Functional Design Specification

For

Tyldesley UID - East Lancs Pumping Station - Chemical Dosing and Storage PLC05

For

United Utilities PLC

Cougar Automation Limited	
Project No:	56938
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1. INTRODUCTION

1.1. Background

The Chemical Storage & Dosing PLC (PLC05) will be one of four new PLC's being provided on an Ethernet network at East Lancs PS as part of the overall Tyldesley UID's project.

- PLC01 – New Inlet Screens & Screenings handling PLC. All control details provided in Functional Design Specification WIG0179_80021608_01_20_61400.
- Existing PLC02 – Foul Pumps PLC. All control details provided in Functional Design Specification WIG0179_80021608_01_20_61401
- PLC03 – New Storm Pumping PLC. All control details provided in Functional Design Specification WIG0179_80021608_01_20_61402
- PLC04 – New Detention Tank. All control details provided in Functional Design Specification WIG0179_80021608_01_20_61403
- PLC05 – New Chemical Dosing PLC. All control details provided in this document which references the Control Philosophy WIG0179/80021608/01/20/61034.

The Plant Specific section (Section 7) of this document shall describe the following control modules of the new Chemical Storage & Dosing PLC (PLC05)

- Module 1: Chemical Dosing & Storage

PLC05 is to be installed in the chemical dosing control panel CP02, located in the new vendor supplied packaged dosing kiosk. The control panel and software will be provided to standard UU design to be used as detailed in Section 6 of this document.

1.2. Project Objectives

This Project addresses two Unsatisfactory Intermittent Discharges (UID's):

- WIG0179 – East Lancs Pumping Station
- NW016920135 – Tyldesley Old Wastewater Treatment Works (WwTW) Storm Tanks

The overflow reference WIG0179 has been identified as UID on aesthetic and river impact grounds.

The overflow reference NW016920135 has been identified as UID on river impact grounds.

Both UID's are to be resolved during AMP5. A general description of the solution to be constructed at each site includes:-

WIG0179 – East Lancs Pumping Station

- New 20m internal diameter 6,000m^3 capacity detention tank
- New CSO / Screening chamber

- New storm pumping station and river outfall
    - New pumps for foul pumping station together with new delivery manifold, pipework, valves, and valve chamber

NW016920135 – Tyldesley Old WwTW

- New 6,250m^3 capacity storm tank
- Modifications to Tyldesley Old WwTW Inlet structure
- New storm tank pumping station
- New spill sewer and outfall to Moss Brook

1.3. Contract Scope Of Supply

The Project Works shall include the following:

1. As part of this project there will be installed:
    - New septicity control chemical storage & dosing; 6000L storage tank, duty only dosing pump, emergency shower & spill containment blind tank
2. Motor control centre (MCC)
3. PLC and HMI to power and control all equipment associated
4. FAT's, SAT's and pre-commissioning testing
5. Testing and Commissioning
6. O&M manuals

2. RELATED DOCUMENTATION

This document should be read in conjunction with the following documentation:

2.1. List of Applicable Standard Specifications

Title	Issue	Date
General Specifications		
S01 - General Requirements	9	Oct 12
UU CESWI 6 – Civil Engineering	2	Mar 08
UU Code of Practice 60024. Installations in Potentially Explosive Atmospheres associated with Water and Wastewater	6	Mar 08
Electrical / ICA Specifications		
S04 – Design of Electrical and ICA Systems	3.3	Dec 12
E101 – LV Control Panels (adopting WIMES 3.01)	15	Jun 11
E103 – LV Electric Motors (adopting WIMES 3.02)	8	Mar 12
E104 – Electrical Installation (adopting WIMES 3.02 & 3.02A)	12	Nov 09
E106 – Instrumentation Components	12	Apr 07
E110 – Development and Testing of Process Control Software	8	Jan 13
E111 – Telemetry Interfacing	2	Apr 07
E118 – SCADA Systems & HMIs	8	Dec 10
E121 – LV Electrical Equipment for Package Plant (adopting WIMES 3.04)	2	Mar 11
Environmental and Safety Specifications		
S08 - Management of Environment and Sustainable Development	7	Jul 09
Roles & Responsibilities		
United Utilities AX4 Preferred Intelligent MCC Commissioning Roles and Responsibilities Document	1	Dec 06
Engineering Instructions		
EI006 – Application of UU SS S09	1	Apr 06
EI007 – Defining Significant Changes to Key Design Deliverables	1	May 06

2.2. List of Applicable Project Related Specifications

Title	Issue	Date
WIG0179 / 80021608 / 01 / 20 / 61034 Chemical Storage and Dosing - Control Philosophy	B	11 June 2013

2.3. List of Project Related Drawings & Documents

Title	Issue	Date
WIG0179 / 80021608 / 01 / 13 / 71001 Incoming Sewers, CSO & Storm Pump PS P&ID	D	31 May 2013
WIG0179 / 80021608 / 01 / 13 / 71002 Inlet Screens P&ID	D	31 May 2013
WIG0179 / 80021608 / 01 / 13 / 71004 Detention Tank P&ID	C	31 May 2013
WIG0179 / 80021608 / 01 / 13 / 71005 Chemical Dosing P&ID	C	31 May 2013
WIG0179 / 80021608 / 01 / 20 / 61001 Instrument Schedule	C	May 2013
WIG0179 / 80021608 / 01 / 20 / 61003 Telemetry Schedule	B	May 2013
WIG0179 / 80021608 / 01 / 20 / 61004 Actuator Schedule	C	July 2013
WIG0179 / 80021608 / 01 / 20 / 61044 CP03 Drive Interlock Schedule	C	24 May 2013
WIG0179 / 80021608 / 01 / 20 / 61052 MCC03 Schedule	C	24 May 2013
WIG0179/80021608/01/20/61073 East Lancs Pump Station Site Architecture Drawing	C	July 2013
WIG0179 / 80021608 / 01 / 20 / 61070 East Lancs Pump Station Site Architecture Drawing	C	July 2013

2.4. References of Applicable UU Standard Module FDS

Title	Issue	Date
Functional Design Specification: Analogue Instrument Alarm Module ANLG_INST Document ref: ANLG_INST_04_03_V1.0.doc	1.0	May 08
Functional Design Specification: Digital Input Processing Module DI DEBOUNCE Document ref: DI_DEBOUNCE_01_01_V1.0.doc	1.0	May 08
Functional Design Specification: DME Pump Block Document ref: DDP1_02_24_V1.0.DOC	1.0	April 12

3. GLOSSARY OF TERMS

AS	Automation Station
CAS	Central Archive Server
CSD	Cyclic Sent Data (from Simocode IMS via Profibus)
CSO	Combined Sewer Overflow
DCS	Distributed Control System
DOL	Direct On Line (Motor)
EICA	Electrical Instrumentation Control and Automation
ES	Engineering Station
FSD	Fixed Speed Drive
FDS	Functional Design Specification
HMI	Human Machine Interface
IA	Integrated Alliance
ICA	Instrumentation Control and Automation
IMCC	Intelligent Motor Control Centre
IMS	Intelligent Motor Starter
LOI	Local Operator Interface
MCC	Motor Control Centre
NOP	Network of Participants
OS	Operator Station
PLC	Programmable Logic Controller
PP	Process Partner
PID	3-term Controller Proportional, Integral & Derivative terms
SCADA	Supervisory Control and Data Acquisition
SDS	Software Design Specification
SHEQ	Safety Health Environment & Quality
SI	Systems Integration
SSB	Solutions Scope Book
SSP	Solutions Service Provider
UID	Unsatisfactory Intermittent Discharge
URS	User Requirement Specification
VSD	Variable Speed Drive
WTW	Water Treatment Works
WwPS	Waste Water Pumping Station
WwTW	Waste Water Treatment Works

4. PROCESS OVERVIEW

The Chemical Dosing PLC (PLC05) will be one of four new PLCs being provided on an Ethernet network at East Lancs PS as part of the overall Tyldesley UID's project.

PLC01 – New Inlet Screens and Screenings handling PLC.

Existing PLC02 – Existing Foul Pumps PLC. New CPU, HMI and software.

PLC03 – New Storm Pumping PLC.

PLC04 – New Detention Tank.

PLC05 – New Chemical Dosing PLC

PLC06 – Storm Tank PLC

PLC07 – Ancillary PLC

PLC05 is to be installed in the Dosing Control Panel CP02.

4.1. Chemical Storage and Dosing

This Control Philosophy will describe how the following processes function in the various modes;

- New septicity control chemical storage & dosing; 6000L storage tank, duty only dosing pump, emergency shower & spill containment blind tank.

An Ultrasonic level instrument (A5-LIT315) shall monitor the level inside the chemical storage tank and provide a high level alarm. A high-high level switch (A5-LS316) shall also be installed.

Dosing shall begin as storm flows enter the detention tank and will be flow proportioned to the incoming flow. There is no flow meter to measure detention tank inlet flows, therefore flowrate will be calculated using rate of rise within the detention tank as measured by the ultrasonic level instrument (A5-LIT312).

5. CONTROL SYSTEM OVERVIEW

This section details the current control system configuration and any subsequent changes to the system based on the project requirements. The section also details the software being employed to implement the system changes, and if any impact of software version changes.

5.1. PLC System

The control system in the new Dosing Control Panel (CP02) shall comprise a S7-300 PLC (S7-315-2PN/DP) (designated PLC05). The PLC shall be linked to the HMI via an Ethernet network.

5.2. HMI System

The new HMI (designated HMI05) will be used to serve as an interface to the control system for the user shall be a Siemens MP277 10'' Touchscreen HMI device.

5.3. Telemetry

An Ethernet link from the Telemetry Outstation to the Ethernet switch mounted within the Telemetry Panel should be installed. UU Telemetry shall be responsible for the final connection of the power supply to the Telemetry Outstation and wiring of any new hardwired signals from the Telemetry Outstation to the Telemetry marshalling terminals mounted within the existing Telemetry Marshalling Enclosure.

The installation shall consist of:

- Software generated signals (non-critical) shall be transmitted to the Telemetry Outstation Master via Ethernet link. The required telemetry signals shall be provided to the Telemetry Outstation.
- Hardwired signals for critical items of plant and instruments, which shall be available in the event of PLC or Profibus network failure and be hardwired direct to the Telemetry Outstation marshalling box

5.4. Supplied Items

Siemens PLC and HMI have been supplied as deliverable items, as part of this project.

Please see WIG0179_80021608_01_20_61418 PLC05 SDS001 Annexure – SDS Annexure for detailed bill of materials.

5.5. System Development

The development and configuration of the control system software is to be carried out as follows.

5.5.1. PLC Software

Siemens SIMATIC Manager Step 7 (Version 5.5) will be used for the configuration and design of the PLC software.

5.5.2. HMI Software

Siemens SIMATIC WinCC Flexible Advanced (2008, SP2) will be used for the configuration, design and deployment of the HMI software.

5.5.3. SCADA Software

There is no SCADA system on site.

6. GENERAL CONTROL STRATEGY

A standardised approach to module development has been implemented to achieve uniform implementation practice throughout the AX5 programme. This strategy increases the familiarity of maintenance personnel and thereby helping to minimise plant downtime.

The following section gives a generalised overview of the functionality the standard software control modules perform.

6.1. Motor Control

6.1.1. Variable Speed Drives

The Unidirectional variable Speed drive (VSD drive) has been identified as one of the standard modules; the UU standard Module document VSD_02_03_V1.1 directly addresses the control strategy & implementation of the Variable Speed Drive module (identified in the software as VSD).

The VSD module is used to control, monitor & operate the variable frequency (speed) AC drive. The following functionality for applies to both 'Standard Simocode VSD' and traditional 'Hardwired' MCC starters.

Drive Availability: - The drive status shall be monitored to ensure availability to operate under PLC control. The following conditions need to be present to allow the drive to operate under PLC control: -

- Auto selected at MCC starter
- Drive available from MCC starter
- Drive healthy from MCC starter
- Node healthy (*Applies to Simocode DOL only*)
- External Interlocks are healthy
- Backup control not active
- PLC derived faults (Failed to run / failed to stop) not active.

Operating Modes: - The drive has 2 operating modes available to PLC Control, namely '*Supervisory*' and '*PLC Auto*'. These operating modes shall be selectable at the HMI/SCADA (see section 6.3). Also the drive shall be operated locally at the MCC starter.

PLC Derived Drive Faults: - The PLC shall monitor the drive for abnormal conditions while operating under PLC control. The drive has 3 derived fault conditions, namely '*Failed to Run'*, '*Failed to Stop'* and '*Failed to Reach Setpoint'*.

'*Failed to Run'* – If the drive is requested to run and the '*Running'* feedback signal has not been detected within a defined time period (seconds) then the drive shall fail. This condition shall inhibit the drive from further operation until the condition has been manually reset via the HMI/SCADA.

'*Failed to Stop'* – If the drive is not required to run and the '*Running'* feedback signal remains detected for a defined time period (seconds) then the drive shall fail. This condition shall inhibit the drive from further operation until the condition has been manually reset via the HMI/SCADA.

The time period for monitoring the '*Running'* signal shall be individual to the drive, however, the same time period applies to both '*Failed to Run'* and '*Failed To Stop'.*

Failed to Reach Setpoint' – If the drive is requested to run then a comparison shall be made between the desired speed and the actual speed. An adjustable '*Speed Deviation'* is used to define the upper and lower acceptable speed limits. If the actual speed remains outside of the calculated limits for a defined time period (seconds) then an alarm shall be raised. The drive shall continue to operate. The condition shall automatically reset when the drive speed returns to within limits or when the drive stops.

Hours Run Monitoring: - The drive hours run shall be determined and updated whenever the drive is running, irrespective of the operating mode. The cumulative hours run value shall reset at 10000.

Current Monitoring: - (*Applies to Simocode DOL only*). The actual drive current shall be determined based on the Full Load Current rating of the associated drive. The actual drive current (as a percentage of FLC) is available from the Simocode unit, and the actual drive current in amps shall be calculated i.e. *Drive Current (A) = (Drive Current (% of FLC) / 100*) x *Full Load Current.*

6.1.1.1. Operator Interaction

The following status, alarms and control functions shall be available for the VSD drive on the HMI/SCADA.

Drive Status

Plant Description	States
Drive Control Status	MCC Control: PLC Auto; Supervisory
Drive Status	Loss of Node: Drive Unavailable: Drive Fault; Drive Failed to Run: Drive Failed To Stop: Interlocks Active: Backup Control Active : Drive Running: Drive Stopped:

Drive Status (Analogue)

Description	Analogue Range		
	Low	High	Units
Drive Hours Run	0	10000	Hours
Drive Current (*Simocode only)*	0	As Reqd.	A
Drive Full Load Current (*Simocode only)*	0	As Reqd.	A
Drive Actual Speed	0	As Reqd.	Hz
Drive Desired Speed	0	As Reqd.	Hz

Drive Alarms

Alarm Description	Reset
Drive Unavailable	Self
Drive Fault	MCC
Drive Failed To Run	HMI Reset
Drive Failed To Stop	HMI Reset
Drive Failed To Reach Speed	Self

Alarm Description	Reset
Drive Interlocks Active	Self
Drive Backup Control Active	Self
Drive Node Fault (*Simocode only)*	Self

Adjustable Control Parameters

Plant Description	Data Access Values			Access Level
	Low	High	Units	
Supervisory Mode Desired Speed	0	50.0	Hz	Operator
PLC Auto / Supervisory Mode Selection				Operator
Supervisory Mode Start / Stop Command				Operator
Drive Fault Reset				Operator

6.2. Actuated Valve Control

6.2.1. Solenoid Valve Control

The solenoid valve has been identified as a standard module; the UU standard Module document SOLENOID_02_05_V1.0 directly addresses the control strategy & implementation of the Solenoid Valve module (identified in the software as SOLENOID).

In general terms, the SOLENOID module is used to control, monitor & operate the single actuated solenoid valve and shall be used for hardwired Solenoid valves which shall have open/close feedback and a command to open (2 DI/1DO). The valve type shall be energized to open.

Valve Availability: - No external plant conditions need to be present to allow the valve to operate under PLC control.

Operating Modes: - The valve has 2 operating modes available to PLC Control, namely '*Supervisory*' and '*PLC Auto*'. These operating modes shall be selectable at the HMI/SCADA (see section 6.3). The valve shall have no local control.

PLC Derived Drive Faults: - The PLC shall monitor the valve for abnormal conditions while operating under PLC control. The valve has 3 derived fault conditions, namely '*Failed to Open'*, '*Failed to Close'* and '*Limit Switch Fault'*.

'*Failed to Open'* – If the valve is requested to open and the '*Opened'* feedback signal has not been detected within a defined time period (seconds) then an alarm shall be raised. The valve shall continue to operate. The condition shall be manually reset via the HMI/SCADA.

'*Failed to Close'* – If the valve is not required to open and the '*Closed'* feedback has not been detected within a defined time period (seconds) then an alarm shall be raised. The valve shall continue to operate. The condition shall be manually reset via the HMI/SCADA.

The time period for monitoring both the '*Opened'* and 'Closed' signals shall be individual to the valve, however, the same time period applies to both '*Failed to Open'* and '*Failed To Close'.*

'*Limit Switch Fault'* – If the '*Opened'* and '*Closed'* feedback signals are detected simultaneously then an alarm shall be raised. The valve shall continue to operate. The condition shall automatically reset when the valve feedback signals change state.

6.2.1.1. Operator Interaction

The following status, alarms and control functions shall be available for the solenoid valve on the HMI/SCADA.

Valve Status

Plant Description	States
Valve Control Status	PLC Auto; Supervisory
Valve Status	Fault: Opened: Closed; Travelling: Failed to Open: Failed to Close

Valve Status (Analogue)

Description	Analogue Range		
	Low	High	Units
None			

Valve Alarms

Alarm Description	Reset
Valve Failed To Open	HMI Reset
Valve Failed To Close	HMI Reset
Valve Limit Switch Fault	Self

Valve Adjustable Control Parameters

Plant Description	Data Access Values			Access Level
	Low	High	Units	
No analogue control setpoints				
PLC Auto / Supervisory Mode Selection				Operator
Supervisory Mode Open / Close Command				Operator
Valve Fault Reset				Operator

6.2.2. Digital Actuator Valve Control

The Digitally Actuated valve has been identified as a standard module; the UU standard Module document **DIG_ACTR_02_06_V1.0** directly addresses the control strategy & implementation of the Digitally Actuated Valve module (identified in the software as DIG_ACTR).

The digital actuator module is used to control, monitor & operate the Digital valve. The module shall be used both for intelligent / hardwired actuators i.e. actuator connected on Profibus DP to PLC or hardwired to PLC.

Valve Availability: - The valve status shall be monitored to ensure availability to operate under PLC control. The following conditions need to be present to allow the drive to operate under PLC control: -

- Remote control selected at valve
- Valve available from valve
- Node healthy (*Applies to Profibus device only*)
- External Interlocks are healthy
- PLC derived faults (Failed to open / failed to close / limit switch fault) not active.
- MCC Mains Supply is healthy

Operating Modes: - The valve has 2 operating modes available to PLC Control, namely '*Supervisory*' and '*PLC Auto*'. These operating modes shall be selectable at the HMI/SCADA (see section 6.3). Also the valve shall be operated locally at the valve.

PLC Derived Drive Faults: - The PLC shall monitor the valve for abnormal conditions while operating under PLC control. The valve has 3 derived fault conditions, namely '*Failed to Open'*, '*Failed to Close'* and '*Limit Switch Fault'*.

'*Failed to Open'* – If the valve is requested to open and the '*Opened'* feedback signal has not been detected within a defined time period (seconds) then an alarm shall be raised. This condition shall inhibit the valve from further opening until the condition has been manually reset via the HMI/SCADA.

'*Failed to Close'* – If the valve is required to close and the '*Closed'* feedback signal has not been detected within a defined time period (seconds) then an alarm shall be raised. This condition shall inhibit the valve from further closing until the condition has been manually reset via the HMI/SCADA.

The time period for monitoring both the '*Opened'* and 'Closed' signals shall be individual to the valve, however, the same time period applies to both '*Failed to Open'* and '*Failed To Close'.*

'*Limit Switch Fault'* – If the '*Opened'* and '*Closed'* feedback signals are detected simultaneously then an alarm shall be raised. This condition shall inhibit the valve from further operation. The condition shall automatically reset when the valve feedback signals change state.

6.2.2.1. Operator Interaction

The following status, alarms and control functions shall be available for the digital actuator valve on the HMI/SCADA.

.**Valve Status**.

Plant Description	States
Valve Control Status	PLC Auto; Supervisory
Valve Status	Loss of Node: Valve Unavailable: Fault; Failed to Open: Failed to Close: Interlocks Active: Opened: Closed; Travelling.

.**Valve Status (Analogue)**.

Description	Analogue Range		
	Low	High	Units
None			

.**Valve Alarms**.

Alarm Description	Reset
Valve Unavailable	Self
Valve Failed To Open	HMI Reset
Valve Failed To Close	HMI Reset
Valve Limit Switch Fault	Self
Valve Interlocks Active	Self
Valve Node Fault (*'Profibus device only'*)	Self

.**Valve Adjustable Control Parameters**.

Plant Description	Data Access Values			Access Level
	Low	High	Units	
No analogue control setpoints				
PLC Auto / Supervisory Mode Selection				Operator
Supervisory Mode Open / Close Command				Operator
Valve Fault Reset				Operator

6.2.3. Positioned Valve Control

Not applicable in this PLC.

6.3. Control Regimes (PLC)

When a plant device is selected to PLC control the device can be controlled in one of two ways, namely '*PLC Auto'* and '*Supervisory'.*

'*PLC Auto*' shall automatically control the device by the process logic within the PLC as defined in the Specific Control Philosophy based on plant conditions.

'Supervisory' shall allow the device to be controlled manually by the operator via the SCADA or HMI independent of the PLC or prevailing plant conditions. The facility to manually set drive desired speed and valve positions shall be available to the user.

Process areas can be switched between '*PLC Auto'* and '*Supervisory'* control from the SCADA or HMI. Note: Individual plant devices cannot be switched unless they form a complete process area on their own.

When changing from '*PLC Auto'* **c**ontrol to '*Supervisory'* control plant equipment shall react as follows: -

- DOL drives (see section 6.1.1) shall stop, even if the drive was previously running in '*PLC Auto'* mode.
- VSD drives (see section 6.1.2) shall stop and the desired speed shall revert to 0%, even if the drive was previously running in '*PLC Auto'* mode.
- Solenoid valves shall close, even if the valve was previously open in '*PLC Auto'* mode.

When switching from '*Supervisory'* control to '*PLC Auto'* control the plant shall return to the operating state determined by the process plant conditions and duty selections.

If a motor starter or actuated valve is switched into 'Local' or 'Hand' at the MCC or in the field, this shall be represented as '*Manual'* on the SCADA or HMI**.** No '*PLC Auto'* or '*Supervisory'* control functionality shall be permitted when the device is in this state.

6.4. Plant Monitoring

6.4.1. Mains Supply Availability

The PLC05 mains supply is currently monitored by a dedicated phase failure. Failure of the mains supply shall be transmitted to the telemetry.

6.4.2. Uninterruptable Power Supply Monitoring

Where actuators are powered by means of an uninterruptible power supply (UPS) the UPS systems shall provide the following alarms and indications:

- Failure of system
- Low volts
- System in by-pass
- Battery charger failure / fault
- A change-over test facility shall be provided

6.4.3. kWHr Monitoring

An Incomer Multi-Function Power Meter will be installed and monitored via Profibus.

6.4.4. Plant Startup Following Mains Supply Restoration

Initially, on power restoration or PLC05 Reset; PLC05 shall wait a minimum time of 10 seconds prior to resumption of process monitoring and control. This delay time is required to allow the process signals to settle to a healthy condition. Alarm monitoring shall be disabled during this power restoration period so that 'spurious' alarms are NOT raised.

6.4.4.1. Normal Start Up Procedure

Normal start up and operation will commence when the main power supply, PLC05 and all associated drives are 'available' and switched to 'PLC Auto' mode. The PLC will ensure a controlled and staged start up to achieve proper operation of the process equipment and avoid unnecessary electrical and hydraulic surges.

6.4.4.2. Normal Shutdown Procedure

Each item will shut down when automatic control is deselected at PLC05 HMI

6.4.5. Plant Shutdown Following Mains Supply Failure

In the event of mains supply failure, the plant shall fail-safe. To avoid electrical or hydraulic surges in the event of power-up or supply restoration after failure, the drives shall re-start in a controlled sequence.

During PLC05 or Power Failure; PLC05 resets to zero. Interfacing with other equipment shall be set to off. An alarm (from the PLC05 software / hardwired watchdog relay) shall be raised on the site telemetry outstation to inform the Operator that PLC05 failure has occurred.
Failure of power supply shall cause the pump drives, if running, to be stopped.

7. FUNCTIONAL DESCRIPTIONS

7.1. Chemical Storage and Dosing

This section details the control and monitoring of the plant equipment associated with the Chemical Storage and Dosing.

7.1.1. Relevant P&ID Reference

Title	Issue	Date
WIG0179 / 80021608 / 01 / 13 / 71005	C	31st May 2013

7.1.2. Component List

Equipment Tag	Equipment Description
A5-AV508	Chemical Tank Outlet Actuated Valve
A5-P504	Chemical Dosing Pump

7.1.3. Instrument List

Equipment Tag	Equipment Description
A5-FIT112	Chemical Dosing Pump Delivery Flowmeter
A5-LIT312	Detention Tank Ultrasonic Level Instrument (Inter PLC comms – from PLC04)
A5-LIT315	Chemical Bulk Storage Tank Ultrasonic Level Instrument
A5-LS316	Chemical Bulk Storage Tank High High Level Switch
A5-LS317	Chemical Storage Tank Bund High Level Switch
A5-LS318	Dosing Pump PRV Catch Pot Level Switch
A5-LS319	Chemical Dosing Skid Drip Tray High Level Switch
A5-LS320	Dosing Line Dual Containment Catch Pot Level Switch
A5-LS321	Dosing Line Dual Containment Catch Pot Enclosure Level Switch
A5-LS322	Emergency Shower Low Level Switch
A5-LIT323	Chemical Blind Tank Ultrasonic Level Sensor
A5-LS324	Chemical Blind Tank High High Level Switch
A5-XS203	Emergency Shower Operated Switch
A5-XS201	Emergency Eyewash Operated Switch 1 – Dosing Rig Station
A5-XS202	Emergency Eyewash Operated Switch 2 – Tanker Delivery Station

Equipment Tag	Equipment Description
A5-TS601	Emergency Shower Low Temperature Switch

7.1.4. Functional Operation (Normal)

The Chemical Dosing shall operate as follows:-

7.1.4.1. Normal Start-Up Procedure

Normal start up and operation will commence when the main power supply, PLC05 and all associated drives and actuators are 'available' and switched to 'PLC Auto' mode.

At start up the Storage Tank actuated outlet valve (A5-AV508) will open fully, the dosing pump A5-P504 will become available to run and control will progress to normal operation.

7.1.4.2. Normal Shutdown Procedure

The operator shall deselect all items from Automatic and the dosing pump (A5-P504) will cease operation and A5-AV508 will close.

7.1.4.3. Chemical Storage & Dosing Normal Operation

Storage Tank

The level as measured by A5-LIT315 will be displayed at the tanker fill point and at PLC05 HMI. When the level reaches the re-order level [20%, 0 – 100%] for a set time [10 secs – not HMI adjustable] a 'Re-Order Chemical' alarm shall be raised.

Chemical deliveries will be carried out by the tanker driver & the operator and all activities are manual operations.

Chemical Dosing

Chemical is dosed into the Combined Sewer Outflow (CSO) spill channel and dosing is controlled using the inlet Flowrate and a target chemical dose (expressed as parts per million or ppm of chemical as supplied). Inlet flowrate is calculated using the rate of change of the level of the detention tank – as measured by the ultrasonic level instrument A5-LIT312.

- Dosing pump A5-P504 will start and run at set flow rate [312 l/hr; 0 – 625 l/hr] when CSO Screen (A5-S101) is called to run.
- Flow proportional dosing will begin after pump has run for a set time [180 secs; 0 – 999 secs].
- Dosing will continue until either ;
  - The CSO Screen (A5-S101) is called to stop OR
  - Any Storm Pump (A5-P102, A5-P103, A5-P104, A5-P105 via PLC03) is called to run (excluding exercising) OR

- The level within the detention tank (A5-LIT312) has not risen [1% – not HMI settable] for a set time [180 secs ; 30 – 999 secs]

Detention Tank Inlet Flowrate Calculation

The detention tank (20.0m internal dia.) has a circular area of 314.2m^2. Thus this defines the volume per vertical metre of the detention tank as being 314.20m^3. The value is actually configurable on the HMI [314.20 m^3; 300.00 – 330.00 m^3]

The inlet flow into the Detention tank will be calculated as follows;

- After the dosing pump (A5-P504) has started the level within the detention tank shall be recorded every set time (t_1) by ultrasonic level instrument A5-LIT312.

- The change in level of the Detention Tank over a (small) time period shall be used for an Inlet Flow l/sec (Q) calculation :-
  - Volume per 1.0m of height (V) i.e. 314.2m^3
  - Time (t_1)

The Detention Tank depth (height) is shown as a percentage and thus needs to be converted to metres for this calculation. The conversion is uses the "A5-LIT312 Actual Tank Height" parameter in the parameter table [28mtrs; 0 – 30.0 mtrs]. This value will be dampened to prevent the dosing rate to the pump from changing too frequently; the result of the rolling average of ten consecutive samples will be used as the input to the equation.

So calculating Q:-

$$Q = \frac{(H \,.\, V).1000}{t1}$$

Example:

If After 10seconds the level has increased by 0.08mtr;

$$Q = \frac{0.08\ x\ 314.2\ x\ 1000}{10} = 2513\ l/sec$$

Dosing Pump Flow Rate Calculation

The PLC shall calculate the required flow using the calculated inlet flow and the adjustable chemical dose rate set point in parts per million. The calculation takes account of the conversion from seconds to hours, and converting PPM to parts per single unit.

$$Pump\ Required\ Flow\ Rate\ (^{l}/_{hr}) = \frac{Q\ x\ 3{,}600\ x\ Dose\ Rate\ in\ ppm}{1{,}000{,}000}$$

Example:

If After 10seconds the level has increased by 0.08mtr – this would indicate an Inlet Flow rate of 2513 l/sec.

Dose rate = 50 parts chemical per million parts storm water

Calculated chemical Flow rate

$$Pump\ Required\ Flow\ Rate = \frac{2513\ x\ 3600\ x\ 50}{1{,}000000} = 452.34\ l/hr$$

7.1.5. Functional Operation (Abnormal)

7.1.5.1. Failure Of Storage Tank Ultrasonic A5-LIT315

If chemical storage tank ultrasonic instrument A5-LIT315 fails (loss of echo etc.) an alarm shall be raised. Dosing shall continue as required.

7.1.5.2. Failure - Storage Tank Level Switch A5-LS316 Operated

If the high high level switch (A5-LS316) is operated an alarm shall be raised. An audible alarm and beacon will also operate at the Chemical Storage tank filling control panel. This will a hardwired signal directly from the instrument to the Chemical Storage tank filling control panel.

7.1.5.3. Failure of Tank Actuated Valve A5-AV508

If the tank actuated valve A5-AV508 fails in the closed position an alarm shall be raised and the dosing pump (A5-P504) shall be stopped.

If the tank actuated valve A5-AV508 fails open or partly open, an alarm shall be raised Dosing pump (A5-P504) shall continue as required.

7.1.5.4. Failure – Bund Level Switch A5-LS317 Operated

If the bund high level switch (A5-LS317) is operated an alarm shall be raised. An audible alarm and beacon will also operate at the Chemical Storage tank filling control panel. This will a hardwired signal directly from the instrument to the Chemical Storage tank filling control panel. The audible alarm and beacon are controlled hardwired and receive hardwired signal directly from the instrument to the Chemical Storage tank filling control panel.

7.1.5.5. Failure of Dosing Pump A5-P504

If the dosing pump (A5-P504) fails an alarm shall be raised. Storage Tank actuated valve A5-AV508 shall close.

7.1.5.6. Failure – Pressure Relief Catchpot level switch A5-LS318 operated

If the pressure relief catchpot high level switch A5-LS318 is operated an alarm shall be raised and the dosing pump (A5-P504) shall stop. Storage Tank actuated valve A5-AV508 shall close.

7.1.5.7. Failure – Drip Tray Level Switch A5-LS319 operated

If the dosing rig drip tray high level switch A5-LS319 is operated an alarm shall be raised and the dosing pump (A5-P504) shall stop. Storage Tank actuated valve A5-AV508 shall close.

7.1.5.8. Failure – Dosing Line Catchpot level Switch A5-LS320 operated

If the dosing catchpot high level switch A5-LS320 is operated an alarm shall be raised and the dosing pump (A5-P504) shall stop. Storage Tank actuated valve A5-AV508 shall close.

7.1.5.9. Failure – Dosing Line Catchpot Enclosure level Switch A5-LS321 operated

If the catchpot enclosure high level switch A5-LS321 is operated an alarm shall be raised and the dosing pump (A5-P504) shall continue to operate as required.

7.1.5.10. Failure of Dosing Flowmeter A5-FIT112

If flowmeter A5-FIT112 fails an alarm shall be raised and dosing shall continue at a pre-set pump flow [312 l/hr ; 0 – 625 l/hr] until stopped as required.

If the calculated chemical flow rate is not reached (A5 -FIT112) after a set time [100mins; 0 – 999 mins] an alarm shall be raised but dosing shall continue at the calculated speed.

7.1.5.11. Failure of Detention Tank Ultrasonic A5-LIT312 OR Loss of Comms to PLC04

If chemical storage tank ultrasonic instrument A5-LIT312 fails (loss of echo etc.) an alarm shall be raised OR if the comms is lost to PLC04:-

The dosing shall continue (providing it was running) at the current flowrate for EITHER a set time [30mins ; 0 – 999 mins] OR until stopped by the CSO (Combined Sewer Overflow) or Storm Pump run signal.

7.1.5.12. Failure of Blind Tank Ultrasonic A5-LIT323

If the level in the blind tank reaches the high level setpoint [80%; 0 – 100%] at ultrasonic A5 -LIT323, an alarm shall be raised. An audible alarm and beacon will also operate at the Chemical Storage tank filling control panel. The audible alarm and beacon are controlled hardwired and receive hardwired signal directly from the instrument to the Chemical Storage tank filling control panel.

If ultrasonic level instrument A5-LIT323 fails (loss of echo etc.) an alarm shall be raised at the HMI.

7.1.5.13. Failure - Blind Tank High High Level Switch A5-LS324

If the level reaches the High High level switch A5-LS324 an alarm shall be raised. An audible alarm and beacon will also operate at the Chemical Storage tank filling control panel. This is a hardwired signal directly from the instrument to the Chemical Storage tank filling control panel.

7.1.5.14. Abnormal operation – Safety Shower or Eye Wash

If any safety shower A5-XS203 or either eyewash (A5-XS201, A5-XS202) is operated an alarm shall be raised.

If the temperature in the shower tank reaches low temperature (A5-TS601) an alarm shall be raised.

If level in the shower tank reaches low level (A5-LS322) an alarm shall be raised on the HMI.

7.1.5.15. Abnormal operation – Power Failure

On power failure, the storage tank actuated valve A5-AV508 will remain in its current position and the dosing pump (A5-P504) will stop.

The control of the dosing system will restart automatically when the power is restored.

7.1.5.16. Failure of the Comms to other PLCs

The Inter PLC communications is specified in Appendix 5 of the SDS document.

- Failure of the watchdog to PLC04 (Detention Tank A5-LIT312) is defined in Section 7.1.5.11 and generates an alarm on HMI05.
- Failure of the watchdog to PLC01 (Inlet PLC) generates an alarm on HMI05.
- Failure of the watchdog to PLC03 (Storm Pumping Station) generates an alarm on HMI05.

7.1.6. Process and Safety Interlocks

7.1.6.1. Chemical Tank Outlet Actuated Valve

The following Process and Safety Interlocks act on the Chemical Tank Actuated Outlet Valve.

- A5-P504 Failure
- A5-LS318 operated
- A5-LS319 operated
- A5-LS320 operated
- Power Failure (of the PLC.)

7.1.6.2. Chemical Dosing Pump

The following Process and Safety Interlocks act on the Chemical Dosing Pump

- A5-LS318 operated
- A5-LS319 operated
- A5-LS320 operated
- Power Failure (of the PLC)

7.1.7. Operator Interaction

The generic operator interface (control parameters, alarms and status) as detailed in Section 6 will be available for the following plant items: -

Plant Description	Plant Tag	States
Chemical Tank Outlet Actuated Valve	A5_AV508	See section 6.2.1.1
Chemical Dosing Pump	A5_P504	See section 6.1.1.1

Items detailed below will be specific functionality.

7.1.7.1. Plant Status (Digital)

Plant Description	Plant Tag	States
Chemical Bulk Storage Tank Level Switch	A5-LS316	Normal , HighHigh
Chemical Storage Tank Bund Level Switch	A5-LS317	Normal , High
Dosing Pump PRV catch pot level switch	A5-LS318	Normal , High
Chemical Dosing Skid Drip Tray Level Switch	A5-LS319	Normal , High
Dosing Line dual containment catch pot level switch	A5-LS320	Normal , High
Dosing Line dual containment catch pot level switch	A5-LS320	Normal , High
Dosing Line Dual containment catch pot Enclosure level switch	A5-LS321	Normal , High
Emergency Shower low level switch	A5-LS322	Normal , Low
Chemical Blind Tank High High Level	A5-LS324	Normal , High High
Emergency Shower Operated Switch	A5-XS203	Normal , Operated
Emergency Eyewash Station 1	A5-XS201	Normal , Operated
Emergency Eyewash Station 2	A5-XS202	Normal , Operated
Emergency Shower Low Temperature Switch	A5-TS601	Normal , Low

7.1.7.2. Plant Status (Analogue)

Plant Description	Analogue Range		
	Low	High	Units
A5-FIT112 - Chemical Dosing Pump Delivery Flowmeter	0	625	l/hr
A5-LIT323 – Chemical Blind Tank Ultrasonic Level Sensor	0	100	%
A5-LIT312 – Detention Tank Level	0	100	%
(A5-LIT312) – Derived Flow into Detention Tank	0	tba	l/sec

7.1.7.3. Plant Alarms

Plant Description	Alarm State	Priority	Reset
Chemical Bulk Storage Tank Level Switch	High High	High	Self
Chemical Storage Tank Bund Level Switch	High	High	Self
Dosing Pump PRV catch pot level switch	High	High	Self
Chemical Dosing Skid Drip Tray Level Switch	High	High	Self

Plant Description	Alarm State	Priority	Reset
Dosing Line dual containment catch pot level switch	High	High	Self
Dosing Line dual containment catch pot level switch	High	High	Self
Dosing Line Dual containment catch pot Enclosure level switch	High	High	Self
Emergency Shower low level switch	Low	High	Self
Chemical Blind Tank High High Level	High High	High	Self
Emergency Shower Operated Switch	Operated	High	Self
Emergency Eyewash Station 1	Operated	High	Self
Emergency Eyewash Station 2	Operated	High	Self
Emergency Shower Low Temperature Switch	Low	High	Self
Re-Order Chemical Level reached	Low	Medium	Self
Dose Rate Not Met	Alarm	Medium	Self

7.1.7.4. Adjustable Control Parameters

The control panel HMI shall include facilities for the operator to monitor the plant and alarms and manually adjust control parameters via password-protected access.

Plant Description	Data Access Values			Access Level
	Low	High	Units	
A5-LIT315 Chemical Re-Order Level [20%]	0	100	%	Operator
A5-P504 Proportional Dosing Set Point [50ppm]	0	80	ppm	Operator
A5-P504 Start-up Flow [312 l/hr]	0	625	l/hr	Operator
A5-P504 Proportional Dosing Delay Timer [180 secs]	0	999	Secs	Operator
A5-LIT312 Dosing Stop Timer [180 secs] (because 'Level not risen')	30	999	Secs	Operator
A5-LIT312 Detention Tank Volume per Vertical mtr [314.20 m3]	300.0	330.00	m3	Operator
A5-LIT312 Actual Tank Height [28 mtrs] (as defined in WIG0179_80021608_01_20_61001)	0	30.0	m	Operator
A5-LIT312 Level Check Interval Timer [10 secs]	0	999	Secs	Operator
A5-FIT112 Flow rate not reached [180secs]	0	999	Secs	Operator
A5-P504 Preset flowsetpoint to Dosing pump if the Flowmeter has Failed [312 l/hr]	0	625	l/hr	Operator
If the Ultrasonic A5-LIT312 has failed then Dosing shall continue (if it were operational) for [30mins]	0	999	mins	Operator
A5-LIT323 Blind Tank High Level [80%]	0	100	%	Operator

7.1.7.5. Additional SCADA Requirements

There are no SCADA requirements for this project.

7.1.7.6. Real Time / Historical Trends

Real Time trends shall be provided for the following signals:-

Signal Description	Sample Rate
(A5-LIT312) Derived Detention Tank Inlet Flowrate (ltrs/sec)	[10 sec]
(A5-LIT312) Derived Detention Tank Inlet Cumulative Flow (m3/day)	[10 sec]
A5-FIT112 Chemical Dosing Flowmeter (ltrs/hr)	[10 sec]
A5-FIT112 Chemical Dosing Cumulative Flow (ltrs/day)	[10 sec]
A5-LIT315 Chemical Storage Tank Percentage Volume (%)	[600 sec]

Historical trends shall be provided for the following signals: -

Signal Description	Sample Rate
A5-LIT312 Detention Tank Inlet Flowrate (ltrs/sec)	[10 sec]
A5-LIT312 Detention Tank Inlet Cumulative Flow (m3/day)	[10 sec]
A5-FIT112 Chemical Dosing Flowmeter (ltrs/hr)	[10 sec]
A5-FIT112 Chemical Dosing Cumulative Flow (ltrs/day)	[10 sec]
A5-LIT315 Chemical Storage Tank Percentage Volume (%)	[600 sec]

7.1.7.7. Reports

There are no report requirements for this project.

7.1.8. Telemetry Functions and Signals

Detail the telemetry functions.

Telemetry Signal Definition		
Data to Telemetry (Digital)	**Off Text**	**On Text**
DOSING CONTROL PLC WATCHDOG	HEALTHY	FAILED
DOSING CONTROL PLC BATTERY LOW VOLTS	HEALTHY	LOW
DOSING CONTROL PROFIBUS NETWORK 1	HEALTHY	FAILED
DOSING CONTROL CP02 MAINS SUPPLY	HEALTHY	FAILED
DOSING CONTROL CP02 110V SUPPLY	HEALTHY	FAILED
DOSING CONTROL CP02 24V SUPPLY A	HEALTHY	FAILED
DOSING CONTROL CP02 24V SUPPLY B	HEALTHY	FAILED
DOSING CONTROL CP02 BOTH 24V SUPPLIES	HEALTHY	FAILED
DOSING CONTROL PLANT	ONLINE	OFFLINE
DETENTION TANK PLANT	NORMAL	TRIPPED
DOSING CONTROL PLANT	NORMAL	TRIPPED
CHEMICAL STORAGE TANK – LEVEL INSTRUMENT	HEALTHY	FAULT
CHEMICAL STORAGE TANK - LEVEL	NORMAL	HIGH HIGH
CHEMICAL STORAGE TANK BUND – LEVEL	NORMAL	HIGH
CHEMICAL BLIND TANK – LEVEL INSTRUMENT	HEALTHY	FAULT
CHEMICAL BLIND TANK - LEVEL	NORMAL	HIGH HIGH
Data to Telemetry (Analogue)	**Range**	**Units**
CHEMICAL STORAGE TANK LEVEL	0 - 100	%
CHEMICAL BLIND TANK LEVEL	0 – 100	%
CHEMICAL BLIND TANK LEVEL - FUTURE	0 - 100	%

Data From Telemetry (Digital)		
none		

There are inter-PLC communications as specified below.

Inter PLC Communications
Data PLC04 (New Detention Tank) to PLC05 (Chemical Dosing)
A5-LIT312 Detention Tank level for Dosing Calculations
Data PLC01 (Inlet Screens) to PLC05 (Chemical Dosing)
A5-S101 CSO Screen running
Data PLC03 (Storm Pumps) to PLC05 (Chemical Dosing)
A5-P102 Any of the storm pumps running (excluding exercising) – Stops chemical dosing A5-P103 A5-P104 A5-P105