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Certificate of Authorization	Professional Seal
	To be Utilized for Demonstration System Purposes Only.

REVISION REGISTER

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00	Issued for Tender	2013-10-31	C. Reimer	B. Cleven	C. Reimer

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1.0 OVERVIEW

This document is intended to provide a description of the control system functionality for the Demonstration System. It is written from a technical perspective, and is intended to be read along with the associated Process & Instrument Diagram (P&ID) drawings.

1.1 Associated Documents

The Process and Instrument Diagrams in association with the included work are listed below. Additional P&ID drawings may be referenced in this document.

Drawing Number	Description
SK-P0001	Legend and Details
SK-P0002	Clarifier 1
SK-P0003	Clarifier 2
SK-P0004	Clarifier 3
SK-P0005	Secondary Clarifier Effluent and Sample System
SK-P0006	Return Activated Sludge Pump P-S101
SK-P0007	Return Activated Sludge Pumps P-S102 & P-S103
SK-P0008	Return Activated Sludge Pumps P-S108 & P-S109
SK-P0009	RAS Header
SK-P0010	Waste Activated Sludge Pumps P-S202 & P-S203

2.0 GENERAL REQUIREMENTS

2.1 General Concepts

The alarms indicated are inherently designated outputs of the Control Interface, even though they are not explicitly identified in the Control Interface.

2.2 Human Machine Interface

2.2.1 Graphic Displays

A graphic (process mimic) display is a graphical representation of the process, showing pumps, instruments, and associated piping. Show sufficient detail from the P&IDs to allow operators a full understanding of the process. Metric units are to be used.

The graphic displays will be organized in a hierarchical fashion with four (4) levels:

- Level 1 Displays – Plant Overview
    - This display contains key operational information for the entire plant operation. Specific areas of the display will be grouped by process function.
- Level 2 Displays – Area Overview
    - This display contains key operational information for a specific process area. Specific areas of the display will be grouped by equipment / system function. The display will not be organized as per the P&IDs.
- Level 3 Displays – Process Graphic
    - This display will be based upon the P&ID drawings and each graphic will represent a system or group of equipment.
- Level 4 Displays – Process Detail
    - Process detail displays shall be utilized where required to further detail the process graphics, further than the Level 3 displays. Typically, these would not be P&ID oriented, but in specific cases a P&ID style graphic would be appropriate if sufficient detail can not be provided on the Level 3 display.

2.2.2 Display Navigation

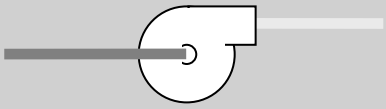
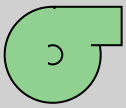
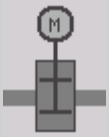
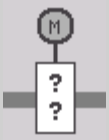
The following navigation context menus or buttons are to be always visible on the HMI:

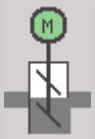
- Home
- Login
- Logout
- Alarm Summary
- Left – All Level 3 displays are to have links to other Level 3 displays via left/right arrows. Similarly, all Level 4 displays are to have links to other Level 4 displays via left/right arrows.
- Right – Rotate screens in the opposite direction of the Left Arrow.
- Up – All Level 3 displays are to link to the Level 2 display on pressing the Up arrow. All Level 4 displays are to link to the corresponding Level 3 display on pressing the Up arrow.

2.3 HMI Animation Plan

The HMI is to utilize a “shades-of-gray” colour scheme where abnormal operating conditions are flagged to the operator via the use of bright colours. Follow the animation plan indicated below.

Item	Condition	Colours	Sample	Notes
Background	-	Gray 208		
Priority 1 Alarm	-	Red	1	Display adjacent to equipment
Priority 2 Alarm	-	Orange	2	Display adjacent to equipment
Priority 3 Alarm	-	Yellow	3	Display adjacent to equipment
Discrete State	Non-Active	Gray 192	Not Occupied	Do not utilize for items that would be considered abnormal states
	Active	Pale Green	Occupied	
Control Mode (PLC) Flag	Auto	-	Invisible	Local switch is in Remote or Auto and control mode is in Auto
	Manual	Cyan Gray 64	M	Display if local Switch is in Remote or Auto and control mode (PLC) is in Manual
Local Mode Flag	Remote	-	Invisible	Local Switch is in Remote or Auto
	Local	Cyan Gray 64	L	Display if local switch in Local, Hand, or Off
Starter Not Ready Flag	Ready	-	Invisible	
	Not Ready	Cyan Gray 64	NR	

Item	Condition	Colours	Sample	Notes
Equipment Graphic	Stopped	White 240 Gray 64		
	Running	Pale Green Gray 64		
On / Off Valve Position	Closed	White 240 Gray 64		
	Open	Gray 128 Gray 64		
	Partial	White 240 Gray 128 Gray 64		
	Invalid	White 240 Gray 64		
Modulating Valve Position	-	White 240 Gray 128 Gray 64		Horizontal Bar Graph Shows Position
Damper	Closed	White 240 Gray 64		
	Open	Gray 128 Gray 64		
	Partial	White 240 Gray 128 Gray 64		
	Invalid	White 240 Gray 64		

Item	Condition	Colours	Sample	Notes
	Moving	Subdued Green White 240 Gray 128 Gray 64		Subdued green colour is applicable to any actuator state where moving.
Analog Measurement Value	-	Black Text Gray 112	**123.4 L/s**	No faceplate link
		Gray 192 Black Text Gray 240 Gray 128 Gray 32	**123.4 L/s** **123.4 L/s** **56.7 ACH**	With faceplate link
Bar Graph	-	Background Gray 192 Text Gray 64 Indicator Gray 128 Threshold – As Per Table 2-2	 **AE-G501 Wet Well Methane**	Indicator to change colour to abnormal state or alarm colour upon exceeding threshold
Link to Trend				Display next to variable that is on trend.
Low Flow Switch	No Flow	White 240 Gray 128 Gray 96 Gray 64		
	Flow	Gray 160 Gray 128 Gray 96 Gray 64		
Low Temp Switch	Low	White 240 Gray 128 Gray 96 Gray 64		
	Normal	White 240 Gray 128 Gray 96 Gray 64		

Item	Condition	Colours	Sample	Notes
Major Equipment ID Tag	-	Gray 64	**SF-G601**	Bold Text, adjacent to equipment. Do not show for minor equipment.
Minor Equipment ID Tag	-	Gray 96	HC-G603	Bold Text, adjacent to equipment. Do not show for minor equipment.
Major Headings		Gray 32	**Wet Well Overview**	
Minor Details		Gray 64	Pressure	
Piping – Path Lines - Major	-	Gray 128		6 Pt
Piping – Path Lines - Med	-	Gray 128		4 Pt
Piping – Path Lines - Minor	-	Gray 128		2 Pt
Ducting - Path Lines		Gray 128		8 Pt
Piping – Line Type	-	Gray 128	GLS	
Faceplate Background	-	Gray 192	**SF-G601** X	
Faceplate Header	-	Gray 96 White		
Faceplate Border	-	Gray 160		
Trend Background	-	Gray 208		
Fill of static vessels				

Item	Condition	Colours	Sample	Notes
Trend Pen Lines	-	Separate Contrasting Colour for Each Pen	No sample	Do Not Use Alarm Colours
Pushbuttons	Enabled	Black Text	No sample	Pushbuttons are to appear bevelled. Utilize pushbuttons for a single purpose only. Do not change the text on a pushbutton.
	Disabled	Dk Gray Text		
String and Numeric Input Boxes	Enabled	Black Text with White Background	**50%**	String and numeric input boxes are not to appear bevelled.
	Disabled	Dk Gray Text with Medium Grey Background	50%	

Note: For instruments / sensors mounted on equipment, display actual field inputs (after moving to internal PLC variables) on the HMI equipment graphic. Utilize alarm variables for displaying the alarm flag and alarms in the list only.

2.3.1 RGB Colour Reference

Colour	Sample	RGB Ref	Notes
White		255,255,255	
White 240		240,240,240	
Gray 224		224,224,224	
Gray 208		208,208,208	
Gray 192		192,192,192	
Gray 176		176,176,176	
Gray 160		160,160,160	
Gray 144		144,144,144	
Gray 128		128,128,128	
Gray 112		112,112,122	
Gray 96		96,96,96	
Gray 64		64,64,64	
Gray 32		32,32,32	
Red		255,0,0	Use for Alarms Only
Pale Red		255,144,144	Acknowledged Priority 1 Alarm
Orange		255,128,0	Use for Alarms Only

Colour	Sample	RGB Ref	Notes
Pale Orange		255,176,97	Acknowledged Priority 2 Alarm
Yellow		255,255,0	Use for Alarms Only
Pale Yellow		255,255,192	Acknowledged Priority 3 Alarm
Cyan		0,255,255	Use for Abnormal States Only
Green		0,255,0	Use for Trending
Pale Green		160,255,160	Future
Subdued Green		144,208,144	Use for equipment running status, and active states. Also utilize for target setpoint indication on graphs.
Blue		0,0,255	Use for Trending
Teal		64,128,128	Use for Trending
Magenta		255,0,255	Use for Trending
Dark Green		0,64,0	Use for Trending

2.3.2 Help Screen

Provide a help screen that includes a legend and clearly indicates to the operator the purpose of each graphical symbol.

2.3.3 Faceplates (Popup Windows)

Create popup faceplates for each major piece of equipment that has control capability. Display equipment faceplates upon a click of the associated equipment on the graphic display. Display the equipment identifier at the top of the faceplate. Display status information and provide for control as specified.

Where a piece of equipment has an alarm that requires a manual reset, include an alarm reset pushbutton at the bottom of the faceplate.

Provide a close button for the faceplate in the top right corner, with an “X” as the caption.

2.3.4 Touchscreen Links

For touchscreen HMI applications, align touchscreen links to touchscreen physical input grid.

2.3.5 Trends

Incorporate pre-configured trend displays. Make trend displays accessible via a button(s) in the bottom right corner of the graphic display. Display a legend which relates the tag name and description to the pen colours.

Group trend screens by system.

2.3.6 Alarms

New alarms are to be displayed in an alarm banner.

Create an Alarm Summary screen so that operators are able to view current (active) and historical alarms. The alarm banner need not be shown when the alarm summary is displayed provided that the alarm summary also displays current (active) alarms.

Use the scheme in Table 2-1 for display of alarms as a function of their state:

Priority	Active	Acknowledged	Returned
1	Red	Pale Red	Gray 208
2	Orange	Pale Orange	Gray 208
3	Yellow	Pale Yellow	Gray 208

Table 2-1: Alarm Summary Colours

For each alarm, configure a touch action, such that the appropriate detail graphic display is shown when the alarm is clicked.

2.3.7 Trend and Bar Graph Thresholds

Trend and bar graph threshold colours are to be as follows:

Priority	Indicator Colour	Threshold Colour
1	Red	(128,0,0)
2	Orange	(144,64,0)
3	Yellow	(144,144,0)
Abnormal State	Cyan	(0,112,112)
Setpoint	Gray 128	Subdued Green

Table 2-2: Graph Threshold Colours

2.3.8 PLC Control from HMI

Configure HMI commands to utilize a SET operation rather than the Momentary On operation. The PLC shall reset the bit. This prevents discrete PLC tags from being stuck on in the event of communication failures, timing issue, or control from multiple HMI nodes.

Enable and disable pushbuttons appropriately.

2.3.9 Security

Implement a logon / logoff security system. Allow for four levels of security: High (H), Medium (M), Low (L) and None (N).

When logged off, the security level will be None (N), however basic viewing of the HMI system will still be allowed.

Automatically logoff after 20 minutes of inactivity.

2.4 Control Interface Requirements

2.4.1 Control Interface Type

Type	Description
I	Input – General
IH	Input from the HMI
O	Output
SP	Setpoint (value retained, typically set from HMI)

2.4.2 HMI Interface Points

Not all points between the HMI and PLC are necessarily specified or listed under the HMI-PLC interface lists. Note that in many cases the points listed as PLC I/O might also be part of the HMI-PLC interface. The requirement is based upon the HMI logging or display requirements.

2.4.3 Range

The Range field is utilized to indicate the extent of acceptable values for the parameter. Examples are indicated in the table below.

Type	Description
0/1	Discrete Value – True / False
0 - 1000	A number between 0 and 1000
10-500 ML	Analog value ranging from 10 to 500 megaliters
W1	A non-maintained command signal from the HMI. One method of implementation is that the HMI can write a variable to a value of 1, which the PLC will immediately reset to 0 after acting on it.

2.4.4 HMI Interface

The HMI column in the Control Interface indicates the typical type and location for the corresponding HMI interface. The HMI Interface Type Codes are indicated below.

HMI Type Code	Description
-	Do not show on the HMI
EF-G	Show as graphic on the equipment faceplate, which will popup when the operator clicks on the specific piece of equipment.
EF-L	Show as an indicator light on the equipment faceplate.
EF-PB	Show as a pushbutton on the equipment faceplate.
EF-T	Show as a text display on the equipment faceplate.
EF-TE	Show as a text entry on the equipment faceplate.
EF2-*	Show as a 2nd tab on the equipment faceplate.
EF3-*	Show as a 3rd tab on the equipment faceplate.
GD*-A	Show as an animation on the graphic display, where * is the level of the display.
GD*-BG	Show as a bar graph on the graphic display, where * is the level of the display.
GD*-BGT	Show as a threshold / setpoint on a bar graph.
GD*-CA	Show as a common animation on the graphic display, where * is the level of the display. More than one variable may affect the same animation.
GD*-F	Show as a flag on the graphic display, where * is the level of the display.
GD*-G	Show as a graphic on the graphic display, where * is the level of the display.
GD*-L	Show as an indicator light on the graphic display, where * is the level of the display.
GD*-PB	Show as a pushbutton on the graphic display, where * is the level of the display.
GD*-T	Show as text on the graphic display, where * is the level of the display.
SW-T	Show as text on a settings window.

Example:

HMI Type Code

Parameter	Type	Description	Range	HMI
CtrlAutoCmd	IH	Set to Auto Control Mode	W1	EF-PB (L)
CtrlManCmd	IH	Set to Manual Control Mode	W1	EF-PB (L)
F	I	Flow	As Req'd	GDx-BG GDx-T

2.4.5 Security

Security Type	Description
N	None
L	Low (Accessible to operator security level)
M	Medium (Accessible to senior operators only)
H	High (Accessible to maintenance only)

Example:

HMI Type Code

Security

Parameter	Type	Description	Range	HMI
CtrlAutoCmd	IH	Set to Auto Control Mode	W1	EF-PB (L)
CtrlManCmd	IH	Set to Manual Control Mode	W1	EF-PB (L)
F	I	Flow	As Req'd	GDx-BG GDx-T

2.4.6 Alarm Priority

Pri	Description
1	Emergency / High Priority. The alarm requires immediate attention. Also, indicates a requirement for a callout when unmanned.
2	Medium (Warning) Priority. The alarm requires attention within approximately a day, but does not require a callout when unmanned.
3	Low (Advisory) Priority. The alarm does not require immediate attention.

Default Priority

Example

Alarm	Description	Logic	DPri	Reset
S_Fault	Speed Fault	ABS(S – CmdS) > 5% for 30 sec	2	Auto

3.0 IMPLEMENTATION

3.1 Graphic Displays

Create a process graphic (process mimic) display containing a representation of the process shown on the process and instrumentation diagrams.

Display the alarm flags, PLC control mode flag, and local mode flag as applicable adjacent to each piece of equipment per the HMI animation plan in Section 2.3.

Analog readings from equipment or instruments are to appear adjacent to the equipment or instrument on Level 4 detail screens. The speed reference of variable frequency drives, in units of %, are to appear adjacent to all pumps and fans powered by VFDs. All values are to be displayed using the International System of Units (SI).

Incorporate touch animation on each pump, fan, and automated valve on the mimic displays so that when touched the corresponding equipment faceplate (popup) window opens overtop the process graphic display.

Below are the anticipated groupings of process displays.

3.1.1 Facility Overview

Level - 1

This is the default display for the system. The Secondary Clarifier process should only utilize a small portion of the available graphic area.

Specific requirements include, but are not limited to:

- Display bar graphs for the following:
    - Total Secondary Clarifier Inflow
    - Total RAS Flow
    - Total WAS Flow
    - RAS Header Flow Splits
        - FIT-S1210 Oxygen Reactor 1 RAS Flow
        - FIT-S1220 Oxygen Reactor 2 RAS Flow
        - FIT-S1230 Oxygen Reactor 3 RAS Flow
        - FIT-S1240 Oxygen Reactor 4 RAS Flow

3.1.2 Secondary Clarifier Overview

Level - 2

Specific requirements include, but are not limited to:

- Display bar graphs for the following:
    - Secondary Clarifier Inflow
        - FIT-S0121 Secondary Clarifier 1 Inflow
        - FIT-S0221 Secondary Clarifier 2 Inflow
        - FIT-S0321 Secondary Clarifier 3 Inflow
    - Sludge Blanket Levels
        - LIT-S0101 Secondary Clarifier 1 Sludge Blanket Level
        - LIT-S0201 Secondary Clarifier 2 Sludge Blanket Level

        - LIT-S0301 Secondary Clarifier 3 Sludge Blanket Level
    - Clarifier 1 RAS Flow
    - Clarifier 2 RAS Flow
    - Clarifier 3 RAS Flow
    - Total RAS Flow
    - Total WAS Flow
    - RAS Header Flow Splits
        - FIT-S1210 Oxygen Reactor 1 RAS Flow
        - FIT-S1220 Oxygen Reactor 2 RAS Flow
        - FIT-S1230 Oxygen Reactor 3 RAS Flow
        - FIT-S1240 Oxygen Reactor 4 RAS Flow

- Equipment graphics (without process flow linking)
    - RAS Pump P-S101 Status
    - RAS Pump P-S102 Status
    - RAS Pump P-S103 Status
    - RAS Pump P-S108 Status
    - RAS Pump P-S109 Status

3.1.3 Process Graphic Displays

Level - 3

Provide a comprehensive set of displays to show the process indicated on the reference P&IDs as a guide.

Provide equipment faceplate links, as well as links to controllers.

3.1.4 Control System Status

Level - 3

Create a graphic display showing a hierarchical layout of the control system components including but not limited to the following:

- Main controller rack(s).
- Remote I/O rack(s), as applicable.
- Networking components,
- Power supplies.

Display comprehensive heath/alarm information adjacent to each control system component.

3.1.5 Process Detail Displays

Level - 4

Provide detail displays as required to detail any portion of the Level 3 displays which cannot be adequately addressed by the Level 3 displays.

Provide equipment faceplate links, as well as links to controllers.

3.2 Trend Displays

3.2.1 Trends

Create, at minimum, the following trend displays, with the indicated pens.

Create appropriate links from the various graphic screens to the trend displays.

- Secondary Clarifier Inflow
  - FIT-S0121 Secondary Clarifier 1 Inflow
  - FIT-S0221 Secondary Clarifier 2 Inflow
  - FIT-S0321 Secondary Clarifier 3 Inflow
- Sludge Blanket Levels
  - LIT-S0101 Secondary Clarifier 1 Sludge Blanket Level
  - LIT-S0201 Secondary Clarifier 2 Sludge Blanket Level
  - LIT-S0301 Secondary Clarifier 3 Sludge Blanket Level
- RAS Pump P-S101
  - P-S101.S RAS Pump P-S101 Speed
  - FIT-S1015 RAS Pump P-S101 Flow
- RAS Pump P-S102
  - P-S102.S RAS Pump P-S102 Speed
  - FIT-S1025 RAS Pump P-S102 Flow
- RAS Pump P-S103
  - P-S103.S RAS Pump P-S103 Speed
  - FIT-S1035 RAS Pump P-S103 Flow
- RAS Pump P-S108
  - P-S108.S RAS Pump P-S108 Speed
  - FIT-S1085 RAS Pump P-S108 Flow
- RAS Pump P-S109
  - P-S109.S RAS Pump P-S109 Speed
  - FIT-S1095 RAS Pump P-S109 Flow
- RAS Header Flow Splits
  - FIT-S1210 Oxygen Reactor 1 RAS Flow
  - FIT-S1220 Oxygen Reactor 2 RAS Flow
  - FIT-S1230 Oxygen Reactor 3 RAS Flow
  - FIT-S1240 Oxygen Reactor 4 RAS Flow

3.2.2 Equipment Control Faceplates

Create equipment control faceplates for all controllable pieces of equipment and controllers. A sample equipment faceplate is shown in Figure 3-1 for a VFD-driven pump.

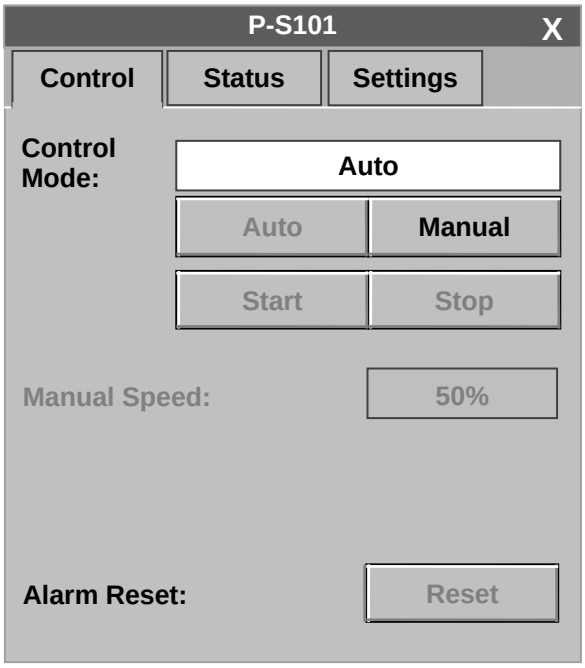


Figure 3-1 – Sample Equipment Faceplate

Each piece of equipment with manual control capability shall have a *Manual* and *Auto* pushbutton. A text display above the buttons will indicate the appropriate Manual or Auto mode that the equipment is currently in.

Disable all buttons that are not currently active or available. Examples:

- Disable the *Auto* button when in Auto mode.
- Disable the *Start* and *Stop* buttons when in Auto mode.
- Disable the *Manual Speed* Entry when in Auto mode.

Pumps and fans powered from variable frequency drives will require a manual speed setpoint numeric input box. Only permit numeric values in the range of 20% to 100% to prevent operators from running motors too slowly.

3.2.3 Pushbuttons

All pushbuttons shall be configured to use the SET operation rather than the Momentary On operation. The PLC shall reset the bit. This prevents PLC tags from being stuck on in the event of communication problems.

Pushbuttons are to appear bevelled and shall be grey in colour.

3.2.4 Settings Windows

Create settings windows specific to each piece of equipment, shown as tabs on the popup windows. Where space is insufficient, utilize multiple tabs/windows.

3.2.5 Alarm Summary

Create an Alarm Summary screen so that operators are able to view active and historical alarms. Provide a means to acknowledge individual alarms and all alarms from this screen.

3.3 PLC Application

3.3.1 Software Automatic/Manual Modes

In addition to the physical Hand-Off-Auto or Local-Remote switch, each piece of equipment that is controlled by the PLC shall also have a software Automatic and Manual mode. The software Manual mode allows operators to manually control equipment from the HMI rather than the MCC room.

3.3.2 PIDs

The PLC logic shall be written such that bump-less transfer occurs when switching from Automatic to Manual, and vice versa. When a change from software Automatic mode to software Manual mode occurs, move the output of the PID into the Manual speed setpoint. This prevents the speed from changing when entering software Manual mode.

PIDs that are controlling variable frequency drives are to have their Lower Limit configured to be the same as the drive's minimum speed setting to prevent integral windup.

3.3.3 Variable Naming Convention

Variables are to be named using positive logic.

Example: if a BOOL variable acted to lockout a pump when in a 0 State then the variable shall, for example, be named "PumpRunPermit" rather than "PumpLockout".

4.0 STANDARD EQUIPMENT CLASSES

4.1 Alm Alarm

The Alm class implements a discrete alarm without time delay.

4.1.1 Control Interface

Parameter	Type	Description	Range	HMI
Enbl	I	Enable Alarm (Default = 1)	0/1	
Inp	I	Alarm Signal Input	0/1	
Rst	I	Alarm Reset (Default = 1)	0/1	

4.1.2 PLC Generated Alarms

Alarm	Description	Logic	DPri	Reset
Alarm	As Req'd	If Inp and Enbl	2	As per Rst

Note: The alarm set logic takes a higher precedence than the reset logic. That is, the alarm will not reset unless the alarm condition is no longer true.

4.2 Alm_TD Alarm Time Delay

The Alm_TD class implements a time delay alarm.

4.2.1 Control Interface

Parameter	Type	Description	Range	HMI
Dly	I	Time Delay	0 – X ms	
Enbl	I	Enable Alarm	0/1	
Inp	I	Alarm Signal Input	0/1	
Rst	I	Alarm Reset	0/1	

4.2.2 PLC Generated Alarms

Alarm	Description	Logic	DPri	Reset
Alarm	As Req'd	If Inp and Enbl for Dly msec	2	As per Rst

Note: The alarm set logic takes a higher precedence than the reset logic. That is, the alarm will not reset unless the alarm condition is no longer true.

4.3 Duty_DS

The Duty_DS class selects a lead pump/fan and a standby pump/fan. The class is not configured to run both pumps in parallel.

4.3.1 Control Interface

Parameter	Type	Description	Range	HMI
Eq1_Rdy	I	Equipment 1 is ready	0/1	EF-L
Eq2_Rdy	I	Equipment 2 is ready	0/1	EF-L
EqLead	SP	Desired Lead Equipment	1 - 2	EF-RB
RunInp	I	Equipment is required to run	0/1	
Eq1_CmdRun	O	Equipment 1 Run Command	0/1	EF-L
Eq2_CmdRun	O	Equipment 2 Run Command	0/1	EF-L

4.3.2 PLC Generated Alarms

Alarm	Description	Logic	DPri	Reset
NoEquipment	No Equipment Available to Run	RunInp AND NOT Eq1_Rdy AND NOT Eq2_Rdy	2	Auto

4.3.3 Control Narrative

Perform range checking on EqLead setpoint.

Eq1_CmdRun = RunInp AND Eq1_Rdy AND ((EqLead == 1) OR NOT Eq2_Rdy)

Eq2_CmdRun = RunInp AND Eq2_Rdy AND ((EqLead == 2) OR NOT Eq1_Rdy)

4.4 Duty_D2S1

The Duty_D2S1 implements a duty / standby arrangement whereby there are two independent duty units of equipment, and one standby unit of equipment, which may be manually set to act as standby for either of the two duty units of equipment. The class is not configured to run the standby in parallel with either of the duty units.

4.4.1 Control Interface

Parameter	Type	Description	Range	HMI
EqD1_Rdy	I	Equipment Duty 1 is ready	0/1	EF-L
EqD2_Rdy	I	Equipment Duty 2 is ready	0/1	EF-L
EqS1_Rdy	I	Equipment Standby 1 is ready	0/1	EF-L
EqS1_Assign	SP	Standby Equipment Assignment	1 - 2	EF-RB
RunP1_Inp	I	Equipment Process 1 is required to run	0/1	
RunP2_Inp	I	Equipment Process 2 is required to run	0/1	
EqD1_CmdRun	O	Equipment Duty 1 Run Command	0/1	EF-L
EqD2_CmdRun	O	Equipment Duty 2 Run Command	0/1	EF-L
EqS1_CmdRun	O	Equipment Standby 1 Run Command	0/1	EF-L

4.4.2 PLC Generated Alarms

Alarm	Description	Logic	DPri	Reset
NoP1Equipment	No Process 1 Equipment Available to Run	RunP1_Inp AND NOT EqD1_Rdy AND NOT EqS1_Rdy	2	Auto
NoP2Equipment	No Process 2 Equipment Available to Run	RunP2_Inp AND NOT EqD2_Rdy AND NOT EqS1_Rdy	2	Auto

4.4.3 Control Narrative

Perform range checking on EqS1_Assign setpoint.

EqD1_CmdRun = RunP1_Inp AND EqD1_Rdy

EqD2_CmdRun = RunP2_Inp AND EqD2_Rdy

EqS1_CmdRun = EqS1_Rdy AND ((RunP1_Inp AND (EqS1_Assign == 1) AND NOT EqD1_Rdy) OR
(RunP2_Inp AND (EqS1_Assign == 2) AND NOT EqD2_Rdy))

4.5 FFC_MOV Flow Ratio Controller Utilizing Most-Open-Valve

The FFC_MOV class allows for flow splitting to ensure a balanced flow to each destination. The flow to each destination is determined by a ratio of the flow capacities of each destination that is in service.

4.5.1 Control Interface

Parameter	Type	Description	Range	HMI
D1_F	I	Destination 1 Flow	As Req'd	
D2_ F	I	Destination 2 Flow	As Req'd	
D3_ F	I	Destination 3 Flow	As Req'd	
D4_F	I	Destination 4 Flow	As Req'd	
D1_F_Cap	SP	Destination 1 Flow Capacity	As Req'd	EF2-TE (H)
D2_F_Cap	SP	Destination 2 Flow Capacity	As Req'd	EF2-TE (H)
D3_F_Cap	SP	Destination 3 Flow Capacity	As Req'd	EF2-TE (H)
D4_F_Cap	SP	Destination 4 Flow Capacity	As Req'd	EF2-TE (H)
D1_InService	I	Destination 1 In Service	0/1	
D2_InService	I	Destination 2 In Service	0/1	
D3_InService	I	Destination 3 In Service	0/1	
D4_InService	I	Destination 4 In Service	0/1	
MOV	SP	Most-Open-Valve	1, 2, 3, 4	EF-RB (L)
D1_F_Perc	O	Destination 1 Percentage of Flow	0 – 100%	GD3-T
D2_F_Perc	O	Destination 2 Percentage of Flow	0 – 100%	GD3-T
D3_F_Perc	O	Destination 3 Percentage of Flow	0 – 100%	GD3-T
D4_F_Perc	O	Destination 4 Percentage of Flow	0 – 100%	GD3-T
D1_F_Tgt	O	Destination 1 Flow Target	As Req'd	EF-T
D2_F_Tgt	O	Destination 2 Flow Target	As Req'd	EF-T
D3_F_Tgt	O	Destination 3 Flow Target	As Req'd	EF-T
D4_F_Tgt	O	Destination 4 Flow Target	As Req'd	EF-T

4.5.2 Alarms

Tagname	Description	Logic	Pri	Reset
MOV_Alarm	Most-Open-Valve Selection Error	MOV out of service	1	Auto

4.5.3 Control Narrative

Perform range checking on all interface inputs.

For below, i is a reference to all numbers from 1 to 4.

F_Total = Σ (Di_F)
Di_F_Perc = 100*Di_F/F_Total (Handle case F_Total = 0)
F_CapacityTotal = Σ (Di_InService * Di_F_Cap)
F_MOV = Select4(D1_F, D2_F, D3_F, D4_F, MOV)
F_MOV_Cap = Select4(D1_F_Cap, D2_F_Cap, D3_F_Cap, D4_F_Cap, MOV)
FOR i = 1 to 4
    IF i == MOV THEN
        Di_F_Tgt = D1_F
    ELSE
        Di_F_Tgt = F_MOV * Di_F_Cap / F_MOV_Cap

4.6 FIC

The FIC class is utilized to implement a Flow-Indicating-Controller control strategy.

4.6.1 Control Interface

Parameter	Type	Description	Range	HMI
CtrlAutoCmd	IH	Set to Auto Control Mode	W1	EF-PB (L)
CtrlManCmd	IH	Set to Manual Control Mode	W1	EF-PB (L)
F	I	Flow	As Req'd	GDx-BG GDx-T
F_Min	SP	Minimum Flow Capability	As Req'd	EF-TE (M)
F_Max	SP	Maximum Flow Capability	As Req'd	EF-TE (M)
IntlA	I	Interlock When In Auto (Default = 1)	0/1	EF-L
ManPos	IH	Manual Mode Position Output	0 – 100%	EF-TE (L)
SP	I	Setpoint	As Req'd	EF-T
CtrlMan	O	Control Mode Manual	0/1	GDx-F EF-T
CV	O	Controlled Variable Output	0-100%	

4.6.2 Alarms

Alarm	Description	Logic	DPri	Reset
InputFail	Transmitter Failure	F is bad quality (Out of range or bad quality from instrument via fieldbus).	2	Auto
SP_FAL	Flow Setpoint Too Low	F > 0 AND F < F_Min	3	Auto
SP_FAH	Flow Setpoint Too High	F > F_Max	3	Auto

4.6.3 Interlocks

Initiating Event	Action	Control Mode		Set Intlocked Output	Description
		Auto	Manual		
IntlA	Set CV = 0	Y	N	-	Set controller output to 0 upon interlock in auto mode.

4.6.4 Control Narrative

When in Auto Mode

Utilize PID control to control the CV based upon the SP (Setpoint). Set the direction of control (direct / reverse acting) as required. Provide bumpless control when in Manual Mode.

Where appropriate, link the Auto/Manual Control mode to the corresponding valve/device control station block. Limit the Flow to within [F_Min, F_Max]

4.7 FIC_MOV

The FIC_MOV class is utilized to implement a Flow-Indicating-Controller that utilizes a MOV (most-open-valve) control strategy to determine the desired flow setpoint.

4.7.1 Control Interface

Parameter	Type	Description	Range	HMI
CtrlAutoCmd	I	Set to Auto Control Mode	W1	EF-PB (L)
CtrlManCmd	I	Set to Manual Control Mode	W1	EF-PB (L)
F	I	Flow	As Req'd	GDx-BG GDx-T
IntlA	I	Interlock When In Auto (Default = 1)	0/1	EF-L
ManPos	I	Manual Mode Position Output	0 - 100%	EF-TE (L)
MOV	I	Most Open Valve	0/1	EF-L
MOV_Open	SP	Most Open Valve – Open Perc	0 - 100%	EF-TE (M)
SP	I	Setpoint	As Req'd	EF-T
CtrlMan	O	Control Mode Manual	0/1	GDx-F EF-T
CV	O	Controlled Variable Output	0-100%	

4.7.2 Alarms

Alarm	Description	Logic	DPri	Reset
InputFail	Transmitter Failure	F is bad quality (Out of range or bad quality from instrument via fieldbus).	2	Auto

4.7.3 Interlocks

Initiating Event	Action	Control Mode		Set Intlocked Output	Description
		Auto	Manual		
IntlA	Set CV = 0	Y	N	-	Set controller output to 0 upon interlock in auto mode.

4.7.4 Control Narrative

When in Auto Mode

If the MOV input is active:

Set the CV value to the MOV_Open setpoint.

If the MOV input is not active:

Utilize PID control to control the CV based upon the SP (Setpoint). Set the direction of control (direct / reverse acting) as required. Provide bumpless control when in Manual Mode.

Where appropriate, link the Auto/Manual Control mode to the corresponding valve/device control station block.

4.8 Ind Indicator

The Ind class is utilized to implement an indicator for an analog value such as flow, temperature, pressure.

4.8.1 Control Interface

Parameter	Type	Description	Range	HMI
PV	I	Process Variable	As Req'd	GDx-BG GDx-T

4.8.2 Alarms

Alarm	Description	Logic	DPri	Reset
InputFail	Transmitter Failure	PV is bad quality (Out of range or bad quality from instrument via fieldbus).	2	Auto

4.8.3 Interlocks

N/A

4.8.4 Control Narrative

N/A

4.9 MTR_FBus

The MTR_FBus class controls a single speed motor via an intelligent motor starter connected via a fieldbus.

4.9.1 Control Interface

Parameter	Type	Description	Range	HMI
CtrlAutoCmd	IH	Set to Auto Control Mode	W1	EF-PB (L)
CtrlManCmd	IH	Set to Manual Control Mode	W1	EF-PB (L)
CtrlRem	I	Remote Control (Pump is Controlled by PLC)	0/1	GDx-F EF-L
Flt	I	Starter Fault	0/1	EF-L
FltCode	I	Starter Fault Code	0 - 1000	EF-T
I	I	Motor Average Current	0 - 150% FLC	GD4-T
Intl	I	Interlock (Man/Auto)	0/1	EF-L
IntlA	I	Interlock When In Auto	0/1	EF-L
KQ_Rst	IH	Runtime Totalizer Reset	W1	EF-PB (M)
ManStart	IH	Manual Start Command	W1	EF-PB (L)
ManStart	IH	Manual Stop Command	W1	EF-PB (L)
PowerOn	I	Motor Starter Input Power On	0/1	
PowerStartDly	SP	Start Time Delay After Power On	0 - 1000 sec	EF-TE (M)
Run	I	Motor Running	0/1	GDx-A EF-L
RunInp	I	Auto Run Input	0/1	
Rst	IH	Reset	W1	EF-PB (L)
StarterRdy	I	Motor Starter Ready	0/1	GDx-F EF-T
Warn	I	Starter Warning	0/1	EF-L
WarnCode	I	Starter Warning Code	0 - 1000	EF-T
CtrlMan	O	Control Mode Manual	0/1	GDx-F EF-T
CmdRun	O	Run Command	0/1	
KQ	O	Runtime	0 - 2^32 -1 min	EF-T
Intlocked	O	Interlocked	0/1	GDx-F

Parameter	Type	Description	Range	HMI
Rdy	O	Motor Ready in Auto	0/1	

4.9.2 PLC Generated Alarms

Alarm	Description	Logic	DPri	Reset
RunFault	Run Fault	PowerOn AND CtrlRem AND ((Run AND NOT CmdRun for 0.5 sec OR (CmdRun AND NOT Run for 0.5 sec) Auto Reset on PowerOn	2	Manual
Starter_Fault	Starter Fault	PowerOn AND Flt	2	Auto

4.9.3 Interlocks

Initiating Event	Action	Control Mode		Set Intlocked Output	Description
		Auto	Manual		
Not PowerOn	Stop	Y	Y	Y	Stop the motor on a power failure.
PowerOn for < PowerStartDly	Stop	Y	N	Y	Prevent motor starting in Auto until the power has been on for the designated time.
NOT StarterRdy OR NOT CtrlRem	Stop	Y	Y	N	Turn off the Run Cmd output if the Starter is not ready or in Remote Mode.
Flt	Stop	Y	Y	N	Stop on a Starter Fault
Intl	Stop	Y	Y	Y	Stop motor regardless if in Auto or Manual Mode.
IntlA	Stop	Y	N	Y	Stop motor if in Auto Mode.

4.9.4 Control Narrative

In Auto mode, set the speed based upon S_Tgt. Limit the speed to the range [S_Min, 100%].

Increment the runtime totalizer (KQ) whenever the pump is running, regardless of Auto/Manual/Local mode.

Ensure that transitions between Auto and Manual are bumpless.

Set the Rdy output to true when the pump is ready for automatic control.

4.10 MTR_VFD_FBus

The MTR_VFD_FBus class controls a VFD driven motor.

4.10.1 Control Interface

Parameter	Type	Description	Range	HMI
CtrlAutoCmd	IH	Set to Auto Control Mode	W1	EF-PB (L)
CtrlManCmd	IH	Set to Manual Control Mode	W1	EF-PB (L)
CtrlRem	I	Remote Control (Motor is Controlled by PLC)	0/1	GDx-F EF-L
Flt	I	VFD Fault	0/1	
FltCode	I	VFD Fault Code	0 - 1000	EF-T
I	I	Motor Current	0 – 150% FLA	EF-T
Intl	I	Interlock (Man/Auto)	0/1	EF-L
IntlA	I	Interlock When In Auto	0/1	EF-L
KQ_Rst	IH	Runtime Totalizer Reset	W1	EF-PB (M)
ManStart	IH	Manual Start Command	W1	EF-PB (L)
ManStart	IH	Manual Stop Command	W1	EF-PB (L)
PowerOn	I	VFD Input Power On	0/1	
PowerStartDly	SP	Start Time Delay After Power On	0 - 1000 sec	EF-TE (M)
Run	I	Motor Running	0/1	GDx-A EF-L
RunInp	I	Auto Run Input	0/1	
Rst	IH	Reset	W1	EF-PB (L)
S	I	Speed Feedback	0 – 100%	GD4-T EF-T
S_Tgt	I	Speed Target	0 – 100%	
S_Man	I	Manual Mode Speed Input	0 – 100%	EF-TE (L)
S_Min	SP	Minimum Motor Speed	0 – 100%	EF-TE (M)
VFD_Rdy	I	VFD Ready	0/1	GDx-F EF-T
Warn	I	VFD Warning	0/1	EF-L
WarnCode	I	VFD Warning Code	0 - 1000	EF-T

Parameter	Type	Description	Range	HMI
CtrlMan	O	Control Mode Manual	0/1	GDx-F EF-T
CmdRun	O	Run Command	0/1	
CmdS	O	Speed Output Signal	0-100%	
KQ	O	Runtime	0 - 2^32 -1 min	EF-T
Intlocked	O	Interlocked	0/1	GDx-F
Rdy	O	Motor Ready in Auto	0/1	

4.10.2 PLC Generated Alarms

Alarm	Description	Logic	DPri	Reset
RunFault	Run Fault	PowerOn AND CtrlRem AND ((Run AND NOT CmdRun for 10 sec OR (CmdRun AND NOT Run for 0.5 sec) Auto Reset on PowerOn	2	Manual
S_Fault	Speed Fault	ABS(S – CmdS) > 5% for 30 sec	2	Auto
VFD_Fault	VFD Fault	PowerOn AND Flt	2	Auto

4.10.3 Interlocks

Initiating Event	Action	Control Mode		Set Intlocked Output	Description
		Auto	Manual		
Not PowerOn	Stop	Y	Y	Y	Stop the motor on a power failure.
PowerOn for < PowerStartDly	Stop	Y	N	Y	Prevent motor starting in Auto until the power has been on for the designated time.
Flt	Stop	Y	Y	N	Stop on a VFD Fault
NOT VFDRdy OR NOT CtrlRem	Stop	Y	Y	N	Turn off the Run Cmd output if the VFD is not ready or in Remote Mode.
Intl	Stop	Y	Y	Y	Stop motor regardless if in Auto or Manual Mode.
IntlA	Stop	Y	N	Y	Stop motor if in Auto Mode.

4.10.4 Control Narrative

In Auto mode, set the speed based upon S_Tgt. Limit the speed to the range [S_Min, 100%].

Increment the runtime totalizer (KQ) whenever the motor is running, regardless of Auto/Manual/Local mode.

Ensure that transitions between Auto and Manual are bumpless.

Set the Rdy output to true when the motor is ready for automatic control.

4.11 Pump_CleanSpd

The Pump_CleanSpd class controls a variable speed pump to be periodically run at a high speed to clean the pump and associated line.

4.11.1 Control Interface

Parameter	Type	Description	Range	HMI
CtrlEnbCmd	IH	Enable Cleanout Mode	W1	EF-PB (L)
CtrlDisCmd	IH	Disable Cleanout Mode	W1	EF-PB (L)
ManStart	IH	Manual Initiate Cleanout	W1	EF-PB (L)
RunInp	I	Countdown Timer	0/1	
K1_SP	SP	Time Before cleanout	0 - 2^32 -1 min	EF-TE (M)
K2_SP	SP	Cleanout duration	0 - 2^32 -1 min	EF-TE (M)
S_Inp	I	Speed Input	0 – 100%	
S_Cleanout	SP	Cleanout Speed	0 – 100%	EF-TE (M)
CtrlEnb	O	Cleanout Mode Enabled	0/1	GDx-F EF-T
CmdS	O	Speed Output Signal	0-100%	
KQ	O	Time Until Next Cleanout	0 - 2^32 -1 min	EF-T
Active	O	Cleanout Active	0/1	GDx-T

4.11.2 PLC Generated Alarms

None

4.11.3 Interlocks

None

4.11.4 Control Narrative

If CtrlEnb THEN

If K1_Timer (K1_SP) expires OR ManStart THEN

Set Active = 1

Initiate K2_Timer

Reset K1_Timer

If K2_Timer expires THEN

Set Active = 0;

Reset K2_Timer

IF Active THEN // cleanout active

CmdS = S_Cleanout

ELSE

CmdS = S_Inp

ELSE // Cleanout not enabled → just pass speed through

CmdS = S_Inp

4.12 RAS_UC RAS Withdrawal Controller

The RAS Withdrawal Controller determines the appropriate flow setpoint for the RAS pumping.

4.12.1.1. Control Interface

Parameter	Type	Description	Range	HMI
CalcModel	SP	Calculation Model (1 = Flow, 2 = Mass)	1 - 2	EF-RB (M)
CtrlAutoCmd	IH	Set to Auto Control Mode	W1	EF-PB (L)
CtrlManCmd	IH	Set to Manual Control Mode	W1	EF-PB (L)
F_Man	IH	Manual Mode Flow	0 – 1000 l/s	EF-TE (L)
F_ML	I	Clarifier Mixed Liquor Flow	0 – 1000 ML/d	
F_Perc_SP	SP	Flow Percentage Setpoint	0 – 100%	EF-TE (M)
CtrlMan	O	Control Mode Manual	0/1	GDx-F EF-T
F_Tgt	O	Target RAS Flow	0 – 1000 l/s	EF-T

4.12.2 Control Narrative

When in manual mode (CtrlMan == 1) set F_Tgt = F_Man

When CalcModel == 1 (1 = Flow)

F_Tgt (l/s) = K (F_ML x F_Perc_SP)

Where

K = 11.574 (unit conversion constant)

F_ML is the mixed liquor flow

F_Perc_SP is the percentage of mixed liquor to be withdrawn as RAS

When CalcModel == 2 (2 = Mass)

Implementation not required as part of demonstration system

4.13 Samp_Init Sample Initiator

4.13.1 Control Interface

Parameter	Type	Description	Range	HMI
F	I	Flow	0 – 1000 ML/d	
FQ_SP	FQ	Volume Setpoint	0 – 1000 ML	EF-TE (M)
Compl	I	Sample Complete	0/1	
Out	O	Initiate Sample	0/1	

4.13.2 Control Narrative

Integrate the Flow (F) until the total volume reaches the Volume Setpoint (FW_SP), at which time set the Initiate Sample output (Out) to true. Reset the integrator when the Sample Complete (Compl) input is activated.

4.14 Sampler

4.14.1 Control Interface

Parameter	Type	Description	Range	HMI
CtrlAutoCmd	IH	Set to Auto Control Mode	W1	EF-PB (L)
CtrlManCmd	IH	Set to Manual Control Mode	W1	EF-PB (L)
CtrlRem	I	Remote Control (Sampler is Controlled by PLC)	0/1	GDx-F EF-L
FailInp	I	Fail	0/1	GD3-F
On	I	On	0/1	GD3-A
ManStart	IH	Manual Start Command	W1	EF-PB (L)
ManStart	IH	Manual Stop Command	W1	EF-PB (L)
Rst	IH	Reset	W1	EF-PB (L)
RunInp	I	Initiate Run	0/1	
CtrlMan	O	Control Mode Manual	0/1	GDx-F EF-T
CmdRun	O	Run Command	0/1	

4.14.2 PLC Generated Alarms

Alarm	Description	Logic	DPri	Reset
Fail	Sampler Failed	FailInp	2	Auto
RunFault	Run Fault	CtrlRem and CmdRun and NOT On for 3 sec	2	Auto

4.14.3 Interlocks

Initiating Event	Action	Control Mode		Set Intlocked Output	Description
		Auto	Manual		
Fail OR RunFault	Stop	Y	Y	N	Turn off the sampler if in alarm.

4.14.4 Control Narrative

In Auto mode, set the run output (CmdRun) whenever the RunInp signal is on.

Ensure that transitions between Auto and Manual are bumpless.

4.15 Tank

The Tank class is utilized to implement a basic tank, with an in-service flag.

4.15.1 Control Interface

Parameter	Type	Description	Range	HMI
InService	SP	In Service	0/1	EF-RB

4.15.2 Alarms

N/A

4.15.3 Interlocks

N/A

4.15.4 Control Narrative

N/A

4.16 TimeRly Timed Relay

The TimeRly class is utilized to control a discrete device for a timed duration based upon an input signal.

4.16.1 Control Interface

Parameter	Type	Description	Range	HMI
Duration	SP	Duration	0 – 10,000 sec	EF-TE
Inp	I	Input Signal	0/1	
Out	O	Output Signal	0/1	

4.16.2 Control Narrative

Upon the Inp signal being activated, set the Output signal to true for the designated Duration.

4.17 ValveD

The ValveD class is utilized to control a discrete valve.

4.17.1 Control Interface

Parameter	Type	Description	Range	HMI
CtrlAutoCmd	I	Set to Auto Control Mode	W1	EF-PB (L)
CtrlManCmd	I	Set to Manual Control Mode	W1	EF-PB (L)
CtrlRem	I	Remote Control (Controlled by PLC)	0/1	GDx-F EF-L
FbkDly	I	Feedback Delay (Default = 2 sec)	0 – 1000 sec	-
Intl	I	Interlock (Man/Auto)	0/1	EF-L
IntlA	I	Interlock When In Auto	0/1	EF-L
OpnReq	I	Open Request - AutoMode	0/1	
ManCls	IH	Manual Close Command	W1	EF-PB (L)
ManOpn	IH	Manual Open Command	W1	EF-PB (L)
ZSC	I	Position Closed	0/1	GD3-A EF-T
ZSO	I	Position Open	0/1	GD3-A EF-T
CtrlMan	O	Control Mode Manual	0/1	GD3-F EF-T
CmdOpn	O	Position Cmd	0 – 100%	EF-T

4.17.2 Alarms

Alarm	Description	Logic	DPri	Reset
ClsFail	Close Fail	NOT CmdOpen AND (ZSO OR NOT ZSC) for FbkDly sec	2	Auto
FbkFail	Limit Switch Feedback Fail	(ZSC AND ZSO) OR NOT (ZSC OR ZSO) for FbkDly sec	2	Auto
OpnFail	Open Fail	CmdOpen AND (ZSC OR NOT ZSO) for FbkDly sec	2	Auto

4.17.3 Interlocks

Initiating Event	Action	Control Mode		Set Intlocked Output	Description
		Auto	Manual		
Intl	Close	Y	Y	Y	Close valve regardless if in Auto or Manual Mode.
IntlA	Close	Y	N	Y	Close valve if in Auto Mode.

4.17.4 Control Narrative

If in Auto mode, open the valve (CmdOpn) when the OpnReq signal is on.

4.18 ValveM

The ValveM class is utilized to control a modulating valve.

4.18.1 Control Interface

Parameter	Type	Description	Range	HMI
CtrlAutoCmd	I	Set to Auto Control Mode	W1	EF-PB (L)
CtrlManCmd	I	Set to Manual Control Mode	W1	EF-PB (L)
Intl	I	Interlock (Man/Auto)	0/1	EF-L
IntlA	I	Interlock When In Auto	0/1	EF-L
PV	I	Position Input Signal	0 – 100%	
ZFbk	I	Position Feedback Signal	0 – 100%	GD3-A EF-T
CtrlMan	O	Control Mode Manual	0/1	GD3-F EF-T
ZCmd	O	Position Cmd	0 – 100%	EF-T

4.18.2 Alarms

Alarm	Description	Logic	DPri	Reset
ZFail	Position Feedback Error	ZFbk Fail (Bad quality or out of range)	2	Auto
ZFbkFail	Position Feedback Fail	ABS(Z – ZCmd) > 5% for 30 seconds	2	Auto

4.18.3 Interlocks

Initiating Event	Action	Control Mode		Set Intlocked Output	Description
		Auto	Manual		
Intl	Close	Y	Y	Y	Close valve regardless if in Auto or Manual Mode.
IntlA	Close	Y	N	Y	Close valve if in Auto Mode.

4.18.4 Control Narrative

Set the output signal (ZCmd) to the PV if in Auto mode. Ensure the manual mode is linked to any upstream controller.

5.0 SECONDARY CLARIFIERS

5.1 Secondary Clarifier 1

P&ID Drawing: SK-P0002 PLC: PLC-S810

5.1.1 Class Instances

Equipment	Instance	Class	Control Input Links	I/O Links & Fieldbus Links
TK-S010	YK-S0100	Tank	-	-
LIT-S0101	LI-S0101	Ind	-	I/O: PV = LIT-S0101
CM-S011	YK-S0110	MTR_FBus	Intl = OAHH-S0110.Alarm PowerOn = MCC-S711.PowerOn RunInp = Set true when YK-S0100.InService for 1 minute OR (NOT YK-S0100.InService for the first 2 minutes)	FBus: MS-S011
	OAH-S0110	Alm_TD	Dly = 2 sec Enb = YK-S0110.Run	I/O: Inp = OSH-S0110
	OAHH-S0110	Alm	Enb = YK-S0110.Run Rst = YK-S0110.Rst	I/O: Inp = OSHH-S0110
-	FFC-S0021	FFC_MOV	D1_F = FIC-S0121.F D2_F = FIC-S0221.F D3_F = FIC-S0331.F D1_InService = YK-S0100.InService D2_InService = YK-S0200.InService D3_InService = YK-S0300.InService	
FIT-S0121	FIC-S0121	FIC_MOV	MOV = (FFC-S0021.MOV == 1) SP = FFC-S0021.D1_F_Tgt	I/O: F = FIT-S0121 FV-S0121.ZCmd = CV
FV-S0121	FK-S0121	ValveM	PV = FIC-S0121.CV IntlA = NOT YK-S0100.InService	HART: FV-S0121.(Z, ZCmd)
XV-S3031	ZY-S3031	TimeRly	Inp = ZS-S3031	ZS-S3031
	XK-S3031	ValveD	OpnReq = ZY-S3031.Out	I/O: XV-S3031.(ZSC, ZSO, Rem, CmdCls, CmdOpn)

5.2 Secondary Clarifier 2

P&ID Drawing: SK-P0003 PLC: PLC-S810

5.2.1 Class Instances

Equipment	Instance	Class	Control Input Links	I/O Links & Fieldbus Links
TK-S020	YK-S0200	Tank	-	-
LIT-S0101	LI-S0201	Ind	-	I/O: PV = LIT-S0201
CM-S011	YK-S0210	MTR_FBus	Intl = OAHH-S0210.Alarm PowerOn = MCC-S711.PowerOn RunInp = Set true when YK-S0200.InService for 1 minute OR (NOT YK-S0200.InService for the first 2 minutes)	FBus: MS-S021
	OAH-S0210	Alm_TD	Dly = 2 sec Enb = YK-S0210.Run	I/O: Inp = OSH-S0210
	OAHH-S0210	Alm	Enb = YK-S0210.Run Rst = YK-S0210.Rst	I/O: Inp = OSHH-S0210
FIT-S0221	FIC-S0221	FIC_MOV	MOV = (FFC-S0021.MOV == 1) SP = FFC-S0021.D1_F_Tgt	I/O: F = FIT-S0221 FV-S0221.ZCmd = CV
FV-S0221	FK-S0221	ValveM	PV = FIC-S0221.CV IntlA = NOT YK-S0200.InService	HART: FV-S0221.(Z, ZCmd)
XV-S3041	ZY-S3041	TimeRly	Inp = ZS-S3041	ZS-S3041
	XK-S3041	ValveD	OpnReq = ZY-S3041.Out	I/O: XV-S3041.(ZSC, ZSO, Rem, CmdCls, CmdOpn)

5.3 Secondary Clarifier 3

P&ID Drawing: SK-P0004 PLC: PLC-S810

5.3.1 Class Instances

Equipment	Instance	Class	Control Input Links	I/O Links & Fieldbus Links
TK-S030	YK-S0300	Tank	-	-
LIT-S0101	LI-S0301	Ind	-	I/O: PV = LIT-S0301
CM-S011	YK-S0310	MTR_FBus	Intl = OAHH-S0310.Alarm PowerOn = MCC-S711.PowerOn RunInp = Set true when YK-S0300.InService for 1 minute OR (NOT YK-S0300.InService for the first 2 minutes)	FBus: MS-S031
	OAH-S0310	Alm_TD	Dly = 2 sec Enb = YK-S0310.Run	I/O: Inp = OSH-S0310
	OAHH-S0310	Alm	Enb = YK-S0310.Run Rst = YK-S0310.Rst	I/O: Inp = OSHH-S0310
FIT-S0321	FIC-S0321	FIC_MOV	MOV = (FFC-S0021.MOV == 1) SP = FFC-S0021.D1_F_Tgt	I/O: F = FIT-S0321 FV-S0321.ZCmd = CV
FV-S0321	FK-S0321	ValveM	PV = FIC-S0321.CV IntlA = NOT YK-S0300.InService	HART: FV-S0321.(Z, ZCmd)

5.4 Samplers

P&ID Drawing: SK-P0005 PLC: PLC-S810

5.4.1 Class Instances

Equipment	Instance	Class	Control Input Links	I/O Links & Fieldbus Links
-	FY-S5291	Samp_Init	F = FI-S0121 – (FIC-S1015.F + FIC-S1025.F + FIC-S1035.F) / 2 Compl = YK-S5290.On	-
SA-S529	YK-S5290	Sampler	Run_Inp = FY-S5291.Out	I/O: SA-S529 (Rem, Fail, On, CmdRun)
-	FY-S5301	Samp_Init	F = FI-S0121 – (FIC-S1015.F + FIC-S1025.F + FIC-S1035.F) / 2 Compl = YK-S5300.On	-
SA-S530	YK-S5300	Sampler	Run_Inp = FY-S5301.Out	I/O: SA-S530 (Rem, Fail, On, CmdRun)
-	FY-S5311	Samp_Init	F = FY-S5291.F + FY-S5301.F + FY-S5321.F Compl = YK-S5310.On	-
SA-S531	YK-S5310	Sampler	Run_Inp = FY-S5311.Out	I/O: SA-S531 (Rem, Fail, On, CmdRun)
-	FY-S5321	Samp_Init	F = FI-S0121 – (FIC-S1085.F + FIC-S1095.F) Compl = YK-S5320.On	-
SA-S532	YK-S5320	Sampler	Run_Inp = FY-S5321.Out	I/O: SA-S532 (Rem, Fail, On, CmdRun)

5.5 Clarifier 1&2 RAS Pumping

P&ID Drawing: SK-P0006 & SK-P0007 PLC: PLC-S810

5.5.1 Class Instances

Equipment	Instance	Class	Control Input Links	I/O Links & Fieldbus Links
P-S101	SY-S1018	Pump_CleanSpd	S_Inp = FIC.S1015	
	SK-S1010	MTR_VFD_FBus	IntI = PAL-S1011.Alarm IntIA = YK-S0100.InService PowerOn = MCC-S711.PowerOn RunInp = YY-S1001.Eq1CmdRun S_Tgt = SY-S1018.CmdS	FBus: VFD-S101 (CtrlRem, Flt, I, Run, Rdy, S, CmdRun, CmdS)
	PAL-S1011	Alm_TD	Dly = 2 sec Enb = SK-S101.Run Rst = SK-S101.Rst	I/O: PSL-1011
P-S102	SY-S1028	Pump_CleanSpd	S_Inp = FIC.S1025	
	SK-S1020	MTR_VFD_FBus	IntI = PAL-S1021.Aalrm IntIA = 1 PowerOn = MCC-S712.PowerOn RunInp = YY-S1001.Eq2CmdRun S_Tgt = SY-S1018.CmdS	FBus: VFD-S102 (CtrlRem, Flt, I, Run, Rdy, S, CmdRun, CmdS)
	PAL-S1021	Alm_TD	Dly = 2 sec Enb = SK-S102.Run Rst = SK-S102.Rst	I/O: PSL-S1021
P-S103	SY-S1038	Pump_CleanSpd	S_Inp = FIC.S1035	
	SK-S1030	MTR_VFD_FBus	IntI = PAL-S1031.Aalrm IntIA = YK-S0200.InService PowerOn = MCC-S711.PowerOn RunInp = YY-S1001.Eq3CmdRun S_Tgt = SY-S1018.CmdS	FBus: VFD-S103 (CtrlRem, Flt, I, Run, Rdy, S, CmdRun, CmdS)
	PAL-S1031	Alm_TD	Dly = 2 sec Enb = SK-S103.Run Rst = SK-S103.Rst	I/O: PSL-S1031
-	YY-S1029	Duty_D2S1	EqD1_Rdy = SK-S1010.Rdy EqD2_Rdy = SK-S1030.Rdy EqS1_Rdy = SK-S1020.Rdy RunP1_Inp = YK-S0100.InService RunP2_Inp = YK-S0200.InService	

5.6 Clarifier 1&2 RAS Flow Control

P&ID Drawing: SK-P0006 & SK-P0007 PLC: PLC-S810

5.6.1 Class Instances

Equipment	Instance	Class	Control Input Links	I/O Links & Fieldbus Links
-	UY-S0129	RAS_UC	F_ML = FIC_S0121.F	-
-	UY-S0229	RAS_UC	F_ML = FIC_S0221.F	-
FIT-S1015	FIC-S1015	FIC	SP = UY-S0129.F_Tgt Intl = YY-S1029.EqD1_CmdRun	FIT-S1015
FIT-S1025	FIC-S1025	FIC	SP = IF UY-S1029.EqS1_Assign == 1 SP = UY-S0129.F_Tgt ELSE SP = UY-S0229.F_Tgt Intl = YY-S1019.EqS1_CmdRun	FIT-S1025
FIT-S1035	FIC-S1035	FIC	SP = UY-S0229.F_Tgt Intl = YY-S1029.EqD2_CmdRun	FIT-S1035

5.7 Clarifier 3 RAS Pumping

P&ID Drawing: SK-P0008 PLC: PLC-S810

5.7.1 Class Instances

Equipment	Instance	Class	Control Input Links	I/O Links & Fieldbus Links
P-S108	SY-S1088	Pump_CleanSpd	S_Inp = FIC.S1085	
	SK-S1080	MTR_VFD_FBus	IntI = PAL-S1081.Alarm IntIA = YK-S0300.InService PowerOn = MCC-S712.PowerOn S_Tgt = SY-S1088.CmdS	FBus: VFD-S108 (CtrlRem, Flt, I, Run, Rdy, S, CmdRun, CmdS)
	PAL-S1081	Alm_TD	Dly = 2 sec Enb = SK-S108.Run Rst = SK-S108.Rst	I/O: PSL-1081
P-S109	SY-S1098	Pump_CleanSpd	S_Inp = FIC.S1095	
	SK-S1090	MTR_VFD_FBus	IntI = PAL-S1091.Aalrm IntIA = YK-S0300.InService PowerOn = MCC-S711.PowerOn S_Tgt = SY-S1098.CmdS	FBus: VFD-S109 (CtrlRem, Flt, I, Run, Rdy, S, CmdRun, CmdS)
	PAL-S1091	Alm_TD	Dly = 2 sec Enb = SK-S109.Run Rst = SK-S109.Rst	I/O: PSL-S1091
-	YY-S1089	Duty_DS	Eq1_Rdy = SK-S1080.Rdy Eq2_Rdy = SK-S1090.Rdy RunInp = YK-S0300.InService	

5.8 Clarifier 3 RAS Flow Control

P&ID Drawing: SK-P0008 PLC: PLC-S810

5.8.1 Class Instances

Equipment	Instance	Class	Control Input Links	I/O Links & Fieldbus Links
-	UY-S0329	RAS_UC	F_ML = FIC_S0321.F	-
FIT-S1085	FIC-S1085	FIC	SP = UY-S0329.F_Tgt Intl = YY-S1089.Eq1_CmdRun	FIT-S1085
FIT-S1095	FIC-S1095	FIC	SP = UY-S0329.F_Tgt Intl = YY-S1089.Eq2_CmdRun	FIT-S1095

5.8.2 RAS Flow Splitting

P&ID Drawing: SK-P0009 PLC: PLC-S810

5.8.3 Class Instances

Equipment	Instance	Class	Control Input Links	I/O Links & Fieldbus Links
-	AI-S1041	Ind	-	I/O: AIT-S1041
-	FFC-S1200	FFC_MOV	D1_F = FIC-S1210.F D2_F = FIC-S1220.F D3_F = FIC-S1230.F D4_F = FIC-S1240.F D1_InService = Reactor1_InService D2_InService = Reactor2_InService D3_InService = Reactor3_InService D4_InService = Reactor4_InService	-
-	FIC-S1210	FIC_MOV	MOV = (FFC-S1200.MOV == 1) SP = FFC-S1200.D1_F_Tgt	FBus: FIT-S1210
-	FIC-S1220	FIC_MOV	MOV = (FFC-S1200.MOV == 2) SP = FFC-S1200.D2_F_Tgt	FBus: FIT-S1220
-	FIC-S1230	FIC_MOV	MOV = (FFC-S1200.MOV == 3) SP = FFC-S1200.D3_F_Tgt	FBus: FIT-S1230
-	FIC-S1240	FIC_MOV	MOV = (FFC-S1200.MOV == 4) SP = FFC-S1200.D4_F_Tgt	FBus: FIT-S1240
-	FK-S1210	ValveM	PV = FIC-S1210.CV IntlA = NOT Reactor1_InService	FBus: FV-S1210
-	FK-S1220	ValveM	PV = FIC-S1220.CV IntlA = NOT Reactor2_InService	FBus: FV-S1220
-	FK-S1210	ValveM	PV = FIC-S1230.CV IntlA = NOT Reactor3_InService	FBus: FV-S1220
-	FK-S1210	ValveM	PV = FIC-S1240.CV IntlA = NOT Reactor4_InService	FBus: FV-S1230

5.9 WAS Pumping

P&ID Drawing: SK-P0010 PLC: PLC-S810

5.9.1 Class Instances

Equipment	Instance	Class	Control Links	I/O Links & Fieldbus Links
-	UY-2011	Custom See 5.9.2	RAS_SS = AI-S1041	
-	FIC-S2012	FIC	SP = UY-2011.F_Tgt	F = FIT-S2011
-	YC-S2013	Duty_DS	Eq1_Rdy = SK-S2020.Rdy Eq2_Rdy = SK-S2030.Rdy RunInp = FIC-S2012.CV > 0 L/s	
P-S202	SK-S2020	MTR_VFD_FBus	IntI = 0 IntIA = TK-S030.InService PowerOn = MCC-S712.PowerOn S_Tgt = IF(YC-S2014.P1_CmdRun, FIC-S2011.CV, 0)	VFD-S202 (CtrlRem, Flt, I, Run, Rdy, S, CmdRun, CmdS)
P-S203	SK-S2030	MTR_VFD_FBus	IntI = 0 IntIA = TK-S030.InService PowerOn = MCC-S711.PowerOn S_Tgt = IF(YC-S2014.P2_CmdRun, FIC-S2011.CV, 0)	VFD-S203 (CtrlRem, Flt, I, Run, Rdy, S, CmdRun, CmdS)

5.9.2 UY-S2011 WAS Withdrawal Rate

The WAS Withdrawal Controller determines the appropriate flow setpoint for the WAS pumping, and also determines when the WAS pumps should run

5.9.2.1. Control Interface

Parameter	Type	Description	Range	HMI
CalcModel	SP	Calculation Model (1 = Solids Retention Time, 2 = Total Mass Removal)	1 - 2	EF-RB (M)
CtrlAutoCmd	IH	Set to Auto Control Mode	W1	EF-PB (L)
CtrlManCmd	IH	Set to Manual Control Mode	W1	EF-PB (L)
F_Man	IH	Manual Mode Flow Input	0 – 1000 l/s	EF-TE (L)
K1_SP	SP	Interval Time When in Interval Mode	6 – 24 hrs	EF-TE (M)
K1_Start	SP	Interval Start Time	0 – 24 hrs	EF-TE (M)
K2_SP	SP	Intermittent Time When in Intermittent Mode	10 – 60 min	EF-TE (M)
ML_SS	SP	Mixed Liquor Suspended Solids	0 – X mg/l	EF-TE (L)
RAS_SS	I	RAS Suspended Solids	0 – X mg/l	
ReactVol	SP	Volume of each Reactor	0 – X ML	EF-TE (L)
ReactNo	SP	Number of Reactors in Service	0 - 4	EF-TE (L)
SRT	SP	Solids Retention Time	1 – 12 days	EF-TE (L)
TMass	SP	WAS Mass Removal Per Day (TMR Mode)	0 – 10,000 kg	EF-TE (M)
WMode	SP	Withdrawal Mode (0 = Continuous 1 = Interval 2 = Intermittent)	0 - 2	EF-RB (M)
CtrlMan	O	Control Mode Manual	0/1	GDx-F EF-T
F_Tgt	O	Target WAS Flow	0 – 1000 l/s	EF-T

5.9.3 Control Narrative

When in manual mode (CtrlMan == 1) set F_Tgt = F_Man

When CalcModel == 1 (1 = Solids Retention Time)

F1 (l/s) = K [(ML_SS x ReactVol x ReactNo) / SRT / RAS_SS)

Where

K = 11.574 (unit conversion constant)

ML_SS is an operator entered value for the mixed liquor suspended solids (mg/l)

ReactVol is the volume of one reactor (Default 1.8 ML)

ReactNo is the number of reactors in service

SRT is the operator entered solids retention time (days)

RAS_SS is the RAS suspended solids value (mg/l)

When CalcModel == 2 (2 = Total Mass Removal)

F1 (l/s) = K x TMass / RAS_SS

Where

K = 11.574 (unit conversion constant)

TMass is the operator entered total WAS mass to be removed per day.

RAS_SS is the RAS suspended solids value (mg/l)

Set the Target WAS Flow Rate based upon the Withdrawal Mode (WMode)

CASE WMode == 0 (Continuous)

F_Tgt = F1

WMode == 1 (Interval)

F2 = F1 * 24 hours / K1_SP

IF current hour is within the interval [K1_Start, K1_Start + K1_SP] THEN

F_Tgt = F2

ELSE

F_Tgt = 0

WMode == 2 (Intermittent)

F2 = F1 * 60 minutes / K2_SP

IF current minute is within the interval [0, K2_ SP] THEN

F_Tgt = F2

ELSE

F_Tgt = 0