipment faceplate for a VFD-driven pump should be linked to the auto/manual mode status to enable the field when the equipment is in manual mode.

Instrument readings on process mimic displays shall use the *Indicator* object.

2.5 Units of Measure

All units of measure shall be in the International System of Units (SI). One exception is that motor ratings shall be displayed in both SI units (kW) and the imperial horsepower (hp) with the horsepower rating shown in brackets.

Follow these rules when units of measure are shown on HMI systems:

1. The first letter of the unit of measure is upper-case when the name of the unit is derived from the name of a person. Examples: Volt (V), Amp (A), Watt (W),
2. The first letter of the unit of measure is lower-case when the name of the unit is not derived from the name of a person. Examples: litre (l), meter (m), gram (g), second (s), day (d),
3. Units of measure are unaltered in the plural. Example: 5 cm, not 5 cms,
4. Capitalization of unit prefixes (p, n, µ, m, c, k, M, G, etc.) shall be as per standard convention,
5. Provide a space between numeric readings and the unit of measure.
6. Percentage (%) is typically used to indicate the position of valves (percent open), the speed of variable-speed motors (percent of full speed), tank level (percent full), and for other process readings that natively use percentage as the unit of measure. However, exceptions to these may be applied in specific cases. It is also permissible to indicate a process measurement in units of percent along with another unit of measure (e.g. wetwell level may be shown in units of percent and in meters).
7. The number of decimal places stored in the PCS should have the same number of significant digits as the source of the data. (e.g. If a flowmeter has an accuracy of 3 decimal places the display reading on the reading stored should have 3 decimal places). The number of decimal places displayed on the HMI should be a useful number to the users. If there are instances where a great number of decimal places are available, this should be discussed with the City during design.

2.6 Display of Equipment Status

Equipment shall be shown on graphic displays using the standard graphic symbols shown in Table 2-2. Where the status of equipment is provided to the control system, the colour and inner detail of the equipment is changed to reflect the current state, as per the following.

1. For equipment such as motors, pumps, fans, and mixers that have the capability of being started and stopped, colour is used to represent the equipment running status following the colour scheme in Table 2-2.
2. If the equipment, that has status reporting, is in an unknown state or position then question marks are shown on the equipment (e.g. equipment control is via an intelligent motor starter using Modbus/TCP but the communication link is down).
3. For on/off valves, fill colour is used to indicate whether the valve is opened or closed. Do not animate the fill colour of the valve based on the running status (e.g. running open or running closed) – this information can be provided on a faceplate if needed. However, if the “running” state of the actuator is known then the actuator fill colour is to be animated based on the running status. On/off valves in the open or closed states will follow the color scheme in Table 2-2. Diagonal lines are shown in the body of the valve if the valve is known to be in an intermediary position (the open limit and closed limit switches are not made). Question marks are shown on the valve if it is in an unknown position (e.g. an intelligent on/off actuator using Profibus communication, but the communication link is down).
4. On/off dampers are shown in an identical manner as on/off valves.
5. Modulating valves do not change colour. The width of the horizontal bar graph within the body of the valve changes to reflect the valve position. When the valve is fully open, the width of the horizontal bar graph shall be at its maximum. When the valve is fully closed, the width of the horizontal bar graph shall be zero. However, if the “running” state of the actuator is known then the actuator fill colour is to be animated based on the running status.
6. Modulating dampers are shown in an identical manner as modulating valves.
7. For *Indicator objects*, indicate three question marks inside the indicator if the value is unknown as a result of some failure in the system (e.g. a communication failure).
8. “Out of Service” state should be used when the piece of equipment is locked out or physically cannot operate.
9. “Not Ready” state should be used when the piece of equipment cannot be run due to a physical or programming interlock.
10. The manual-only equipment that are on the current treatment plants HMI graphics (e.g. S+ HMI system) should be migrated to the PCS HMI for DCS migration projects. For HMI graphics that will be developed for other new and upgrade projects, the display of manual-only equipment will be subject to City review/approval.

The applicable alarm and abnormal condition icons, as per Table 2-2, shall be shown adjacent to each piece of equipment that have alarms or abnormal states. Standard icons are provided for each alarm priority level, and for indicating the equipment is in hand mode, manual mode, not ready, has alarms disabled, or a signal is overridden. Use visibility animation to show and hide these icons depending on the state of the equipment. Some operating modes are mutually exclusive and therefore the icons may overlap each-another since they will not both be shown at the same time. For example, the ‘Hand’ control mode is mutually exclusive with the ‘Manual’ PLC mode, therefore the “H” and “M” icons may overlap. The icons should be located consistently throughout the screens. For example, the H/M icon should remain at the location as shown in Table 2-3 throughout the HMI screens.

When an alarm or control mode flag icon for an equipment appears visible, a rectangle of the same colour as the icon shall be shown around the equipment. The rectangle is coloured the same colour as the highest

priority alarm or abnormal condition to handle cases where multiple alarms of different priority levels may be active at the same time. If no alarms are active but a control mode icon is shown, show a light blue rectangle around the equipment. There should be a defined border around the devices to ensure the status does not cover any device detail text and will ensure consistency throughout process mimics. At no time should the rectangle cover other pieces of information on or around the graphic.

Refer to the sample figures in Table 2-3 for the standard method of displaying equipment status.

Table 2-3: Display of Equipment Status

State	Sample	Notes
All symbols shown (in development environment)		All symbols are organized around the equipment in close proximity. The “Hand” (H) icon overlaps the “Manual” (M) icon as these are mutually exclusive. As such, the “Manual” (M) icon is unseen. The same would apply if “Local” (L) was needed in certain cases instead of Manual.
Equipment Running in Hand with a Priority 1 and Priority 2 alarm.		The rectangle is shown in red since the Priority 1 alarm condition supersedes both the Priority 2 alarm condition and the “Hand” abnormal condition.
Equipment Running in Hand with Priority 2 alarm.		The rectangle is shown in orange since the alarm condition supersedes the abnormal condition (Hand).
Equipment Running in Manual mode with a Priority 3 alarm.		The rectangle is shown in yellow colour since the alarm condition supersedes the abnormal condition (Manual).

State	Sample	Notes
Equipment Running in Hand mode with no alarms.		The rectangle is shown in blue because there are no active alarms.
Equipment stopped with Priority 1, Priority 2, and Priority 3 alarms active.		The rectangle is shown in red since the Priority 1 alarm condition supersedes the Priority 2 and Priority 3 alarms.
Equipment stopped in Manual mode with no alarms.		The rectangle is shown in blue because there are no active alarms and blue matches the Manual (M) icon.
Equipment Not Ready and stopped with no alarms.		The rectangle is shown in blue because there are no active alarms and blue matches the Not Ready (NR) icon.
Equipment running in remote with one or more disabled alarms.		Disabled Alarms (D) icon. The colour of the rectangle and the disabled box should follow the highest priority disabled alarm. In this case the highest disabled alarm is a Priority 2.
Equipment running in Remote with no alarms.		No rectangle is shown around the equipment since there are no alarms.

State	Sample	Notes
Equipment stopped in Remote with no alarms.		No rectangle is shown around the equipment since there are no alarms.
Unknown State – Communication Failure between PLC and equipment		A question mark is shown inside the equipment to reflect that the equipment state is unknown. A Priority 1 alarm is shown as a result of the communication failure; however, the priority level may vary depending on the equipment.

2.7 Display Types

2.7.1 General

HMI applications will include several types of displays for viewing various levels of detail, and for operator tasks such as viewing trends and alarms. For multiple screen support, the functionality of each screen will be the same. Displays are generally broken down into the following categories:

1. Header/Footer Displays
2. Navigation Displays
3. Dashboard Displays
4. Process Mimic Displays
5. Equipment Detail Displays
6. Equipment Faceplates (Popups)
7. Trend Displays
8. Alarm Summary Displays
9. Historical Event Displays

Where a header or footer display is provided in an HMI system, the term “full-screen display” refers to a display that occupies all of the remaining screen space that is not already occupied by the header or footer. On system start-up, the system shall display the Facility Layout Overview page.

Each of these display types are discussed in the following sections.

2.7.2 Header/Footer Displays

A header or footer display shall be provided on each HMI system for locating elements that are common to all displays. The header or footer will always be present on the screen, and not covered or replaced by other displays.

For facility HMI systems, a header display shall be provided which contains the following:

1. The facility name (e.g. NEWPCC, SEWPCC, or WEWPCC) to convey to operators which site they are operating, which is useful for remote applications (e.g. control of SEWPCC from NEWPCC),
2. A Display Navigation button (icon) that links to the Facility Layout Overview page,
3. Log In/Out button,
4. Button to close all/unpinned faceplates,
5. Button to open an on-fly process analysis trend with the ability to add signals manually,
6. Button to launch historical events (including historical alarms, operator actions, user log in/log out information, and PCS system alarms,
7. Back and forward buttons (icons) for display navigationaccording to navigation history,
8. Separate back, forward, and up buttons to navigate according to navigation hierarchy,
9. A print button to print current active display.
10. A display page open button, which will allow operator to choose a display to open with option to replace the existing open display or open as a new tab.

11. The list of the buttons and sequence of the buttons shall be configurable without editing the template,
12. If possible, a breadcrumb trail showing the path to the current display within the display hierarchy,
13. The currently logged in user,
14. A row of tabs listing the open full-screen displays.

For facility HMI systems, a footer display shall be provided which contains the following:

1. A table of alarms by process area. The process area shall start with All, which encompass the whole facility. The process area shall end with PCS system status.
2. The number of process areas and sequence of the process area shall be configurable without modifying template,
3. An alarm list that shows the three most recent alarms at the facility,
4. The present date and time, and

A sample footer for a wastewater treatment facility HMI is shown in Figure 2-1.

Figure 2-1: Sample Facility HMI Footer

The breadcrumb trail indicates the path to the current full-screen display within the display hierarchy, and allows operators to navigate to other displays. Levels within the hierarchy are separated by right-hand arrows. Clicking an arrow opens a list of all displays at that level in the hierarchy, and clicking on a display in the list shall open the display. This is similar to the breadcrumb navigation system of Windows Explorer (File Explorer) in Windows 7 and above.

The table of alarms lists the quantity of unacknowledged alarms and acknowledged alarms in each process area. Coloured triangles are used to indicate the priority level of the highest priority alarm. Clicking on a column (process area) within the table of alarms brings the operator to an Active Alarm Display that lists only the alarms in that process area. If no alarms are active in a specific process area, a hyphen rather than a zero (“0”) shall be shown.

The alarm list shows the three most recent alarms at the facility, along with the date/time that the alarm occurred, alarm tag name, alarm tag description, alarm status, and the associated alarm icons (without the numbers “1”, “2”, or “3” inside the icons). Clicking on the alarm list brings the operator to a full-screen Active Alarm display that lists all of the active alarms for the facility. In the three-line alarm list, unacknowledged alarms are shown using bold and blinking text and acknowledged alarms are shown using non-bold and non-blinking text. The state of the alarms (e.g. “ON” or “OFF”) are shown at the far right of the alarm list.

Along the bottom of the header is tab bar that may be used to immediately go to any open display. When an operator opens a new display, a new tab is added to the tab bar. New tabs are added to the right-hand side of the list of tabs. The active tab is shown using Grey 242 fill with black text, and non-active tabs are shown using Grey 208 fill and Grey 128 text. Clicking an in-active tab brings the associated display to the foreground. A configurable maximum number of tabs can be opened. This is only to be configured at the Administrator level. When the maximum number of tabs is reached, the most left tab will be closed automatically before open new tab. The initial maximum number of tabs is 4.

The background (fill) colour of the items the header display (except for the active tab) shall be Grey 208.

Regarding touchscreen HMIs used for local equipment control, a footer display shall be provided which contains a button bar for display navigation, an indication of the number of unacknowledged and acknowledged alarms, the current user, and the present date and time, as applicable. Header displays are generally not provided on local touchscreen HMIs.

Additional information or controls that are common to all full-screen displays may be added to header/footer displays as required and agreed upon by the City.

2.7.3 Navigation Displays

Navigation displays are provided within facility HMI applications as the primary means for display navigation, and to open external applications and documentation used by operators. Navigation displays are implemented as full-screen displays.

Facility Layout Overview is the highest hierarchy navigation display, which is the first display when the system starts and it can always be accessed by using the Display Navigation button described in item 2 of section 2.7.2

Navigation displays contain links to other full-screen displays in the HMI application. The display shall have previous and next display configured for the same hierarchy, and parent page be configured for higher hierarchy. Links shall be provided to trends associated to key variables that are on the display. Trend display shall be opened in a new trend tab if it is the first trend tab or it shall replace an existing trend tab. In case maximum number of tabs is reached, the tab on the most left is closed before the new tab is opened. Equipment faceplates or other popup displays are not typically listed on navigation displays.

For each process flow path, a display link is implemented using a rectangular arrow following the process flow that contains a description of the item it links to. The rectangles are sufficiently sized to ensure compatibility with touchscreen HMI clients. The borders of the rectangles are colour coded based on the type of display or item they link to. Use blue colour for Dashboard displays, green for process mimic displays, and purple for equipment detail displays. Other colours may be used as required, but do not use alarm colours (red, orange, and yellow).

Design and implement navigation displays such that the operator is able to access any full-screen display with ideally three (3) or fewer clicks. Note that clicking on the Display Navigation button in the header counts as one click, leaving two more clicks on the navigation display to open the desired item.

The display shall be embedded with a hidden hot key command (Esc), which will be linked to a display at the higher hierarchy.

A sample overview navigation display is shown in Figure 2-2.

Figure 2-2: Sample Overview Navigation Display

Notes:

1. *Process area links (rectangles with a grey outline) are provided. These are used to show the display links for each process area. This should be provided before any area specific design to ensure proper implementation.*
2. *A typical navigation screen for a major process area would contain more Detail Displays.*

2.7.4 Dashboard Displays

A Dashboard display shows an overview of a facility, process area, or one or more process trains and appears like a dashboard or instrument panel.

A facility HMI system will incorporate numerous dashboard displays, one for the entire facility, one for each small process area, and multiple dashboard screens as required for larger process areas. The area dashboard displays shall be accessible via a page link on facility/process area overview display.
A local touchscreen HMI will typically have a single dashboard display, but additional dashboard displays may be provided if required.

The content and organization of dashboard displays shall be focused on the operators' tasks and goals. The display should not appear like a process mimic, but rather a dashboard or instrument panel. Show only the important operating modes and major process readings such as major flows, levels, and analytical readings.

Dashboard displays should not be designed to represent the physical configuration of the facility or process. They should generally be organized left to right, top to bottom, in terms of major process flow.

Group related information together. In some cases, it may be useful to group together all elements associated with a single piece of equipment. In other cases, it may be useful to group together one element from multiple pieces of equipment for the sake of comparison.

Important numerical information shall be presented inside a gauge or bar graph to give the operator a sense of where the reading lies with respect to the control and alarm limits. Indicate control and alarm limits on gauges and bar graphs wherever possible.

If a fraction of a reading, difference between two readings, or an average of two readings is important to operators, provide the information on the display rather than making operators do the mental arithmetic. Note that the computation of these shall be in the PLC, and the HMI is used for display only.

Where practical, incorporate small trends into Dashboard displays to allow operators to anticipate future alarm conditions, and react before the alarm occurs. The trends should have minimal detail, showing only the applicable setpoint, control limits, and alarm limits, and do not need to be fully-functional in terms of zooming and scrolling back in time. Link these small trends to full-screen trend displays that have the complete functionality.

A small process flow diagram should be included on dashboard displays where applicable. A process flow diagram is a high-level flow diagram without all the detail that would be shown on a process mimic display. The process flow diagram helps operators understand the process and may also be used as an alternative means to navigate between displays. The process flow diagram may appear like a typical block diagram, or the standard equipment symbols of Table 2-2 may be used. Where the standard equipment symbols are used, they may be reduced in size.

Indicate alarms and abnormal conditions using the standard icons listed in Table 2-2. In addition, a coloured rectangle shall be shown around the equipment, as per Section 2.6.

A sample dashboard display for an intake wetwell and the raw sewage pumps at a wastewater treatment facility is shown in Figure 2-3.

Figure 2-3: Sample Dashboard Display – Wet Well and Raw Sewage Pumps

Notes:

1. *This Dashboard display is applicable to a portion of the Headworks Area at a wastewater treatment facility. Additional Dashboard displays would be provided for the remaining equipment in the Headworks Area.*
2. *Small trends are incorporated into the display to show the wet well level. This allows operators to predict future low- or high-level conditions, and react before they occur. These trends shouldn't be used if they are not easily visible to the operator.*
3. *Bar graphs and gauges are used to indicate process readings and are accompanied by text displays to give the exact value.*
4. *Text displays (without bar graphs and gauges) are used for information that does not change frequently and does not have alarm limits, such as the pump duty assignments.*
5. *A Priority 1 high-high level alarm associated with the Average Wet Well Level is shown. The wet wells in the process flow diagram and the wet well level bar graph are highlighted with a red rectangle, which matches the Priority 1 alarm colour.*
6. *Only the important information is shown on the display. Setpoints and operating modes that are infrequently changed are accessible via equipment faceplates. Pushbuttons are provided to open the equipment faceplates where not available by clicking on the equipment.*

2.7.5 Process Mimic Displays

Process mimic displays are full-screen displays that show a mimic of the process, similar to a P&ID drawing but without unnecessary detail as shown on Figure 2-5. The display shall have previous and next display configured for the same hierarchy, and parent page shall be configured for higher hierarchy.

Links shall be provided to trends the associated key variables that are on the display. Trend display shall be opened in a new trend tab if it is the first trend tab or it shall replace an existing trend tab. In case maximum number of tabs is reached, the tab on the most left is closed before the new tab is opened.

Equipment that is not controlled or monitored by the PLC system shall be omitted from the process mimic. Examples of such equipment include hand valves, strainers, flex couplings, reducers, pressure regulators, and back-flow preventers. Instruments, PLC I/O, and PLC functions that are typically shown on P&IDs are also omitted from process mimic displays, though instrument readings are still shown.

Instrument readings are shown using the *Indicator* graphic symbol (see Table 2-2). Instrument readings for tanks are shown inside the tank, whereas readings for instruments installed within pipes are shown adjacent to the pipe. Provide touch animation on instrument readings as required to open the associated instrument faceplate display.

Where a particular piece of equipment is outfitted with numerous sensors, it may be appropriate to display only the important readings and show the other readings on an equipment detail display or equipment faceplate.

Equipment such as pumps, motors, mixers, and valves that have state feedback to the PLC shall be colour animated, using shades of grey, to reflect their state. Refer to Table 2-2 for standard graphic display objects. Note that Table 2-2 only lists typical objects and additional objects may be created as required and are subject to review by the City.

Pipes are shown using Grey 192. Pipes are shown in three different widths (see Table 2-2) to reflect the sizes (diameters) of pipes in the field.

Tanks and other static equipment are shown using the colours in Table 2-2.

Indicate alarms and abnormal conditions using the standard icons listed in Table 2-2. In addition, a coloured rectangle shall be shown around the equipment or instrument reading, as per Section 2.6.

Display equipment identifiers for major and minor pieces of equipment. Identifiers for tanks should be shown inside the tank wherever possible. For equipment other than tanks, the identifier should be located below the equipment. Use *Medium Text* for major equipment identifiers and *Small Text* for minor equipment identifiers see Table 2-2 for the font type and point size.

Provide a means to navigate across the process mimic displays, such as with pushbuttons or with touch links on process line continuation symbols. Provide pushbuttons to navigate up to the associated dashboard display as required.

When a value (analog/digital) is displayed on HMI, the tag name associated with the value should be easily accessible to user via context menu (brings up the tag definition), tooltip, or other means.

Figure 2-4: Sample Process Mimic Display

Notes:

1. *A high-level alarm in tank TK-D415-2 is shown with a Priority 2 Alarm. An orange rectangle is shown around the level indicator.*
2. *Mixers MXR-D415 and MXR-D416 are shown as running and stopped, respectively.*
3. *Rotating drum thickeners RDT-D415 and RDT-D416 are shown as running and stopped, respectively.*
4. *Pump D-D419 is in Manual mode, therefore a blue rectangle is shown around the equipment.*
5. *The width of the pipes shown is indicative of the pipe size in the field, as per* Table 2-2.

2.7.6 Detail Displays

2.7.6.1 General

Detail displays shall have previous and next display configured for the same hierarchy, and parent page shall be configured for higher hierarchy. Links shall be provided to trends the associated key variables that are on the display. Trend display shall be opened in a new trend tab if it is the first trend tab or it shall replace an existing trend tab. In case maximum number of tabs is reached, the tab on the most left is closed before the new tab is opened. Detail displays are typically provided for equipment that has many status and control points that cannot fit on an equipment faceplate (popup). As such, equipment detail displays are not usually provided for pieces of equipment that have an equipment faceplate, such as a motor or valve.

Detail displays can be implemented in several ways, depending on the type of information to be displayed. Several types of detail displays are defined below.

2.7.6.2 Equipment Detail Displays

Sophisticated pieces of equipment typically require a dedicated full-screen display to show all the equipment information and HMI controls. While process mimic displays typically only show high-level information, equipment detail displays show most or all of the information associated with the equipment.

The exact equipment shape and inner detail is omitted from process mimic displays but may be shown on equipment detail displays if required. This may help convey instrument locations, etc. Process mimic pages should be based on the P&ID drawings.

The typical information to present on equipment detail displays includes equipment operating modes, status information, operating statistics, and instrument readings. Pushbuttons, numeric input fields, and sliders are provided to facilitate control and setpoint adjustment. A small process or equipment mimic diagram may be provided as required to assist operators, and may also be used for navigation.

Pushbuttons may be provided to open popup windows that contain additional information and controls that would not fit on the equipment detail display. However, if the information is critical to operators it should be shown on the equipment detail display rather than a popup.

A sample equipment detail display for a UV reactor is shown in Figure 2-5 below.

Figure 2-5: Sample Equipment Detail Display – UV Reactor

Notes:

1. *The most important operating modes and status information are provided at the top of the display.*

2. *The equipment is shown with some inner detail to reflect the equipment in the field.*
3. *Pushbuttons are provided at the bottom of the display to open popup windows with additional information and controls.*
4. *A Priority 2 alarm is shown next to the UVT bar graph. The bar graph is also outlined with an orange rectangle.*
5. *UV Disinfection Bank UV-U214 is in manual mode and therefore a blue rectangle is shown around this bank.*

2.7.6.3 Sequencer Detail Displays

Where equipment is controlled via sequencing logic in the PLC system, the details of the sequence shall be provided on a sequencer display. The display shall have previous and next display configured for the same hierarchy, and parent page be configured for higher hierarchy. Links shall be provided to trends the associated key variables that are on the display. Trend display shall be opened in a new trend tab if it is the first trend tab or it shall replace an existing trend tab. In case maximum number of tabs is reached, the tab on the most left is closed before the new tab is opened.

The following is applicable to process displays associated with sequencing logic.

Show all states of the sequence on the left side of the display. Each state is represented with a rectangle containing the state number at the top and a brief description within. The state rectangles shall normally be grey, and turn a different shade of grey when the associated state is active. Arrows are used to illustrate the normal progression through the sequence. Arrows may be shown to illustrate abnormal progression through the sequence (e.g. for fault conditions) but may be omitted if there is insufficient room for them.

Clicking on a specific state will show information regarding that state on the right side of the display. Additionally, when the sequencing logic in the PLC transitions from one state to the next, the information area shall be automatically updated to show the information related to the new state.

The information area on the right side of the screen contains a brief description of the state, the actions that will be taken in that state, and the conditions required to progress to the next state(s). In the list of actions, list all actions that are performed by the sequencer, such as starting/stopping of equipment. Note that actions are the commands generated by the sequencer, and are not based on feedback from the field. In the list of conditions to transition to the next state, list all the conditions that are required to progress to the next state, such as seeing that equipment is currently running/stopped, seeing that equipment is running/stopped for a period of time, or waiting for a certain process condition. Provide circular indicator lights beside each action and condition to indicate whether they have been satisfied. The indicator light shall be grey if not satisfied, and green if satisfied. Alarm conditions are shown using a red, orange, or yellow indicator lights, coloured based on the priority of the alarm.

Provide hyperlinks to equipment faceplates inside the information area using blue underlined text. Operators may use these hyperlinks to view equipment faceplates or equipment detail displays to reset equipment-specific alarms, should they occur.

Near the bottom of the information area, indicate the current status of the sequencer, such as “Running”, “Waiting”, “Faulted”. This status information shall be customized for the associated sequencer.

Some sequencers have maximum step timers that generate an alarm if the sequencer becomes stuck. Where maximum step timers are used, show the elapsed time and maximum allowable time for each state in the sequence at the bottom of the information area.

Pushbuttons are provided at the bottom of the display to pause, resume, and reset the operation of the sequence. These buttons may not always be required, and shall be customized for the applicable sequencer.

A sample sequencing display for a high-rate clarifier is shown in Figure 2-6.

Figure 2-6: Sample Process Detail Display for a Sequencer

Notes:

1. *State 30 is the active state and is shown in green colour.*
2. *Information regarding State 30 is shown on the right side of the screen.*
3. *Hyperlinks to the CM-K1100 equipment faceplate are provided in blue, underlined text.*
4. *In the list of Actions, the HRC 1 clarifier mechanism has been commanded to start, which is represented using a green indicator light.*
5. *If the list of conditions, the sequencer has not seen the clarifier mechanism running for 30 seconds, therefore the indicator light is still grey.*

2.7.6.4 Electrical Single Line Detail Displays

Single line diagrams are provided in the facility HMI system to view the operation of the electrical system. The electrical system should be shown down to the lowest monitored level, which at minimum shall include the 600V buses.

For switchgear that contains power meters or feeder protection relays, provide the voltage and ampere readings from these devices on the detail display. Clicking these will open the associated power meter or protection relay equipment faceplate (popup).

Electrical equipment detail displays are also shown using the “shades of grey” colour scheme. Energized equipment is shown in darker grey, and de-energized equipment is shown in lighter grey. If the state of the equipment is unknown, it is shown in light grey with a question mark. Provide a legend at the top corner for all electrical single line displays.

Refer to Table 2-1 and Table 2-2 for the specific colours and symbology used on electrical single line detail displays.

Avoid showing transformer kVA or MVA ratings, circuit breaker ampere ratings, or fuse ampere ratings as these details are not required for normal operations.

A sample electrical equipment detail display is shown in Figure 2-7 below.

Figure 2-7: Sample Electrical Single Line Detail Display

Notes:

1. *Circuit breaker CB-S701 status is unknown and therefore the breaker and downstream cable are shown in the unknown state.*
2. *Circuit breaker CB-S702 is shown as "Not Ready" (e.g. racked out).*
3. *Circuit breakers CB-C701-T and CB-G702 are shown in the open state.*

2.7.7 Equipment Faceplates

Equipment faceplates are provided for individual instruments and equipment such as pumps, fans, and valves to view equipment status and facilitate control. Some control system functions, such as PID controllers, will also require a faceplate for viewing the process value and control value.

Equipment faceplates may be sized as required to accommodate the required status and control objects. If a particular faceplate needs to be larger than approximately 25% of the display, then a secondary screen to support details should be used.

The faceplate information should be populated by the associated equipment definition. No duplicated data entry or manual entry should be required.

The input to the genie should not be duplicated information already exist in the equipment definition. The input information entered on the genie should be the minimum required.

If possible, configure equipment faceplates such that they can be pinned or unpinned. When pinned, the equipment faceplate shall not automatically close when the operator navigates to a new full-screen display. However, when un-pinned the faceplates do automatically close when navigating to a new full-screen display. This allows multiple equipment faceplates to be open at a time for simultaneous control and monitoring. There should be a standard location where the equipment faceplates are located when pinned.

Provide a title at the top of the faceplate containing the equipment tag based on the P&IDs and a description of the equipment. Use the *Primary Title* font style for the equipment identifier and the *Secondary Title* font style for the equipment description. Refer to Table 2-2 for standard font styles.

Provide a series of tabbed pages on equipment faceplates for grouping common elements. Refer to Table 2-2 for standard tab icons. The following tabs are typically provided, but may be customized to suit the equipment:

- Home: primary tab for viewing status information and for manual control.
- Details: tab for viewing detailed equipment status information, alarm setpoints, and for adjusting equipment control setpoints (where desired by the City).
- Alarms: filtered alarm list, showing only those alarms that are applicable to the equipment.

The specific content on each tabbed page is dependent on the type of equipment the faceplate is associated with, and will be detailed in the equipment class definitions of the project's Enhanced Process Control Narratives. Faceplates should be standardized for each type. Typical equipment faceplate content for various types of equipment is provided in Table 2-4.

Table 2-4: Typical Equipment Faceplate Status and Controls Information

Equipment	Tabbed Page	Typical Content
Motors (FVNR)	Home	• Ready indication • Running indication • Interlocked indication • Local/Remote mode indication • Auto/Manual mode indication • Auto/Manual mode pushbuttons • Manual mode Start/Stop pushbuttons • Fault indication • Alarm Reset pushbutton
	Details	• Contactor Delay setting indication • Start Time Delay after Power On setting indication • Runtime Totalizer • Pushbutton to reset Runtime Totalizer

Equipment	Tabbed Page	Typical Content
		• Elapsed time of current run • Elapsed time since last run
Motors (VFD)	Home	Typical content for Motors (FVNR) plus: • Motor Speed (feedback) indication • Manual Motor Speed setting
	Details	Typical content for Motors (FVNR)
Pumps	Home	Typical content for Motors (FVNR or VFD) plus: • Low Flow status • Low Seal Water Pressure status
	Details	Typical content for Motors (FVNR or VFD) plus: • Low Flow alarm delay setting indication • Low Seal Water Pressure alarm delay setting indication
Valves	Home	• Power Fail Indication • Interlocked indication • Local/Remote mode indication • Auto/Manual mode indication • Auto/Manual mode pushbuttons • Position command (Open / Close, or % Open) • Position indication (Open / Closed, or % Open) • Manual mode Open/Close pushbuttons • Interlocked indication • Fault indication • Alarm Reset pushbutton
	Details	• Feedback delay setting indication
Instruments	Home	• Process Variable(s) • Alarm / Fault indication • Alarm Reset pushbutton
	Details	• Hi-Hi Alarm setpoint indication • Hi-Hi Alarm delay setting indication • Hi Alarm setpoint indication • Hi Alarm delay setting indication • Low Alarm setpoint indication • Low Alarm delay setting indication • Low-Low Alarm setpoint indication • Low-Low Alarm delay setting indication

Equipment	Tabbed Page	Typical Content

Electrical Power Meters	Home	• Voltage
		  ○ Line-to-line (Vab, Vbc, Vca)
		• Current:
		  ○ Per Phase (Ia, Ib, Ic)
		  ○ Demand (average of phases, Ia, Ib, Ic, and date/timestamp of peak demand)
		• Power
		  ○ Real Power
		  ○ Reactive Power
		  ○ Apparent Power
		• Energy
		  ○ kWh with timestamp since start of accumulated value
		• Power Factor
		  ○ Per phase
		  ○ Total
		• Frequency
		• Harmonics
		  ○ TDD
		  ○ THD (Ia, Ib, Ic), (Vab, Vbc, Vca)

Power Circuit Breakers	Home	• State (open / closed) (from protection relay)
		• Open / Close Command (if available)
		• Average Line-to-Line Voltage (from protection relay)
		• 3 Phase Currents (from protection relay)
		• Power Factor (from protection relay)
		• Average Reactive Power (from protection relay)
		• Average Apparent Power (from protection relay)
		• On the details page (tab):
		  ○ Date of last trip / operation,
		  ○ Cause of trip (first out),
		  ○ Readings (Current, Voltage, Power) prior to trip.

On the right side of the tab bar, provide links to resources that open in an external popup window or an external application. Links may be provided for, but not limited to, the following:

- Device Webpage: link to open the device webpage in a web browser window.
- Drawings: link to a set of drawings (typically in PDF format) for the equipment.
- Documents: link to an external document associated with the equipment.
- Help: link to help system.

Regarding the device webpage link, some field devices such as the Schneider Electric TeSys T intelligent overload have a built-in device webpage that is accessible through a web browser. The device webpage may be used by operators and maintenance personnel to view detailed information that is not provided on the HMI system.

The Help system link must be provided on equipment faceplates to open a help system for the specific equipment. Help systems are typically implemented with PDF documents and as such the Help link is right-aligned on the toolbar. If the help system is implemented within the HMI system (e.g. the information appears within the equipment faceplate, or a different popup) then the Help link in the toolbar should be left-aligned on the toolbar.

Numeric values and strings shall be shown on equipment faceplates using either the *Indicator* or *Input Field* graphic display objects. If the field shows a read-only variable, such as equipment running status, then an *Indicator* shall be used. If the field is read/write, such as the manual speed entry field for a VFD, then an *Input Field* shall be used.

A sample equipment faceplate for a VFD-driven pump is provided in Figure 2-8.

Figure 2-8: Sample VFD Pump Equipment Faceplate

Notes:

1. *The sample shown is for a VFD driven pump. The specific layout and information provided on equipment faceplates is dependent on the equipment.*
2. *The equipment faceplate comprises multiple tab pages of information to group together common information and controls.*
3. *The device webpage and help system icons in the toolbar are on the right-side, implying these will open in a new window.*

4. *Up/Down arrows to increase/decrease the setpoint are not shown but should be included (similar to Figure 2.10)*

A sample PID controller faceplate is provided in Figure 2-9, and shall be used as the basis for PID controller faceplates.

The PID controller faceplate is organized in a specific manner, as follows:

1. The units of measure of the process variable are indicated in the top left corner.
2. The process variable (PV) is indicated in the centre with a vertical bar graph.
3. The shaded grey areas left of the PV bar graph represent alarm limits of the process variable.
4. The numeric display to the left of the PV bar graph represents the current process value.
5. The arrow and numeric indicator to the right of the PV bar graph represent the setpoint (SP).
6. The control variable (CV) output is indicated using a horizontal bar graph.

Figure 2-9: Sample PID Controller Equipment Faceplate

2.7.8 Trend Displays

Trend displays are provided for operators to view real-time and historical signals associated with an instrument or equipment. Trend displays may also be used to view setpoints, control limits, and alarm limits. Trends shall be adjustable by the user and those settings to remain until the trend is closed. Trend display will be opened through a link on displays where associated signal pens are related to.
Provide a sample trend to the City for review.

Trend displays are full screen displays and typically contain a single trend viewer object. For facility HMI systems that use Schneider Electric AVEVA Plant SCADA, the trend viewer object shall be the Process Analyst object. The amount of available data on the HMI server shall be enough to satisfy the plant requirements. For signals long term archived to the historian, the trend should be capable of showing current value and the long term archived value from historian.
Set the background colour of the trend object to *Black*. Thickness of the signal lines and thickness and color of the grid lines should be reviewed with the City and consistent with best practices.

The trend object shall show the engineering units of measure on the vertical axis, and time on the horizontal axis. Fixed scaling of the vertical axis is to be used and configurable, and operators may select automatic scaling values. Fixed scaling will be the default upon opening of any trend. The horizontal time axis should be scaled appropriately for the given signals. For example, if the trend is used to view daily flows, the range of the time axis should be set to 24 hours. These scales shall be reviewed by the City before implementation.

Zoom-in and Zoom-out option shall be provided to quickly change the time span. There should be option for Operators to add more signal pens to predefined trend, but not to save to the predefined trend. There should be option to add scooter/cursors onto the trend displaying the signal values at the scooter/cursor. The current signal values should be displayed on the signal span.

The engineering units of the signal should be displayed on the signal span.

2.7.9 Active Alarm Displays

Active Alarm displays are full-screen displays that show a listing of all active alarms for the facility or a process area. Active alarm display tab shall be opened by clicking alarm table on the header. The active alarm display shall display all alarms in the facility or all alarms for a specific process area depending on which area is clicked on the header page. Active alarm display shall be opened in a new tab if it is the first active alarm tab or it shall replace an existing active alarm tab. In case maximum number of tabs is reached, the tab on the most left is closed before the new tab is opened. Alarm display shall provide quick page up and page down button in addition to the scroll bar to facility the alarm browsing.

The active alarm display shall provide the following quick filter operation:

- Filter different alarm priorities
- Different process area
- Shelved alarms
- Suppressed alarms
- Out of service alarms
- Acknowledged alarms
- Unacknowledged alarms

The active alarm display shall provide a freeze button to temporarily stop the active alarm display being updated.

The active alarm display shall provide a comprehensive alarm filter where operator can choose time frame, including/excluding specific tags with capability to use wild characters, specific priorities, specific area, specific alarm tag type, and specific alarm status (i.e. high, high-high, return to normal, inactive, shelved, suppressed, out of service, bad quality, hardware failure, deviation alarm, acknowledges, unacknowledged, information and etc.).

The alarm display shall occupy the whole width of the screen with the minimum following columns:

- Alarm icons
- Group/Process Area
- Date and Time
- Tag name
- Tag description
- State of alarm.
- Acknowledged/Unacknowledged status

The column width should be automatically adjustable according to the content each column. The sequence of the column can be adjustable by drag and drop.

For facility HMI systems, clicking the three-line alarm summary in the header display takes the operator to an unfiltered active alarm display, showing all alarms at the facility. Clicking on a process area in the header's table of alarms takes the operator to a filtered active alarm display showing only the alarms for the selected process area.

Alarms shall be sorted by alarm occurrence with the most recent alarms appearing at the top.

Each alarm shall be colour coded as per the assigned priority; red for Priority 1, orange for Priority 2, and yellow for Priority 3 alarms. Unacknowledged alarms are shown using blinking text, and acknowledged alarms are shown using solid (non-blinking) text.

For each alarm, indicate the date and time of alarm occurrence, and the date and time of alarm acknowledgement.

Provide the ability to right-click on an alarm to view additional information on the alarm:

- Disable the alarm
- Acknowledge the alarm
- Operating parameters
- Operator Notes
- Operator Actions
- On-the-fly Trend
- Navigation to the alarming equipment associated display

Provide pushbuttons on the display to acknowledge alarms as follows:

- ACK – Acknowledge the selected alarm.
- ACK AREA – Acknowledge all unacknowledged alarms for the current process area (applicable only to filtered alarm summary displays for a specific process area).
- ACK PAGE – Acknowledge all unacknowledged alarms on the current alarm page.
- ACK ALL – Acknowledge all unacknowledged alarms.

Provide a means for operators to filter alarms by one or more user-defined text filters, including an ability for operators to filter or display disabled alarms.

The active alarm display should open and produce filtered result when filtering alarms in a reasonable time and subject to City review/approval.

2.7.10 Historical Events

The historical event display must include the historical alarms, operator actions, user login/logout information and PCS systems alarms. A historical event display should have a default time frame on opening with predefined filter for each process area. It shall provide quick buttons to change the time frame to back or forward by 2 hours, display events for the last 1 hour, 1 day, 1 week or 1 day and provide comprehensive custom filter function by selecting specific time frame, process area, specific tags, specific message, etc. It should include a query table that the Users can use to customize the data they want to appear on the alarm table list when required.

The historical events display should open and produce filtered result when filtering events in a reasonable time and subject to City review/approval.

2.8 Organization

Organize graphic displays in a hierarchical manner that allows operators to drill down for further information on a process area and/or equipment of interest. The display hierarchy shall mimic the facility equipment hierarchy.

Four display levels are defined within the display hierarchy, as follows:

- Level 1 displays are for facility dashboard displays such as the Facility Process Dashboard, Facility Process Flow Diagram, the Facility Security Dashboard, and help system.
- Level 2 displays are for process area dashboard displays.
- Level 3 displays are for process mimic displays.
- Level 4 displays are for equipment detail displays.

While distinct levels are defined within the display hierarchy, it is not required to follow a strict drill-down approach to display navigation. Shortcuts may be provided to jump from any level to any other level if it is practical for the operator. Left arrow, Right arrow and Up arrow shall be provided on the manual bar to navigate to previous and next page at same level and navigate to the upper level.
In most cases there will be a one-to-one relationship between the Level 3 and Level 4 displays but there may be cases where a one-to-one relationship does not exist.

A typical facility HMI application would have a display hierarchy like that shown in Figure 2-10.

Figure 2-10: Typical Facility HMI Application Display Hierarchy

Notes regarding Figure 2-10*:*

1. *The Level 3 and Level 4 displays shown are associated with Process Area '2' only. A similar arrangement would exist for the other process areas.*
2. *Links between the Level 3 displays (process mimics) are typically provided using process and signal line continuation symbols.*
3. *A mesh is shown to represent the relationship between process mimics at Level 3 and the equipment detail displays at Level 4. The specific relationship is dependent on the equipment and the implementation of the displays.*
4. *Shortcuts between displays are omitted for clarity. For example, it may be possible to link from a Level 2 process area Dashboard to a Level 4 process detail display if such a shortcut was provided.*

3 ALARMING SYSTEM

3.1 Alarm Presentation Philosophy

For facility HMI systems, new alarms are presented in the three-line alarm banner within the header display. Unacknowledged alarms are to appear blinking in order to get the attention of the operator, and acknowledged alarms are shown using non-blinking text.

For touchscreen HMIs used for local equipment control based on the Schneider Electric Magelis HMI, new alarms shall appear in a scrolling marquee across the top of the screen, which is the default method for display alarms on the Magelis HMI terminal.

An alarm summary screen shall also be provided which lists the active and historical alarms.

Alarms associated with equipment shall be shown on the dashboard displays, process mimics, and equipment detail displays as per Section 2.6 for both facility HMIs and touchscreen HMIs for local equipment control.

3.2 Alarm Priorities

Three priority levels of alarms are defined within the HMI alarming system:

- Priority 1 – High Priority / Emergency. The alarm indicates a condition that required manual or automatic functions to avoid unacceptable operating conditions or product. Also, indicates a callout when unmanned. See Section 3.3 for further information on Alarm Callouts.
- Priority 2 – Medium Priority. The alarm indicates a condition that requires manual or automatic functions to avoid unacceptable operating conditions or product. The alarm requires attention, but on its own, does not require a callout when unmanned.
- Priority 3 – Low Priority. The alarm indicates a condition that may result in off-quality product or may lead to more severe consequences. Such as equipment override and alarm disabled.
- Priority 4 – Abnormal Condition. This priority indicates an abnormal condition that does not require immediate attention. In general, Local, Manual, or Not Remote mode alarms will be in this category.

Alarm priority levels for new alarms are to be specified in the project's Enhanced Process Control Narratives (EPCNs).

3.3 Alarm Callouts

SEWPCC and WEWPCC are not manned 24 hours per day. After-hours Priority 1 alarms from these sites are monitored by NEWPCC Operations. Currently, a monitoring system (referred to as "Plantmonitor") has been implemented by City staff to meet this requirement. Any changes to the alarming system at any of the three plants shall include the design and implementation of a system to ensure high after-hours Priority 1 alarms from SEWPCC and WEWPCC are effectively monitored at NEWPCC.

- NEWPCC shall monitor SEWPCC and WEWPCC "Operator" on duty status.
    - When a Priority 1 alarm occurs at SEWPCC or WEWPCC, a signal indicating occurrence of priority 1 alarm at SEWPCC or WEWPCC shall be sent to NEWPCC PCS; NEWPCC PCS shall confirm the signal received with positive feedback. If the respective facility operator is not on duty, the alarm will be activated at NEWPCC and the PA siren shall be activated.

- Heartbeat signals shall be implemented to monitor the communication between NEWPCC and SEWPCC, and between NEWPCC and WEWPCC. Alarms and siren shall be activated in case communication link breaks down.
- A separate Plantmonitor user interface shall provide detailed priority 1 alarm information to NEWPCC operators, including at least time stamp, tag name and tag description, and alarm status. The Plantmonitor user interface shall be available from any of the PCS operator workstations across the NEWPCC campus.

As the system is interacting among three facilities, any design change at SEWPCC or WEWPCC shall be coordinated with NEWPCC, and any design change at NEWPCC shall be coordinated with both SEWPCC and WEWPCC. Both the design consultant and the contractor are expected to work closely with the City to implement any change to the Plantmonitor system.

4 MISCELLANEOUS

4.1 Help System

A help system shall be provided for each HMI system that include the following:

1. A symbol legend for equipment, alarm icons, and abnormal state icons,
2. Display navigation procedures,
3. User login/logout procedures,
4. User security information, and
5. Operating procedures and equipment manuals for complex equipment as required.

4.2 Commands Originating from the HMI

Commands that originate from the HMI shall utilize the SET action, rather than the Momentary ON action. The PLC shall reset the bit after it is utilized in the program. This prevents discrete PLC tags from being stuck on in the event of communication failures, timing issues, or control from multiple HMI nodes.

4.3 HMI Security

HMI systems shall incorporate security to prevent unauthorized setpoint changes and to prevent unauthorized control of equipment. All graphic display objects that can change a tag value in a PLC shall incorporate user security. Typical examples of such display objects include pushbuttons for starting/stopping equipment and numeric input fields for setpoint adjustment.

Where a graphic display object is secured and the current user does not have the required access privileges, show the *Lock* icon inside the field to represent the fact that the field is currently locked.

Four levels of security are to be implemented as per Table 4-1 below.

Security Level	User Job Function	Typical Capabilities	Typical Restrictions
Administrator	Automation and Industrial Controls Group	• System Administration/Configuration • Viewing HMI • Automatic mode control limit and control setpoint adjustment • Manual equipment control • Alarm acknowledgement • Alarm limit adjustment • Enabling and disabling alarms	• None

		• Viewing reports, trends, and alarms	

Special (S)	Electrical and Instrumentation Group	• Operate medium voltage and distribution-related electrical equipment (4160V and above) if configured for operation from SCADA
		• Operate 600V electrical equipment that is not limited to a single piece of equipment (e.g. one side of an MCC).
		• Viewing HMI
		• Viewing reports, trends, and alarms
			• System Administration/Configuration
			  • Automatic mode control limit and control setpoint adjustment
			  • Manual equipment control
			  • Alarm acknowledgement
			  • Alarm limit adjustment
			  • Enabling and disabling alarms

High (H)	Senior Operator	• Operate single point 600V electrical equipment (e.g. a blower or HVAC unit). • Viewing HMI • Automatic mode control limit and control setpoint adjustment (This should be reviewed on a case by case basis with the City) • Manual equipment control • Alarm acknowledgement • Alarm limit adjustment • Enabling and disabling alarms • Viewing reports, trends, and alarms	• System Administration/Configuration • Operate medium voltage and distribution-related electrical equipment (4160V and above) if configured for operation from SCADA • Operate 600V electrical equipment that is not limited to a single piece of equipment (e.g. one side of an MCC).
Low (L)	Operator	• Viewing HMI • Manual equipment control • Alarm acknowledgement • Viewing reports, trends, and alarms	• Automatic mode control limit and control setpoint adjustment • Alarm limit adjustment • Enabling and disabling alarms

Table 4-1: HMI User Security Levels

Notes:

1. *The capabilities and restrictions indicated above are typical. The functional requirements specification for each project may have different user security requirements.*
2. *The Administrator level users should have all the rights of a Senior Operator plus the system administration/configuration rights.*