HMI/SCADA Programming Standards

Las Virgenes Standards
6518021-STD-01

Document Revision History

Revision	Date	Description	Author
00	10/31/19	Issued for release.	M. Gassaway

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1   Introduction

The purpose of this document is to define the design criteria and guidelines to be applied to the Human Machine Interface (HMI) and Supervisory Control and Data Acquisition (SCADA) computer display screens for operation, trouble shooting and maintenance. Screens must:

- Be effective tools for the safe and efficient control of the process.
- Assist in the early detection, diagnosis, and proper response to abnormal situations.
- Structured to aid operators to prioritize response to major or multiple simultaneous system upsets.
- Make failure of a display or items on the display immediately apparent to the operator.

The criteria defined in this document shall apply to all HMI/SCADA displays programmed by LVMWD or its contractors. Package system suppliers shall be requested to comply as far as possible.

While this document provides design criteria and guidance, it shall not be a substitute for good engineering judgment and practice. Deviations from these criteria shall be formally submitted for approval from LVMWD before incorporating in project design.

2   Codes and Standards

Except as amended by this specification, the latest approved editions of the following codes and standards shall form an integral part of this design document:

- ISA-101.01-2015 - Human Machine Interfaces for Process Automation Systems
- Rockwell Automation – The High-Performance HMI
- Rockwell – Using the Process Library
- Rockwell Automation Publication SYSLIB-RM002G-EN-E - June 2016
- Rockwell Automation Library of Process Objects Publication Version 4.0 PROCES-RM002G-EN-P - July 2018

3   Las Virgenes Municipal Water District Specifications

- 6518021-STD-00   Design Criteria for Programming Control Systems
- 6518021-STD-02   Design Criteria for Tag Naming

4 Definitions and Abbreviations

Term	Definition
CV	Controlled Variable
HMI	Machine Interface
LCN	Local Control Network
MOC	Management of Change
P&ID	Piping and Instrumentation Diagram
PV	Process Variable
LVMWD	Las Virgenes Municipal Water District
SCADA	Supervisory Control and Data Acquisition

5 Purpose and Function

These design criteria aim to promote uniformity and consistency of design and operational equipment and computer screens in compressor stations. While HMI/SCADA details may vary because of differences in equipment or system design, the essential elements of HMI/SCADA design shall follow these design criteria.

5.1 Display

HMI/SCADA Screens shall be optimized for display on Allen Bradley Series Panelview Plus 7 Touchscreen Terminals and 1920x1080 resolution Monitors.

5.2 Objectives of the design criteria are to:

- Provide consistency across the company Stations which aids in cost of implementation, operator training and trouble shooting.
- Take advantage of industry experience and recommendations for HMI/SCADA design.
- Minimize the operator's cognitive load by presenting data in context and reducing the need for display interpretation.
- Provide a Style Guide to standardize HMI/SCADA system depictions and design symbology for operator interfaces in company Stations.
- To guide building an information heirachy.
- To standardize some programming function blocks.

5.3 Logic Execution

- The HMI/SCADA shall not be used to execute PLC logic except for commands (e.g. Start/Stop; changing setpoint for PID).
- Reset logic shall be executed in the PLC.

6 Operator Interface Design

6.1 General Principles

The design of the operator interface aims to:
- Optimize the operators situational awareness. Show important parameters and deviations at a glance.
- Help the operator to quickly assess situations.
- Reduce the Operator's "Cognitive Load" by making plant status easy to see:
  o Put data in context to minimize the need for interpretation.
  o Make the most important information stand out. Red indicates an abnormal situation. See alarm levels.
  o Avoid presenting unnecessary information, which detracts from the clear presentation of needed data, such as unnecessary and/or elaborate depictions of equipment
  o Avoid using unnecessary animation.
  o Avoid colored backgrounds, other than light grey
  o Only use bright colors to draw the operator's attention to abnormal conditions (e.g. alarm colors red, yellow, orange and magenta). If other colors are used for a specific purpose, be consistent in meaning.
  o Limit the number of colors on a screen to avoid confusion.
  o Distinguish alarms by more than color alone (use shape and number) to avoid problems with color blindness.
  o Use analog presentations where helpful to reduce cognitive load.
  o Show analogs as vertical or horizontal bars.
  o Show pointer and upper and lower analog limits.
  o Upper and lower limit areas can change color when to pointer enters. Red, Yellow and Orange are alarms.
  o Show related values side by side.
  o Use trends where useful
  o Group data that belongs together. Use separate areas on a screen if necessary.
  o Use same type of graphic for similar information
  o Use specific colors for specific things. Avoid duplicate meanings for colors. See Styles.
  o Be consistent in naming objects across all related screens.
  o Place navigation buttons in a consistent place.
  o Show live values differently from static numbers or units
  o Line up columns of numbers by location of the decimal point.
  o Flow generally from left to right
  o Do not present information in P&ID format unless it helps recognition of situations. If a P&ID format is used, include only objects necessary to convey situational information.

7   Style Guide

- The Style Guide is a collection of graphic elements, indicators, sub-pictures, trend objects, templates, and other specific graphic parts to be used consistently in creating the HMI/SCADA.
- The basis for this guide is to use the latest edition of the Rockwell Automation Library of Process Objects PROCES-RM002G-EN-P. The function blocks in the following table and the associated faceplates shall be used. Other function blocks from the Rockwell Library may be used , if required. For all Schneider applications Contractors shall provide a comparable library for approval by an LVMWD representative.

Function Block	Library Object
Analog Input	P_Ain
Analog Input (HART)	P_AInHART
Advanced Analog Input	P_AinAdv
Analog Output	P_Aout
Analog Output (HART)	P_AoutHART
Discrete Input	P_Din
Discrete Output	P_Dout
PID Loop	P_PIDE
Analog Control Valve	P_ValveC
Hand Operated Valve	P_ValveHO
Motor Operated Valve	P_ValveMO
Solenoid Operated Valve	P_ValveSO
Discrete 2,3 or 4 State Device	P_D4SD
Variable Speed Drive	P_VSD
Single Speed Motor	P_Motor
Two Speed Motor	P_Motor2Spd
Hand Operated Motor	P_MotorHO

- If additional function blocks and/graphic symbols are needed, they may be built and used. Any new function blocks and symbols shall be documented and added to the list of available function blocks. Cross references to documents and descriptions shall be added to this Design Criteria.
- If vendor does not use FactoryTalk function blocks or screen objects, vendor system shall be submitted to LVMWD for approval.

- General Rules for graphics and use of color are:

Display background	Light grey
Navigation buttons	Light grey fill, 3D effect.
Descriptor Fonts	Arial/Arial narrow. All descriptor to fit face of button. Must be readable.
Equipment, e.g. vessels. Shape determined by equipment.	Dark grey filled shape
Process Pipe	Dark grey 3.5 pt wide
Subsidiary pipe or alternate process pipe not in use	Dark grey 1.5 pt wide
Control signals – hard wired	Dark grey broken lines 1.5 pt
Control signals – soft link	Dark grey solid line 1.5 pt with circles
Valve control, manual Open/Close	Control by two rectangular touch push buttons above or below the valve symbol with black letters indicating OPEN and CLOSE. Button background Light Grey. Status label under valve symbol states "OPEN" , "CLOSED" or "TRAVELING". Black letters on Light Grey screen background.
Valve open command example for a double acting actuator or single acting Fail Closed actuator.	Valve is closed and has dark grey fill. OPEN button has Light Grey background. CLOSE button has Light Grey background. Valve actuator is dark grey. Valve body is dark grey. Label under valve symbol is "CLOSED". Press OPEN button, OPEN button turns Dark Grey. Valve actuator turns White. Valve body turns light blue as valve moves off the closed position switch. Label under valve symbol becomes "IN TRANSIT" Valve completes transition. Valve body color turns White on signal from open position swich. Actuator turnsWhite. Label under valve symbol becomes "OPEN" Open button turns Light Grey.
Valve close command for a double acting actuator or single acting Fail Closed actuator	Valve is open and has White fill. CLOSE and OPEN OPEN buttons have Light Grey background. Valve actuator is White.

	Label under valve symbol is "OPEN". Press CLOSE button, CLOSE button turns White. Valve actuator turns light blue. Valve body turns light blue as valve moves off the open position switch. Label under valve symbol becomes "IN TRANSIT" Valve completes transition. Valve body color turns Dark Grey on signal from closed position swich. Actuator turns dark grey . Label under valve symbol becomes "CLOSED" Open button turns Light Grey.
Valve does not travel in allotted time	If valve travel times out in either direction the a Magenta border displays around the valve body and the OPEN or CLOSED button The label "FAULT" appears under the valve symbol.
Valve trips open or closed (single acting actuator)	If valve is automatically tripped open or closed, a border will display around the valve and the label under the valve will state "TRIPPED OPEN" or TRIPPED CLOSED". Operator can reset the Valve to its current position by pressing the appropriate Open or Closed pushbutton.
Valve position indicator	If variable valve position is indicated, position information shall be shown below the valve symbol using blue numbers and black letters on a light grey background.
Motor or Pump Control	Motor/Pump symbol outline same as FactoryTalk. Status label under motor/pump symbol indicating "RUNNING" or "STOPPED". Two pushbuttons above symbol for "START" and "STOP" and a STATUS button above symbol for "AUTO" .
Motor/Pump stopped	Motor/Pump symbol black outline with dark grey fill. Status label under symbol indicates "STOPPED". Black letters on Light Grey background. START pushbutton background Light Grey.

	STOP pushbutton background Light Grey. AUTO status button Green if local handswitch is in "AUTO", White if local handswitch is "NOT AUTO".
Start Motor/Pump	Status label under Motor/Pump is "STOPPED" AUTO status button Green Press START button. Button background turns from Light Grey to Dark Grey. Motor symbol displays light blueFeedback from MCC turns symbol to White fill. START button turns back to Light Grey background. Status label under symbol indicates "RUNNING". if AUTO status button is White, local handswitch is not in AUTO and START button has no effect.
Stop Motor/Pump	AUTO status button is Green. Press STOP pushbutton. Background turns White. Equipment symbol displays light blue. Feedback from MCC turns Motor/Pump symbol to Dark Grey fill. Status label turns to STOPPED. STOP button turns back to Light Grey
Motor/Pump Start/Stop Fault	If AUTO status button is Green and START or STOP sequence times out START or STOP button Turns magenta and motor/pump symbol turn is highlighted by Magenta border. Label under symbol turns to "FAULT"
Equipment with variable status	Equipment symbol from FactoryTalk. Status label under equipment symbol indicating status e.g. "RUNNING" {or "ON") or "STOPPED" (or "OFF"). START and STOP are used in this example. Three rectangular buttons above or below the equipment symbol with black letters on a Light Grey background. Two buttons indicate "START" and "STOP". One button indicates "AUTO" or "MANUAL" or "LOCKED OUT" .

	It has a Green background and reads "AUTO" when in local AUTO It has a Blue background and reads "MANUAL", when in local MANUAL It has an Orange background and reads "LOCKED OUT" when in local LOCKED OUT.
Equipment stopped.	Equipment is stopped. Equipment symbol is outlined in black with dark grey fill. Label under equipment symbol is "STOPPED" in Black letters on the Light grey screen background. START and STOP pushbutton backgrounds are Light Grey. AUTO button is displaying AUTO on a Green background.
Equipment start	Press START button. Button background turns Dark Grey. Equipment symbol displays light blue. Feedback from the MCC turns symbol Whiteand returns START button to Light Grey background. Label under symbol reads "RUNNING"
Equipment Stop	Press STOP button. Button background turns dark grey. Equipment symbol displays light blueFeedback from the MCC turns symbol Dark Grey and returns STOP button to Light Grey background. Label under equipment symbol reads "STOPPED".
Equipment Start/Stop Fault	If AUTO status button is Green and START or STOP sequence times out START or STOP button and equipment symbol turn Magenta. Label under symbol turns to "FAULT"
Equipment with no status feedback (e.g. locally manually operated)	Equipment outline symbol, same as FactoryTalk symbol. Light grey fill, same color as background.
Graphs Background same as screen	Light grey
Graph axes	Dark grey lines 1 pt
Graph axes font	Black Ariel/Ariel Narrow, size to fit. Must be easily readable.

Graph variables	Identify variable and color in graph legend
Variable values displayed on graphic	Variable values are displayed as Blue numbers on the screen. If in alarm, a border appears around variable and object color of the border changes to reflect the alarm level, Red, Yellow, Orange, or Magenta (error).
Bar Chart bar	Bar width appropriate to number of bars, but easily readable. Generally between 5 to 13 points.
Bar chart background	Light grey
Bar chart axes	Dark grey lines 1 pt
Bar Chart Axes Font	Black Ariel/Ariel Narrow, size to fit. Must be easily readable.
Bar Chart, multiple variables	Identify variable and color in chart legend
Analog scale	Appropriate Scale to left of analog vertical bars with units.
Analog PID controller setpoint bar	Light Blue bar. Top of bar indicates variable value.
Analog PID controller setpoint value	value below set point bar containing digital value, blue numbers on the screen.
Analog PID controller process variable (PV) .	Light Blue bar. Top of bar indicates variable value. If beyond alarm limits, bar changes color to match alarm level - Red, Yellow, Orange or Magenta (error).
Alarm limits	Alarm limits indicated by line across PV bar with arrowhead color of alarm level. Setpoint not adjustable by operator.
Analog PID controller PV value	Value below PV bar containing digital value, blue numbers on the screen. If beyond alarm limits, background of box changes color to match alarm level or error.
Analog PID controller output command (CV)	Green bar. Top of bar indicates variable value.
Analog PID controller CV value	Box below bar containing digital value, black numbers on green background.
Analog bar process variable alarm range above and below normal when process is in normal range.	Dark grey bar fill.
Analog bar process variable alarm range when process is above or below normal.	As PV bar exceeds alarm setpoint, alarm range color changes from Dark Grey to

	match bar color so top of bar still shows value of PV.
Vessel levels on graphic display	A Blue vertical analog bar in, or on the side of, the vessel symbol with a scale on either side of the bar. Alarm level set points shown as horizontal lines with an arrow head across the analog bar at the level of the alarm on the scale. Scale units shown by the side of the scale in black letters. If beyond alarm limits, bar changes color to match alarm level - Red, Yellow, Orange or Magenta (error).
Vessel level alarm range above and below normal when process is in normal range.	Dark grey bar fill.
Vessel level alarm range in alarm	As level bar exceeds alarm setpoint, alarm range color changes from Dark Grey to match bar color so top of bar still shows value of level.
Vessel level value	digital value below vessel, Blue numbers If beyond alarm limits, background of box changes color to match alarm level – Red, Yellow, Orange or Magenta (error).
Static numbers displayed on the graphic	Black on the Light Grey background
Equipment Tag Numbers	Black lettering on grey backgound adjacent to equipment symbol or value. Use ISA tags for instruments (P&ID tags).
Level 2 PID Controller face plate	Three vertical bars. Same as Rockwell – Level 2 display
Radio Button indicator	Black outline circle. If status agrees with label, circle filled Dark Grey or Green. If status does not agree with label, circle filled White.
Alarm - Shutdown Level (HighHigh/LowLow etc) (Urgent Severity in FactoryTalk)	Red Outline border around object and variable with embedded double exclamation points in red circle
Alarm - Warning level (High/Low etc.) (Medium Severity in FactoryTalk)	Orange outline border around object and variable with single exclamation point in Orange Diamond or Yellow outline border around object and variable with single exclamation in Yellow Triangle

Alarm – Low priority (Low Severity in FactoryTalk)	Magenta outline border around object and variable with single exclamation point in Magenta square
Unacknowledged alarm on alarm screen	Flashing color border
Acknowledged alarms on alarm screen	Steady color border
Alarm – Fire, shown on graphic	Black outline Square with red fill and embedded black F
Alarm – unacknowledged on graphic	Flashing border color
Alarm – acknowledged on graphic	Steady border color

- In most cases it should not be necessary to differentiate piping by color code. If such a case arises, use LVMWD piping color code.
- Alarm Symbols and Colors
  - Alarm symbols shown in FactoryTalk equipment faceplates shall be modified to match the table above. Only three alarm priorities shall be used. The FactoryTalk High Severity alarm symbol shall not be used.
  - See Rockwell Automation Publication SYSLIB-RM002G-EN-E - June 2016 Page 21, Table 9 – Alarm Indicators
  - Developer may use any color scheme to facilitate programming on Level 3 and 4 screens as long as the scheme is recorded an made available for future use.

8 RGB Colors Codes

Colors specified in this document shall conform to the following RGB Color table:

Color	Red	Green	Blue	Hex
Light Grey	192	192	192	C0C0C0
Dark Grey	128	128	128	808080
White	255	255	255	FFFFFF
Light Blue	68	114	196	4472C4
Blue	119	184	237	77B8ED
Red	255	0	0	FF0000
Green	0	255	0	00FF00
Yellow	255	255	0	FFFF00
Orange	255	104	0	FF6800
Magenta	255	0	255	FF00FF

9 Tags

9.1 Screen Symbol Tags

Values displayed on graphic and tabulated screens shall be associated with the tag identity of the source as applied on the P&ID and the field nameplate. Use P&ID ISA tag numbers for instrumentation. The source tag shall be identified in programming wherever the tag value is used so that it is easy to trace. Tags shall also be maintained in the HMI/SCADA Tag Database.

10 Graphic Object Library

The displays will use the process objects depicted in the Rockwell Automation Publication PROCES-RM002G-EN-P – July 2018. If new process objects are created, a representation of the process object shall be submitted to LVMWD for record and cross reference in this document.

11 Display Hierarchy – Station Overview

11.1 Level 0

The Level 0 Screen is used for multiple plant stations and gives an overview of the key Station parameters which may include:
- An overview of the plants and major pipelines.
- Major plant and pipeline valve status
- Pipeline flow rates

11.2 Level 1 – Plant Overview

The Level 1 Screen gives an overview of the key Plant parameters which may include:
- Safety system information
- Priority 1 Alarms and acknowledgement status
- Major equipment status,
- Pipeline pressures and flow rates.
- Power source

11.3 Level 2 – Process Unit Control

Level 2 Screens are the primary screens for Station operation. There will be at least one screen for each subsystem. Each Level 2 Screen will be designed with the operator's need for information for tasks and actions. Data included on Level 2 Screens include:
- Equipment status. Use FactoryTalk pop-up faceplates.
- Alarms
- Process Controllers
- Process values
- Trends

11.4 Level 3 - Process Unit Display

Level 3 Screens show details of items on the Level 2 Screens, such as:
- Equipment Faceplates
- Process Control loops
- Trouble shooting
- Drawings & P&IDs if useful

11.5 Level 4 – Diagnostic Displays and supporting documentation.

12 Display Screen Layout

The display screen layout will be as follows:

12.1 Top of screen

- Two rows of 3D screen navigation buttons, light grey background with black lettering in sentence case.
- The buttons shall be highlighted by using a white background to show selection.
- Top row of buttons contains static navigation buttons (i.e. same on all screens), including Station Overview, Plant Overview, Unit Summary, Auxiliary Systems etc
- Top row right side – alarm button (see 11.8)
- Bottom row left box – system in black capitals
- Bottom row center box – Identification of display screen (equipment, etc.) in black capitals
- Bottom row right side box – time and date in black capitals
- Although the layout above is preferred, the positioning may be changed e.g. navigation buttons on the side. However, the positions shall be common on all screens at a Station.

12.2 Alarm Screen

- Bottom row – Screen Title, Time and Date.
- Second row from bottom – Buttons for Acknowledge, Reset, Sort, Up List, Down List, Top of List, Bottom of List, Back to Last Screen.

13 Display Navigation

- Navigation buttons shall be provided on every screen. The navigation buttons shall be collected in the same location on every screen at a Station, i.e. top, side or bottom. The level 0 and level 1 screens shall be in the same locations on all screens.
- The screen title, system, and time and date shall be displayed in the same location on every screen at a Station.
- The Level 0 Screen will have navigation buttons to all the level 1 Screens. Some Level 1 Screens may be collected under a System button to save space if necessary. These sub screens will navigate back to the System screen.

- Each Level 1 Screen shall have a navigation button to the Level 0 Screen and navigation buttons to all other Level 2 Screens.
- Level 1 Screens will have links to Level 2 Screens if detailed views of controllers, set points etc. shown on the Level 2 Screen are needed for operator view or maintenance. Controller settings and alarm set points will be password controlled and available through the Engineering Work Station.
- Level 3 Screens will have navigation buttons to all Level 2 Screens and to appropriate Level 4 Screens.
- Level 4 Screens will have buttons to return to the level 3 screen.
- Pipeline arrows pointing off the screen may be linked to the Level 1 Screen that logically follows the current screen. An inactive active arrow will be the same light grey as the background. An active arrow will be colored Dark Grey.

14 Alarm Management

- There will be an "Alarm Summary Screen" that will show a list of all alarms that have not been reset.
- The alarm screen will list alarms by date and time of arrival, the most recent being at the top of the list. Each alarm will be identified by number and/or the identifier of the source of the alarm (e.g.PSH 1234) and by a descriptor.
- Alarms can be selected by touch or mouse.
- A priority 1 alarm shall suppress the associated priority 2 or 3 alarm. If the priority 1 alarm disappears the priority 2 or 3 alarm will reappear if still activated.
- The alarm screen will have alarm acknowledge and reset buttons located one line up from the bottom of the screen.
- An unacknowledged alarm will flash the background color assigned to the alarm. The descriptors will be in black and will not flash.
- Acknowledging an alarm will cause the background to the alarm to go steady with the same color.
- The alarm screen shall identify the whether the alarm is a shutdown, warning or low proirity by color and by an associated priority number (See Style Guide above). Priority 1 (Square) is Shutdown (Red), Priority 2 (Triangle) is Warning (Yellow) and Priority 3 (Circle) is low priority (Orange). This aids operators who may have color perception difficulties.
- Priority 1 alarms shall remain on the screen until reset.
- Priority 2 alarms shall not require a reset to remove from the screen. If the source of the alarm disappears after the alarm has been acknowledged, the alarm will also disappear.
- It will not be possible to reset a Priority 1 alarm from the screen when the source of the alarm is still in the alarm condition.
- A history of alarms shall be stored. It will be possible to call up a screen showing a historical list of alarms with sort capabilities.
- Each screen will have a button at the top right that will indicate the arrival of a new alarm, showing the numerical importance and shape associated with that alarm, and flashing the background color. Clicking on the button will call the Alarm Screen.
- Clicking on the alarm identifier on the alarm screen will call up the Level 2 or Level 3 screen where the source of the alarm is shown.
- Level 2 and 3 Screens will indicate the source of an alarm with the assigned alarm symbol per the Style table shown adjacent to the source.

- There will be a level 4 screen that lists all alarms and assigns colors and numbers. This screen will allow alarms to be silenced during maintenance work so as not to distract the operator. If an alarm is silenced it will be shown as such on Level 2 and 3 screens. Changing or silencing alarms shall be password protected.
- It will be possible to sort alarms on the Alarm Screen. There will be a button in the second from bottom row to select sort and a drop down menu to select alarm type and order, including silenced alarms.

15 Management of Change

Once the HMI/SCADA is in service changes to the HMI/SCADA shall be handled with a Management of Change (MOC) process which includes definition of the portions of the HMI/SCADA to be covered. This process will include adherence to these system standards. This process will ensure that changes to equipment, operating procedures, set points etc. will be incorporated in Level 4 documentation and, if necessary, result in prompt changes to corresponding display screens.

Revisions will be documented and subject to revision control.

16 Example Alarm Screen