



Assets Planning and Delivery Group
Engineering

DESIGN STANDARD DS 73-02

Bulk Sodium Hypochlorite Storage and Dosing System Control Functional Specification

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FOREWORD

The intent of Design Standards is to specify requirements that assure effective design and delivery of fit for purpose Water Corporation infrastructure assets for best whole-of-life value with least risk to Corporation service standards and safety. Design standards are also intended to promote uniformity of approach by asset designers, drafters and constructors to the design, construction, commissioning and delivery of water infrastructure and to the compatibility of new infrastructure with existing like infrastructure.

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Head of Engineering

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REVISION STATUS

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DESIGN STANDARD DS 73-02

Bulk Sodium Hypochlorite Storage and Dosing System - Control Functional Specification

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1 SYSTEM OVERVIEW

1.1 Scope

This design standard is primarily intended for bulk Sodium Hypochlorite Storage and Dosing facilities that are used for drinking water disinfection (although much of this standard is also relevant to Sodium Hypochlorite facilities for wastewater treatment or other treatment purposes).

This Sodium Hypochlorite control functional specification is written specifically for the Water Corporation's Bulk Sodium Hypochlorite standard design arrangement with two (2) inter-connected chemical storage tanks and with two (2) dosing panels (duty and standby)..

1.2 References

This document shall be read in conjunction with

- DS 73-01 Bulk Sodium Hypochlorite Storage and Dosing System – Basis of Design; and
- DS 40-08 Standard for the Control of Chemical Dosing.

The tag numbers used in this functional specification have been taken from the Water Corporation's Design Standard P&IDs for Sodium Hypochlorite Dosing Systems with the following drawing numbers:

- JD71-060-082.1
- JD71-060-082.2
- JD71-060-082.3
- JD71-060-082.4

All values used in this control functional specification for set points, defaults, timers and alarms etc. are typical values that have been provided for information only. These values will need to be revised by designers and contractors to make them specific for each particular site.

1.3 Process Description

Sodium hypochlorite (Hypo) is delivered in bulk tanker as a 12.5% w/v solution (12.5% w/v minimum available chlorine) and stored in two tanks inside a bund within the storage/dosing room. During delivery, sodium hypochlorite solution is pumped from the bulk tanker into the storage tanks through a transfer pipe camlock connection on a load-in panel. Tank volume indication displays, tank level alarm lights and sirens are mounted on the front of the panel.

The Hypo storage tanks are inter-connected at the outlet pipes which means the tanks are effectively operating as one large tank. The benefits of inter-connecting the tanks are explained in the Basis of Design document DS 73-01. Even though the tanks are inter-connected, it is possible to operate using only a single tank if it becomes necessary to take one tank out of service due to failure or maintenance. The volume inside each tank is monitored by a pressure transmitter. A magnetic level gauge is also installed on each tank to provide local visual indication of the tank level and to assist in checking the calibration of the pressure transmitters.

Each tank has a manual isolation valve and an actuated isolation valve connected as close as possible to the tank process outlet nozzle. The tanks outlets are connected to two separate dosing panels (duty and standby) through a common U-PVC process pipeline. The isolation valves of each tank are normally open so the tanks are operating "inter-connected".

Each dosing panel may be equipped with the following items:

- Strainer
- Calibration tube, which also acts as a gas purge column (mandatory)
- "Smart" Dosing pump

- Pressure relief valve (optional)
- Pressure sustaining valve
- Pulsation Dampener
- Pressure gauge (optional)
- Degassing valve (optional)
- Flow meter
- Hypo dosing pipework, along with other valves and equipment.

The dosing panels are mounted along the dosing room walls and have PVC enclosure with transparent front cover for additional protection from leaks and sprays. The standby panel will commence operation should:

- A device in the duty dosing panel fail; or
- A low or high residual alarm be detected

When the standby panel is requested, the complete standby panel will commence operation taking the place of the entire failed panel system, not just part of the standby panel. This arrangement allows maintenance to be carried out safely on one dosing panel, while the other dosing panel is in operation, safely sealed in a separate dosing cabinet.

The sodium hypochlorite dose rate is flow-paced from a magnetic flow meter installed in the recipient water main. An online chlorine analyser is used to monitor the residual chlorine in the recipient water main downstream of the dose point and provide residual trim control of the hypo dose rate. Low-low, low, high and high-high alarms generated from this analyser are used to initiate changeover to the standby dosing system or shut down the source water. In the event of a low-low or high-high alarm the control system will initiate stoppage of the recipient water flow, however while flow remains detected, the operating dosing system will continue to dose to ensure dosing is maintained, even if this is not at the ideal amount.

The sump of the storage bund is equipped with a conductivity sensor and a high level switch to assist in the detection of Hypo leaks onto the bund.

Safety shower and eyewash units are located both inside and outside the Hypo storage room. Each unit is equipped with a thermostatic bleed valve and a flow switch to indicate continuous operation.

1.4 Operation and Control

The Sodium Hypochlorite dosing system normally operates automatically but may also be operated manually from the local control panel (Operator Interface Panel or OIP) located in the entry vestibule of the Hypo room or from the supervisory control system (HMI). Most of the information provided on the HMI for the Hypo system is also duplicated and displayed on the OIP.

Except for those defined as Critical Control Points (CCPs) in Drinking Water Quality standards and without compromising on safety and water quality, all automatic shutdowns should have the option for operator to override the system locally or remotely.

Control and monitoring of new Sodium Hypochlorite dosing systems from the Operations Centre in Leederville shall be through the Utility Wide SCADA System (UWSS) based on ClearSCADA platform.

To provide consistency for maintenance personnel and Operations Centre controllers, design of SCADA screens shall be the same across all Chlorination Modules.

All SCADA design must comply with Water Corporation Operational Technology standards and design guidelines (Water Corporation DS40 suite of standards).

1.5 Group Controller

To facilitate the control sequences within each process unit, the PLC controlled valves and drives associated with that unit are grouped together within the control system under a Group Controller. The purpose of the Group Controller is to allow the operator to select:

1. Duty for the Duty/Standby setup. The selections available are:
 - a. Unit 1 Duty Select. Process unit 1 is the duty unit, process unit 2 is the standby unit; or
 - b. Unit 2 Duty Select. Process unit 2 is the duty unit, process unit 1 is the standby unit; or
 - c. Alternate Duty Select. Duty alternates between the two process units at each start or when the duty cycle time conditions are met (Daily or Weekly – when duty system has run for at least 12 hours)
2. Duty cycle type, which is only applicable when duty is selected as Alternate. The selections available are:
 - a. Daily. Duty system changes when it has continuously run for more than 12 hours at 8am each day; or
 - b. Weekly. Duty system changes when it has continuously run for more than 12 hours on Tuesday at 8am.

The control sequences are prevented or stopped from executing if any of the valves or drives that are critical to process unit (i.e. no redundant device) are in a fault state or if its Control Selector Switch (CSS) is not in 'Normal'. In the case of dual redundant plant devices configured as duty/standby, both devices would need to be in a fault condition or the CSS not in 'Normal'.

The CSS has at least three selectable positions:

| | |
|----------------------|---|
| OFF | Equipment is disabled and switched off. Equipment cannot be operated from any location. |
| LOCAL (EMERGENCY) | Start equipment using hardwired schematic logic (No PLC control/protection). Only equipment primary protection is enabled in this mode (i.e. motor overload protection). |
| NORMAL | Disables the physical start/stop pushbuttons on the Control Cubicle with control performed by the PLC. This mode allows the UWSS operator to select Auto or Manual control for the dosing equipment |

When in Normal mode, there are two operating modes that can be selected on the HMI mimic for the PID controller,

| | |
|--------|--|
| AUTO | Dosing is flow paced with residual trim. Dosing rate in mg/L is determined via aPID controller based on the chlorine residual. The PID controller output (scaled as mg/L) is multiplied by the recipient water flowrate and the hypo strength to determine the required hypo dosing flow rate. |
| MANUAL | Dosing is flow paced. Dosing flow rate is set to the Manual Dose Rate. |

1.6 Dosing System Functionality

The Sodium Hypochlorite facility consists of a number of sub-modules that provide various functions in monitoring and controlling the chlorine levels in the process water. The Sodium Hypochlorite module is normally enabled, and the following sub-sections describe operations in this mode.

When the Sodium Hypochlorite module is disabled, the Sodium Hypochlorite will not be initiated under any conditions, and all Sodium Hypochlorite alarms will be deactivated. The following alarms will, however, remain active:

- Power Failure
- Tank Faults (if selected)

- Communications Fail

The Sodium Hypochlorite facility incorporates two dosing panel systems, operating in a duty/standby configuration. The operator is able to select the duty system on the HMI display. When a changeover is initiated, the complete dosing panel system including its associated pump and flow meter will changeover. There is no flexibility in this arrangement (it is not possible, for example, to have dosing panel 1 working with the dosing pump from dosing panel 2 and vice versa).

In the event that the duty system is ‘Not Available’ or failed, the standby system will automatically commence operation, providing it is in the ‘Available’ operational state. The failed system will not be available for selection until the alarm condition is acknowledged and reset (i.e. the failed system will be latched out unless the other system is also in a failed state).

The two systems are referred to as,

- Sodium Hypochlorite Dosing System 1
- Sodium Hypochlorite Dosing System 2

The control system allows either manual (flow pacing only) or automatic (flowing pacing plus feedback) control capability of the Hypo dosing system. In either mode of operation, the dosing system can be in any one of the following operational states depending on the flowrate in the recipient water main:

- Running
- Stopped

The Hypo dosing system is moved between each of these operational states when initiated or when stopped by the flowrate being less than the dosing initiate value or a fault condition.

The main dosing control sequences associated with the Sodium Hypochlorite dosing system are listed in **Table 1.1**. The step action details of each control sequence are not included in this standard.

| Sequence No. | Description |
|--------------|--|
| SH1_01 | ‘Running’ Sequence for Dosing System 1 |
| SH1_02 | ‘Stopped’ Sequence for Dosing System 1 |
| SH2_01 | ‘Running’ Sequence for Dosing System 2 |
| SH2_02 | ‘Stopped’ Sequence for Dosing System 2 |

Table 1.1 Operational Parameters Configurable on HMI Displays

The devices within the Hypo dosing system are selected by group controller as discussed in Section 1.1. The devices associated with each Dosing System are shown in **Table 1.2** and **Table 1.3**.

| Dosing System SH1 | | |
|-------------------|--------------------------|---|
| Device | | Condition for Dosing System to be ‘Available’ |
| VA 82137 | Hypo Tank 1 outlet valve | At least one of these valves has to be ‘Open’ for the Dosing System to be ‘Available’ |
| VA 82147 | Hypo Tank 2 outlet valve | |
| PU 82210 | Hypo dosing pump | Must be ‘Available’ for the Dosing System to be ‘Available’ |

Table 1.2 Devices Associated with Dosing Panel SH1

| Dosing System SH2 | | |
|-------------------|--------------------------|---|
| Device | | Condition for Dosing System to be 'Available' |
| VA 82137 | Hypo Tank 1 outlet valve | At least one of these valves has to be 'Open' for the Dosing System to be 'Available' |
| VA 82147 | Hypo Tank 2 outlet valve | |
| PU 82310 | Hypo dosing pump | Must be 'Available' for the Dosing System to be 'Available' |

Table 1.3 Devices Associated with Dosing Panel SH2

Individual devices, if faulted, alarmed, electrically isolated, selected in manual (IED 'Off') or tagged as 'Out of Service', will present their status on the HMI and will be unavailable to the associated Dosing System.

Disinfection is initiated once the mains water flow rate is above the 'Initiate disinfection flow' setpoint, should the hypochlorite system have been running within the previous two minutes, it will not re-initiate until the two minute delay has expired. Once started, the hypochlorite system runs for a minimum of two minutes. If during or after this time the mains water flow rate falls below the initiate hypochlorite flow setpoint the hypochlorite system will be shutdown. This feature prevents flow instability during the minimum run time from unnecessarily starting and stopping the system.

The hypo system dose rate is normally controlled by a flow pacing calculation and is adjusted by a PID loop monitoring the chlorine residual. The PID loop gain and integral time control parameters can be set from the local OIP.

The PID loop can be in auto or manual mode. Auto mode allows the PID loop to adjust the hypochlorite output continuously to achieve the desired chlorine residual defined by an entered setpoint (Flow Paced plus Trim). This setpoint is password protected. The hypo system output is also subject to varying flow conditions in this mode. Manual mode ignores the chlorine residual feedback and the hypo system output adjusts to varying flow conditions only (Flow Paced only).

A configurable delay (in minutes) is set to ensure that the PID loop is started a short period after hypo system is initiated. This allows the hypo system and residual analyser to stabilize at each system start before feedback control commences.

The PID loop is halted (i.e. the output is locked, but flow pacing still occurs) under the following conditions:

- The hypochlorite system is not initiated (to prevent the PID loop from adjusting the output when the hypochlorite pump is not running);
- The chlorine residual analyser sample water flow is low (the chlorine residual analyser sample water flow low alarm is produced by the flow switch not detecting a flow); the system would then continue dosing chlorine at current dose rate.
- Operator initiated PID manual mode. In this mode the operator is able to set a fixed hypochlorite dosing rate with flow pacing.

For flow pacing the hypo flow rate that is sent to the hypo pump is calculated using the formula:

$$\text{Required Hypo Flow Rate (L/h)} = \text{Mains Water Flow Rate (m}^3\text{/h)} * \text{Dose Rate (mg/L)} / 100 \text{ (g/L}^*\text{)}$$

*The above calculation is based on a Sodium Hypochlorite nominal strength of 10% or 100 g/L (hypo is delivered at 12.5% or 125g/L available chlorine)

If the calculated hypo flow is above 100% it is limited to 100%. If the required dose rate is greater than the upper dose rate limit a warning is displayed on the local OIP and the control is limited to the upper dose rate. If the required dose rate is greater than the upper dose rate limit continuously for a period of thirty minutes then a dose rate high alarm is activated and sent to UWSS. The hypo flow rate upper limit is calculated per the formula:

$$\text{Required Hypo Flow Rate (L/h)} = \text{Mains Water Flow Rate (m}^3\text{/h)} \times \frac{\text{Upper Dose Rate Limit (mg/l)}}{100}$$

Conversely if the required dose rate is less than the lower dose rate limit continuously for a period of thirty minutes then a dose rate low warning alarm is activated. The chlorine gas flow rate lower limit is calculated per the formula:

$$\text{Required Hypo Flow Rate (L/h)} = \text{Mains Water Flow Rate (m}^3\text{/h)} \times \frac{\text{Lower Dose Rate Limit (mg/l)}}{100}$$

Both upper and lower dose rate limits are settable locally from the OIP and remotely from SCADA.

Note: On SCADA the flow rates are indicated as litres per second (l/s) whereas the PLC requires m³/h to calculate the required hypo flow rate (L/h) flow, the conversion factor is 3.6

1.7 Storage Tank Filling

The filling (load-in) of the storage tanks is basically a manual operation whereby the delivery tanker driver connects the hose to the transfer point at the load-in panel, opens the tank inlet valves and pumps the Hypo into the tanks. This operation can occur irrespective of the operational state of the Sodium Hypochlorite dosing system. The only automation in this procedure is:

- a) the automatic operating of the 3-way drain valve (VA82105) of the load-in apron sump initiated by the opening of the door to the load-in panel. Under normal conditions, this valve is opened to discharge to the soakwell/site drainage preventing rainwater accumulating on the load-in apron. The opening of the door will automatically initiate the 3-way valve to open to the waste holding tank (and close to site drainage) in anticipation of any potential spillage during Hypo delivery.
- b) If an operator error results in overfilling of a storage tank, then LAHH82134 (Tank 1) or LAHH82144 (Tank 2) will automatically isolate power to the GPO that supplies the tanker mounted filling pump.

The level displays and alarms located on the load-in panel and on the HMI assist the operator with the filling operation.

Refer to DS73-01 Bulk Sodium Hypochlorite Storage and Dosing System - Basis of Design for further details.

1.8 Bund Sump Discharge

Another operation that can occur irrespective of the operational state of the Sodium Hypochlorite dosing systems is the draining of the bund sump. The bund sump contents can be discharged to the waste holding tank or site drainage via an actuated drain valve (VA82106) located in an external valve pit. So long as the conductivity in the bund sump is not high, the operator can manually open and close this valve from the HMI or OIP at any time. If the conductivity is high-high, an interlock will prevent this valve from being opened and will close the valve if it is already open. The operator is able to override this interlock by selecting the 'sump drain override on' from the OIP. However, if this valve is left open for longer than 5 minutes, the control system will automatically close the valve whether the override is selected or not.

A level switch and a conductivity analyser are installed in the bund sump to detect high sump levels and Hypo leaks. Should the level switch register a high level for longer than 10 seconds then an alarm will be raised.

Should the conductivity meter register a high conductivity for longer than 10 seconds then an alarm will be raised. The high conductivity alarm setting shall be 2.5 mS/cm which indicates the possibility of dilute (~ 1%) hypo in the bund sump. Note that the high conductivity alarm may also be triggered by evaporation of water in the bund sump over an extended duration.

Should the conductivity meter register a high-high conductivity for longer than 10 seconds then an alarm will be raised and the interlock with the sump drain valve described above will be triggered. The high-high alarm setting shall be 5mS/cm.

The level and conductivity alarms should initiate an operator investigation of the bund and sump upon their next visit to site. However, should both of these devices reach an alarm state at the same time

then an interlock will be triggered to close the automated outlet valves on both of the storage tanks, which will subsequently stop the dosing systems if they are operating.

1.9 Operational Parameters

The main process information that has to be entered on the HMI display by the Operator is given in **Table 1.4** with typical values as shown. The values entered are used in the calculations embedded in the process control loops or timers that are initiated within sequences. Entering or changing the process control loops or timer parameters along with configuration of the site process shall only be accessible to key personnel with Supervisor and Engineer privilege levels.

| Parameter | Tag Number | Typical Value (Example Only) |
|--|------------|--------------------------------|
| Min. recipient water flow to initiate dosing (X m ³ /h) | - | 10% of actual flow |
| Target chlorine residual setpoint | HC82419A | 1.0 mg/L |
| Upper dose rate limit | HC82419B | Demand + Target SP + 0.2 mg/L |
| Lower dose rate limit | HC82419C | Demand + 0.3 mg/L |
| High chlorine residual setpoint offset | HC82419D | 0.5 mg/L |
| Low chlorine residual setpoint offset | HC82419E | 0.5 mg/L |
| High high chlorine residual setpoint* | HC82419F | 2.5 mg/L |
| Low low chlorine residual setpoint* | HC82419G | 0.2 mg/L |
| Fixed mode chlorine dose rate | HC82426A | Demand + Target SP mg/L |
| Low Hypochlorite flow rate setpoint | Panel 1 | 50% of required Hypo flow rate |
| | Panel 2 | |
| De-gassing valve opening duration | Panel 1 | 10 secs |
| | Panel 2 | |
| Max. dosing pump speed | Panel 1 | Pump specific |
| | Panel 2 | |

* Critical water safety setting - only adjustable on remote HMI with approval of Water Quality Branch

Table 1.4 Operational Parameters Configurable on HMI Display

1.10 Dosing Startup

Hypochlorite dosing is initiated once the flow rate of the source water mains registered by its flowmeter FIT XXXXX is above the pre-set minimum flow of X m³/h. If the dosing pump has been running within the previous two minutes, it will not re-initiate until the two minute delay has expired. The hypochlorite dosing system runs for a minimum run time (two minutes). If after this time the mains water flow rate is less than the X m³/h setpoint the dosing system will be shut down. This feature prevents flow instability during the user-definable minimum run time from unnecessarily starting and stopping the system.

1.11 Mains Flow Discrepancy

Sources of recipient water requiring Hypochlorite chlorination may be from a tank, borefield or a pump station. When the source starts to deliver water, “Flow Established” is set to ‘ON’. The signal to set “Flow Established” could be the pump running status of a source pump station or tank valve

open. If no such signal is available, a flow switch may have to be installed on the recipient water mains to confirm the flow. Flow switch should be the last option as it is not always reliable. The “Flow Established” signal shall not be derived from the same flow meter that is providing the flow pacing input.

A “Mains Flow Discrepancy” alarm can be generated to flag problems encountered with the mains flow meter. If the “Flow Established” is ‘ON’ and the mains flow meter FIT XXXXX has not detected a flow greater than the minimum flow $X \text{ m}^3/\text{h}$ setpoint for a period of two minutes a “Mains Flow Discrepancy” alarm is set and annunciated on the OIP and on SCADA. “Water Quality Breached” alarm is generated after 30 seconds which would subsequently inhibit the source water.

If the “Flow Established” is ‘OFF’ and the mains flow meter FIT XXXXX has detected a flow greater than the minimum flow $X \text{ m}^3/\text{h}$ setpoint for a user definable period (up to fifteen minutes) a “Mains Flow Discrepancy” alarm is set but the dosing will continue to operate normally. It is possibly more likely that there is a problem with the “Flow Established” signal especially if it is from a faulty flow switch. If, however, there is a problem with the flow meter and it is not indicating correctly, the dosing should shut down on ‘dosing fault’ (e.g. free chlorine residual high high alarm) after some time.

If installed, the flow switch feature shall be able to be disabled from the OIP by users with Supervisor and Engineer privilege levels. This is to prevent stopping of Hypo dosing due to faulty flow switch (a common problem).

1.12 Water Quality Breached

A “Water Quality Breached” alarm is generated 30 seconds after the Sodium Hypochlorite dosing system shutdown (neither of the dosing pumps is running) or “Mains Flow Discrepancy” alarm is activated with “Flow Established” enabled.

The “Water Quality Breached” alarm shall initiate shutdown of recipient water source pump station, tank inlet control valve, bore field, or whatever sources of water requiring treatment to prevent delivery of poor quality water to consumers. Water Safety Plans may have other requirements.

The “Water Quality Breached” alarm must be manually reset either locally or remotely (unless reset on power restore) before the system can be returned to operation. If the “Water Quality Breached” alarm was set due to a power failure, the alarm will be reset automatically on restoration of power.

1.13 Plant Power Failure

A UPS provides continuous power to the Control system and the OIP for a minimum period of 30 minutes in the event when no input power supply is available. In addition to this the chlorine residual analyser is connected to this backup power supply so chlorine residual levels can continue to be monitored and alarms annunciated. Bund containment, security alarms and process alarms generated in the PLC will continue to be active during this time.

In the event of a plant power failure during Sodium Hypochlorite dosing, the system shall resume dosing automatically following restoration of power (either from mains or generator) and return of the permissive conditions such as the minimum set point flow rate in the water main. The low chlorine level in the treated water or other fault/alarm directly due to the plant power failure should not trigger a shutdown or system changeover when the power is restored i.e. a time delay (typical default setting of 2 minutes) shall be allowed for the chlorine residual to return to normal. Automatic closing of the Sodium Hypochlorite storage tank isolation valve during the period of power failure is considered unnecessary as other safety measures are in place in the unlikely event of a leak.

At sites where backup generator is available, automatic start-up of the generator backup power supply (typically 5 seconds after loss of power) will allow chemical dosing to continue with all loads supported except for miscellaneous non-essential loads. The fuel tank of the generator backup power supply is typically sized to provide continuous running on normal load for 3 days.

1.14 Functional Description Overview

The controls of the bulk Sodium Hypochlorite Storage and Dosing System are summarized in the Functional Description Overview provided in Appendix B.

2 CHEMICAL STORAGE INSTRUMENTATION

2.1 Storage Tank No.1 TA 82110

The storage tank no.1 TA 82110 incorporates the following instrumentation.

2.1.1 Level Transmitter LIT 82115

The level/volume in this tank is measured by a pressure transmitter LIT 82115, calibrated to 0 – 100% displayed in litres L. (0% is defined as the bottom of the tank, and 100% is defined as the invert level of the tank overflow).

| Tag Number | Example Set Point | Functionality |
|------------|-------------------|---|
| LI 82115 | | Displays tank level (in L) on HMI and OIP screens; and load-in panel. |
| LAH 82115 | 85% (litres) | HMI alarm displayed on HMI and OIP screens “LAH 82115 Sodium Hypo Tank TA 82110 level high (tank full)” Load-in panel alarm light “Hypo Tank 1 full” activated to alert delivery tanker driver to stop filling. <ul style="list-style-type: none"> No interlock |
| LAL 82115 | 30% (litres) | HMI alarm displayed on HMI and OIP screens “LAL 82115 Sodium Hypo Tank TA 82110 level low (re-order Hypo)” <ul style="list-style-type: none"> No interlock |
| LALL 82115 | 5% (litres) | HMI alarm displayed on HMI and OIP screens “LALL 82115 Sodium Hypo Tank TA 82110 level low low (tank empty)” <ul style="list-style-type: none"> Interlock to close tank isolation valve VA 82137 and terminate operation of duty dosing pump preventing it from running dry. |

Note: The set point values listed above are provided as examples only. They will need to be determined for each site based on tank volume, delivery volume and delivery turn around. Some guidance on the determination of these set points (and also that for LSHH 82134 below) are provided in Appendix A.

2.1.2 Level Gauge LG 82134

A magnetic bar graph level gauge LG 82134 complete with a level switch LSHH 82134 is also installed on tank TA 82110 to provide visual indication of the tank level and to trigger the high high level alarm.

| Tag Number | Example Set Point | Functionality |
|------------|---|---|
| LG 82134 | | LG 82134 is a visual indication of tank level only. |
| LSHH 82134 | 95% (litres) or tank volume-2 minutes of tanker pumping time- | HMI alarm LAHH 82134 displayed on the HMI and OIP screens “LAHH 82134 Sodium Hypo Tank TA 82110 level high high” Load-in panel alarm light “Hypo Tank 1 overflow” and audible alarm activated to alert that the tank is close to overflowing. <ul style="list-style-type: none"> Interlocked with the GPO that supplies power to the tanker transfer pump so that tank filling is ceased. |

2.1.3 Outlet Valve VA 82137

Tank TA 82110 discharge valve VA 82137 is a motorised valve with limit switches to indicate valve position on the HMI and OIP displays.

| Tag Number | Set Point | Functionality |
|------------|--------------|---|
| ZSH 82137 | Fully open | ZIH 82137 notifies the control system that the outlet valve VA82137 is open |
| ZSL 82137 | Fully closed | ZIL 82137 notifies the control system that the outlet valve VA82137 is closed. <ul style="list-style-type: none"> If Tank 2 outlet valve VA82147 is also closed or not available, initiates shutdown of dosing system and triggers “Water Quality Breached” alarm. |
| ZA 82137 | Valve fault | HMI alarm displayed on HMI & OIP screens “Tank 1 outlet valve VA82137 fault” <ul style="list-style-type: none"> If Tank 2 outlet valve VA82147 is also closed or not available, initiates shutdown of dosing system and triggers “Water Quality Breached” alarm. |

2.2 Storage Tank No.2 TA 82120

The storage tank no.2 TA 82120 incorporates the following instrumentation and automated valve.

2.2.1 Level Transmitter LIT 82125

The level/volume in this tank is measured by a pressure transmitter LIT 82125, calibrated to 0 – 100% displayed in litres L. (0% is defined as the bottom of the tank, and 100% is defined as the invert level of the tank overflow). Note: A specific gravity of 1.2 should be used for sodium hypochlorite.

| Tag Number | Example Set Point | Functionality |
|------------|-------------------|---|
| LI 82125 | | Displays tank level (in L) on HMI and OIP screens; and load-in panel. |
| LAH 82125 | 85% (litres) | HMI alarm displayed on HMI and OIP screens “LAH 82125 Sodium Hypo Tank TA 82120 level high (tank full)” Load-in panel alarm light “Hypo Tank 2 full” activated to alert delivery tanker driver to stop filling. <ul style="list-style-type: none"> No interlock |
| LAL 82125 | 30% (litres) | HMI alarm displayed on HMI and OIP screens “LAL 82125 Sodium Hypo Tank TA 82120 level low (re-order Hypo)” <ul style="list-style-type: none"> No interlock |
| LALL 82125 | 5% (litres) | HMI alarm displayed on HMI and OIP screens “LALL 82125 Sodium Hypo Tank TA 82120 level low low (tank empty)” <ul style="list-style-type: none"> Interlock to close tank isolation valve VA 82147 and terminate operation of duty dosing pump preventing it from running dry. |

Note: The set point values listed above are provided as examples only. They will need to be determined for each site based on tank volume, delivery volume and delivery turn around. Some guidance on the determination of these set points (and that for LSHH 82144 below) are provided in Appendix A.

2.2.2 Level Gauge LG 82144

A magnetic bar graph level gauge LG 82144 complete with a level switch LSHH 82144 is also installed on tank TA 82120 to provide visual indication of the tank level and to trigger the high high level alarm.

| Tag Number | Example Set Point | Functionality |
|------------|--|---|
| LG 82144 | | LG 82144 is a visual indication of tank level only. |
| LSHH 82144 | 95% (litres) or tank volume-2 minutes of tanker pumping time | HMI alarm LAHH 82144 displayed on the HMI and OIP screens “LAHH 82144 Sodium Hypo Tank TA 82120 level high high” Load-in panel alarm light “Hypo Tank 2 overflow” and audible alarm activated to alert that the tank is close to overflowing. <ul style="list-style-type: none"> Interlocked with the GPO that supplies power to the tanker transfer pump so that tank filling is ceased. |

2.2.3 Outlet Valve VA 82147

Tank TA 82120 discharge valve VA 82147 is a motorised valve with limit switches to indicate valve position on the HMI and OIP displays.

| Tag Number | Set Point | Functionality |
|------------|--------------|---|
| ZSH 82147 | Fully open | ZIH 82147 notifies the control system that the outlet valve VA82147 is open |
| ZSL 82147 | Fully closed | ZIL 82147 notifies the control system that the outlet valve VA82147 is closed. <ul style="list-style-type: none"> If Tank 1 outlet valve VA82137 is also closed or not available, initiates shutdown of dosing system and triggers “Water Quality Breached” alarm. |
| ZA 82147 | Valve fault | HMI alarm displayed on HMI & OIP screens “Tank 2 outlet valve VA82147 fault” <ul style="list-style-type: none"> If Tank 1 outlet valve VA82137 is also closed or not available, initiates shutdown of dosing system and triggers “Water Quality Breached” alarm. |

2.3 Load-in Panel

The load-in panel registers the level of Hypo in the storage tanks. Its main purpose is to inform the delivery vehicle driver of a potential overflow condition. The display on the panel includes high level alarm indication of the load-in apron sump and opening status indication of the sump’s 3-way drainage valve.

The alarm lights, sirens and valve status indication on the panel are shown in the table below.

| Parent Instrument | Instrument alarm status | Load in panel indication |
|-------------------|-------------------------|--|
| LIT 82115 | LI 82115 | Displays volume (in L) in tank TA 82110 |
| LIT 82115 | LAH 82115 | “Hypo Tank 1 level high” light illuminated, alerts delivery driver to stop filling. |
| LSHH 82134 | LAHH 82134 | “Hypo Tank 1 level high high” light illuminated and siren sounds, alerts tank is close to overflowing. |
| LIT 82125 | LI 82125 | Displays volume (in L) in tank TA 82120 |

| Parent Instrument | Instrument alarm status | Load in panel indication |
|-------------------|-------------------------|--|
| LIT 82125 | LAH 82125 | “Hypo Tank 2 level high” light illuminated, alerts delivery driver to stop filling. |
| LSHH 82144 | LAHH 82144 | “Hypo Tank 2 level high high” light illuminated and siren sounds, alerts tank is close to overflowing. |
| LSH 82104 | LAH 82104 | “Load-in Apron Sump level high” light illuminated |
| ZSH 82105 | ZIH 82105 | “Open to Drainage” light illuminated |
| ZSL 82105 | ZIL 82105 | “Open to Waste Tank” light illuminated |

The sirens can be silenced by a local “acknowledge” hand switch (HS82109). This “acknowledge” switch does not interface with the control system; it only mutes the audible alarms. The alarms will not reset until the alarm conditions are removed.

2.4 Load-in Apron Sump

The load-in apron sump incorporates the following instrumentation and automated valve.

2.4.1 Drain Valve VA 82105

Drain valve VA 82105 operation is normally automated either from a load-in door switch (YS82101) or from a link to the site security system.

Under normal conditions, the load-in apron sump drains to the soakwell (or site stormwater drainage) through the motorised 3-way valve (VA 82105), preventing rainwater accumulating on the load-in apron. When Sodium Hypochlorite delivery is to take place, as indicated by the opening of the load-in door, the PLC sets the 3-way valve to direct the contents of the load-in apron sump to the Waste Tank in anticipation of any potential spillage.

At sites where the security system is not linked to the Hypochlorite load-in system, this change in the 3-way valve opening position is triggered automatically by de-activation of a switch (YS 82101) when the door to the load-in panel is opened. At the end of the load-in process, the door to the load-in panel would be closed activating the switch to revert the valve back to its normal state of ‘open to site drainage’ and ‘closed to the waste holding tank’.

In the event of the switch failure or power outage, the apron sump drain valve shall automatically position to open to the waste holding tank (and closed to the site drainage).

The displays and alarms located on the load-in panel and on the HMI assist with the filling operation, but do not have any control functionality over the operation. Manual override operation of the apron sump 3-way valve is also possible with a two position switch to select the valve to open to waste holding tank or to open to drainage.

The apron sump 3-way valve VA 82105 has limit switches to indicate valve position on the HMI and OIP displays.

| Tag Number | Set Point | Functionality |
|------------|------------------|---|
| YS 82101 | | Switch activated by closing of the load-in door <ul style="list-style-type: none"> VA 82105 opens to site drainage (close to waste holding tank). Switch de-activated by the opening of the load-in door. HMI indication YI 82100 on HMI & OIP screens “Load-in door open” <ul style="list-style-type: none"> VA 82105 opens to waste holding tank (and close to drainage). YS 82101 shall fail-safe to the de-activated state. |
| ZSH 82105 | Open to drainage | ZIH 82105 notifies the control system that valve VA 82105 is open to drainage (closed to waste holding tank) including a light indication on the load-in panel. |

| Tag Number | Set Point | Functionality |
|------------|--------------------|---|
| ZSL 82105 | Open to waste tank | ZIL 82105 notifies the control system that valve VA 82105 is open to waste holding tank (closed to drainage) including a light indication on the load-in panel. |
| ZA 82105 | Valve fault | If VA 82105 fails an alarm is registered. <ul style="list-style-type: none"> VA 82105 opens to waste holding tank (and closed to drainage) on failure. |

2.4.2 Level Switch LSH 82104

Level switch LSH 82104 is installed in the apron sump to register a high level alarm condition.

| Tag Number | Set Point | Functionality |
|------------|-----------|---|
| LSH 82104 | 75% | HMI alarm LAH 82104 displayed on the HMI & OIP screens “LAH 82104 Apron Sump level high” including a light indication on the load-in panel. |

2.5 Bund Sump

The bund sump is operated as a wet sump with the water level automatically replenished by a float type level valve (cistern valve). The bund sump incorporates the following instrumentation and automated valve.

2.5.1 Level Switch LSH 82152

Level switch LSH 82152 is installed in the sump to register a high level alarm condition.

| Tag Number | Typical Set Point | Functionality |
|------------|-------------------|---|
| LSH 82152 | 50% | HMI alarm displayed on the HMI & OIP screens “LAH 82152 Bund Sump level high”. <ul style="list-style-type: none"> No interlock if only high level alarm triggered. When high-high conductivity alarm AAHH 82153 is active at the same time, interlock to close the tanks’ outlet isolation valves (VA 82137 & VA82147) and generate a “Water Quality Breached” alarm which will shut down the source. |

2.5.2 Conductivity Transmitter AE 82153

Conductivity transmitter AE 82153 registers the conductivity of the water maintained in the bund sump. Conductivity is indicated locally (with a display mounted on the wall above the bund sump) and on the HMI and OIP screens.

| Tag Number | Typical Set Point | Functionality |
|------------|-------------------------|---|
| AI 82153 | | Conductivity (in mS/cm) displayed on HMI and OIP screens |
| AAH 82153 | 2.5 mS/cm (250 mS/m) | HMI alarm displayed on HMI and OIP screens “AAH 82153 Bund Sump conductivity high” indicating the likely presence of Hypochlorite in the sump <ul style="list-style-type: none"> Closes sump drain valve VA 82153 if it is open, and prevents it from opening if it is closed. |

| Tag Number | Typical Set Point | Functionality |
|------------|-----------------------|--|
| AAHH 82153 | 5 mS/cm (500 mS/m) | HMI alarm displayed on HMI and OIP screens “AAHH 82153 Bund Sump conductivity high high” indicating the increasing quantity of chemical in the sump <ul style="list-style-type: none"> When sump high water level alarm LAH82152 is active at the same time, interlock to close the tanks’ outlet isolation valve (VA 82137 & VA82147), which will shut down dosing system and generate “Water Quality Breached” alarm. |

2.5.3 Drain Valve VA 82106

The bund sump drain valve VA 82106 is a motorised valve with limit switches to indicate valve position on the HMI and OIP displays. The operation of the valve is initiated from the OIP screen. Interlocks will apply to the valve position if a high conductivity is registered by AIT 82153.

The operator can override these interlocks by selecting the sump drain valve ‘Override On’ from the OIP. However if the valve is left open for longer than 5 minutes continuously then control system will automatically close the valve whether override is selected or not.

| Tag Number | Set Point | Functionality |
|------------|--------------|--|
| HS 82106A | | Override selector on/off switch at OIP |
| HS 82106B | | Switch to open or close valve manually at OIP. |
| HS 82106C | | Override selector on/off switch near valve |
| HS 82106D | | Switch to open or close valve manually near valve. |
| ZSH 82106 | Fully open | ZIH 82106 notifies the control system that valve VA 82106 is open. <ul style="list-style-type: none"> If valve open for longer than 5 mins continuously, control system automatically closes valve whether override is selected or not. |
| ZSL 82106 | Fully closed | ZIL 82106 notifies the control system that valve VA 82106 is closed. |
| ZA 82106 | Valve fault | If VA 82106 fails an alarm is registered, no control action. |

2.6 Waste Holding Tank

The waste holding tank is used to store Hypo waste, spillage and contaminated washdown generated in the Hypo storage room or from the load-in apron. Once sufficient volume has been collected the waste is pumped out onto a tanker for off-site disposal.

The waste holding tank incorporates the following instrumentation:

2.6.1 Level Switch LSH 82107

Level switch LSH 82107 is installed in the waste holding tank to register a high level alarm condition to provide warning that the tank is nearly full and will require emptying.

| Tag Number | Typical Set Point | Functionality |
|------------|-------------------|---|
| LSH 82107 | 75% | HMI alarm LAH 82107 displayed on the HMI & OIP screens “LAH 82107 Waste Holding Tank level high” <ul style="list-style-type: none"> No control action is associated with this alarm. |

3 CHEMICAL DOSING INSTRUMENTATION

3.1 Sodium Hypochlorite Dosing System 1

The following instruments and automated valve are associated with the Sodium Hypochlorite dosing system 1.

3.1.1 Dosing Pump PU 82210

The speed of the dosing pump is dictated by recipient water flow control loop FC 82426 for the addition of Hypo. Minimum pump speed limit will be set in the control (HC 82210C) to prevent damage to the pump motor and prevent infrequent “slugs” of Hypo dosage. .

| Tag Number | Functionality |
|------------|---|
| IY 82210 | Pump motor run activated <ul style="list-style-type: none"> Open de-gassing valve VA 82221 for set duration, with pump running full speed. |
| YS 82210B | Motor running, indication YL 82210 on the HMI and OIP screens. |
| YS 82210C | Motor fault alarm YA82210A raised on HMI/OIP. <ul style="list-style-type: none"> Pump shuts down and changeover to standby system initiated. |
| SI 82210 | Hypo Pump Flow Rate on the HMI and OIP screens. |
| HC 82210A | Maximum Dose Rate Range (20mA) |
| HC 82210B | Hypo Pump Flow Rate manual adjustment (local on pump) |
| KQI 82210 | Number of hours running will be totalised and displayed on the HMI and OIP screens |

3.1.2 De-gassing Valve VA 82221

Valve VA 82221 is a de-gassing valve used to bleed off accumulated gas in the delivery pipeline primarily on pump start-up. The de-gassing valve shall be set to open for user defined duration from the OIP. This is usually 10-20 seconds on pump operating at full speed on start-up. On closure of the valve, the pump should continue to be operated at full speed for a preset adjustable period of time to pressurise the line before adjusting to the required dosage.

The de-gassing valve shall be set to open when the dosing panel is taken offline and upon failure or power outage (fail open).

It shall be possible to operate the de-gassing valve manually from the OIP or UWSS when required.

| Tag Number | Typical Set Point | Functionality |
|------------|-------------------|--|
| HC 82221 | 10secs | Set duration of valve opening. |
| ZA 82221 | Valve fault | HMI alarm displayed on HMI/OIP screen “ZA 82221 De-gassing Valve fault” <ul style="list-style-type: none"> initiates shutdown of duty dosing system and changeover to standby system. |

Note: The degassing valve may be integral to the dosing pump

3.1.3 Flow Transmitter FIT 82224

A magnetic flow meter FIT 82224 is used to monitor and record the Hypo dosing pump discharge flow rate, and totalise the amount of Hypo used. A low flow alarm indicating a dosing hydraulic fault (e.g. due to blockage at the dosing spear or gassing) will initiate shutdown of duty dosing system and changeover to the standby system.

| Tag Number | Typical Set Point | Functionality |
|------------|--------------------------------|--|
| FI 82224 | | Hypo flow displayed locally on dosing panel and on HMI and OIP screens. |
| FQI 82224 | | Totalised amount of Hypo used, displayed on HMI and OIP screens |
| FAL 82224 | 50% of required Hypo flow rate | HMI alarm displayed on HMI/OIP screen “FAL 82224 Dosing hydraulic fault” when flow fell below setpoint for longer than 10 secs. <ul style="list-style-type: none"> initiates shutdown of duty dosing system and changeover to standby system. |

3.2 Sodium Hypochlorite Dosing System 2

The following instruments and automated valve are associated with the Sodium Hypochlorite dosing system 2.

3.2.1 Dosing Pump PU 82310

The speed of the dosing pump is dictated by recipient water flow control loop FC 82426 for the addition of Hypo. Minimum pump speed limit will be set in the control (HC 82310C) to prevent damage to the pump motor and prevent infrequent “slugs” of Hypo dosage.

| Tag Number | Functionality |
|------------|---|
| IY 82310 | Pump motor run activated <ul style="list-style-type: none"> Open de-gassing valve VA 82321 for set duration, with pump running full speed. |
| YS 82310B | Motor running, indication YL 82310 on the HMI and OIP screens. |
| YS 82310C | Motor fault alarm YA82310A raised on HMI/OIP. <ul style="list-style-type: none"> Pump shuts down and changeover to standby system initiated. |
| SI 82310 | Hypo Pump Flow Rate indication on the HMI and OIP screens. |
| HC 82310A | Maximum Dose Rate Range (20mA) |
| HC 82310B | Hypo Pump Flow Rate manual adjustment (local on pump) |
| KQI 82310 | Number of hours running will be totalised and displayed on the HMI and OIP screens |

3.2.2 De-gassing Valve VA 82321

Valve VA 82321 is a de-gassing valve used to bleed off accumulated gas in the delivery pipeline primarily on pump start-up. The de-gassing valve shall be set to open for user defined duration from the OIP. This is usually 10-20 seconds on pump operating at full speed on start-up. On closure of the valve, the pump should continue to be operated at full speed for a preset adjustable period of time to pressurise the line before adjusting to the required dosage.

The de-gassing valve shall be set to open when the dosing panel is taken offline and upon failure or power outage (fail open).

It shall be possible to operate the de-gassing valve manually from the OIP when required.

| Tag Number | Typical Set Point | Functionality |
|------------|-------------------|--|
| HC 82321 | 10secs | Set duration of valve opening. |
| ZA 82321 | Valve fault | HMI alarm displayed on HMI/OIP screen “ZA 82321 De-gassing Valve fault” <ul style="list-style-type: none"> initiates shutdown of duty dosing system and changeover to standby system. |

Note: The degassing valve may be integral to the pump

3.2.3 Flow Transmitter FIT 82324

A magnetic flow meter FIT 82324 is used to monitor and record the Hypo dosing pump discharge flow rate, and totalise the amount of Hypo used. A low flow alarm indicating a dosing hydraulic fault (e.g. due to blockage at the dosing spear or gassing) will initiate shutdown of duty dosing system and changeover to the standby system.

| Tag Number | Typical Set Point | Functionality |
|------------|--------------------------------|--|
| FI 82324 | | Hypo flow displayed locally on dosing panel and on HMI and OIP screens. |
| FQI 82324 | | Totalised amount of Hypo used, displayed on HMI and OIP screens |
| FAL 82324 | 50% of required Hypo flow rate | HMI alarm displayed on HMI/OIP screen “FAL 82324 Dosing hydraulic fault” when flow fell below setpoint for longer than 10 secs. <ul style="list-style-type: none"> initiates shutdown of duty dosing system and changeover to standby system. |

4 WATER ANALYSIS INSTRUMENTATION

4.1 Water Sampling System

The following equipment and instruments are associated with the Water Sampling system.

4.1.1 Sample Water Pump PU 82406

Sample water pump PU 82406 pumps treated water from a location downstream of the dosing point to the chlorine residual analyser.

| Tag Number | Functionality |
|------------|---|
| IY 82406 | Pump motor run activated (Run Request). |
| YS 82406A | Pump motor running. |
| YS 82406B | Motor fault. <ul style="list-style-type: none"> • Pump shuts down and alarm “YA82406 Sampling Water Pump motor fault” raised on the HMI and OIP screens. Dosing control system switches to flow paced only mode. • Chlorine Residual continued to be monitored. Should the residual reach the high high or low low alarm levels, “Water Quality Breached” alarm is generated and the source water flow will be stopped / isolated to prevent supply of unsafe water |
| KQI 82406 | Number of hours running will be totalised and displayed on the HMI and OIP screens |

4.1.2 Low Flow Switch FSL 82418

Low flow switch FSL 82418 fitted on the rotameter FI 82418 is used to raise alarm when the sampling water flow to the chlorine analyser is interrupted.

| Tag Number | Typical Set Point | Functionality |
|------------|---|--|
| FI 82418 | | Sample water flow displayed on the rotameter locally. |
| FSL 82418 | <Minimum chlorine analyser requirement> | When FSL 82418 is activated (low flow detected), dosing control system switches to flow paced only mode and doses according to the PID controllers output (in mg/L) at the last recorded healthy chlorine residual. A delay timer is set for 15 min. If flow is not restored after 15 min, HMI alarm FAL 82418 displayed on the HMI & OIP screens “FAL 82418 Sampling Water flow low”, prompting operator to take remedial action. No other control action is triggered. If flow is restored within 15 min, a second 10 min timer will cut in to allow flow to stabilize before reverting dosing control to flow paced with residual trim. |

4.2 Residual Chlorine Analyser AIT 82419

Residual chlorine analyser AIT 82419 will continuously monitor and register the chlorine residual in the recipient water main (downstream of the dose point). Target chlorine residual setpoint; high and low residual offsets; high high and low low residual levels; upper and lower chlorine dose rate limits; and time delays are configurable by appropriate level authorised personnel.

| Tag Number | Typical Set Point | Functionality |
|------------|---|---|
| AI 82419 | | Chlorine residual in recipient water main (in mg/L) displayed on HMI and OIP screens. |
| AAH 82419 | 1.5 mg/L (Target Chlorine Residual SP + offset) | HMI alarm displayed on HMI and OIP screens “AAH 82419 Chlorine residual level high” when chlorine residual is registered above this high level SP continuously for 6 min (configurable). <ul style="list-style-type: none"> Initiate pump changeover sequence or continue running if other system has already faulted. If chlorine residual still stays above high level SP after changeover, HMI alarm would remain active, but no further changeover would occur. |
| AAHH 82419 | 2.5 mg/L (Fixed as per site Water Safety Plan) | HMI alarm latched and displayed on HMI and OIP screens “AAHH 82419 Chlorine residual level high high alarm” when chlorine residual is registered above this high high level SP continuously for 1 min after changeover sequence. <ul style="list-style-type: none"> Initiate pump changeover sequence or continue running if other system has already faulted. After 30 secs, “Water Quality Breached” alarm will be triggered. A peer inhibit is activated for source water site and recipient water source initiated shutdown to stop continued supply of source water and delivery of poor quality water to consumers. Dosing system stops once flowrate falls below the initiation chlorination flow setpoint |
| AAL 82419 | 0.5 mg/L (Target Chlorine Residual SP – offset) | HMI alarm displayed on HMI and OIP screens “AAL 82419 Chlorine residual level low” when chlorine residual is registered below this low level SP continuously for 6 min (configurable). <ul style="list-style-type: none"> Initiate pump changeover sequence or continue running if other system has already faulted. If chlorine residual still stays below low level SP after changeover, HMI alarm would remain active, but no further changeover would occur. |
| AALL 82419 | 0.2 mg/L (As per site Water Safety Plan) | HMI alarm latched and displayed on HMI and OIP screens “AALL 82419 Chlorine residual level low low alarm” when chlorine residual is registered below this low low level SP continuously for 1 min after changeover sequence. <ul style="list-style-type: none"> Initiate pump changeover sequence or continue running if other system has already faulted. After 30 secs, “Water Quality Breached” alarm will be triggered. A peer inhibit is activated for source water site and recipient water source initiated shutdown to stop continued supply of source water and delivery of poor quality water to consumers. . Dosing system stops once flowrate falls below the initiation chlorination flow setpoint |

| Tag Number | Typical Set Point | Functionality |
|------------|-----------------------|---|
| YA 82419 | Reading < 3.5mA | HMI alarm displayed on HMI and OIP screens “YA 82419 Instrument Failure” when chlorine analyser reading goes below 3.5mA. <ul style="list-style-type: none"> • Dosing control system switches to flow paced only mode and doses according to the last recorded chlorine residual. • “Water Quality Breached” alarm activated after 30s. |
| QAH 82419 | User Defined Setpoint | HMI alarm displayed on HMI and OIP screens “QAH 82419 Required dose rate high” when the required chlorine dose rate is greater than the upper dose rate limit continuously for 30 min. Flags possible problem with dosing process. <ul style="list-style-type: none"> • limit dose rate to upper dose rate limit |
| QAL 82419 | User Defined Setpoint | HMI alarm displayed on HMI and OIP screens “QAL 82419 Required dose rate low” when the required chlorine dose rate is less than the lower dose rate limit continuously for 5 min. Flags possible problem with dosing process. <ul style="list-style-type: none"> • limit dose rate to lower dose rate limit |

5 MISCELLANEOUS INSTRUMENTATION

5.1 Miscellaneous Equipment

5.1.1 Safety Showers

The Hypo facility will have at least 2 safety shower/eyewash units and 2 hose reels. Each safety shower/eyewash unit shall be fitted with a flow switch to indicate operation.

| Tag Number | Typical Set Point | Functionality |
|------------|-------------------|---|
| FSH82428 | 1 L/h | Flow alarm high FAH 82428 is raised on HMI indicating that the safety shower near the load-in panel is in use. This high flow must be registered for 1 minute continuously before an alarm condition is initiated. This is so not to raise an alarm when safety shower is simply being tested (prior to delivery) or the thermal relief valve is bleeding. |
| FSH82431 | 1 L/h | Flow alarm high FAH 82431 is raised on HMI indicating that the safety shower near the dosing panels is in use. This high flow must be registered for 1 minute continuously before an alarm condition is initiated. This is so not to raise an alarm when safety shower is simply being tested (prior to delivery) or the thermal relief valve is bleeding. |

5.1.2 Hose Reels

The hose reels are not fitted with any flow switches or other devices and there is no control associated with these units.

5.1.3 Exhaust Fans

The exhaust fans in the Hypo storage room will be activated by a hand switch located in the entry vestibule. If required, the fan units can be automated with ambient temperature setpoint.

6 PROCESS CONTROL

6.1 Hypochlorite Dosing Flow Control

Flow control loop FC 82426 is responsible for the introduction of a controlled addition of chlorine into the recipient water. The dosing controller FC 82426 is flow paced from recipient water mains flow transmitter (FIT XXXXX) and computes the required Sodium Hypochlorite dose flow rate (in L/h) to be delivered by the duty dosing pump. The magnetic flow meter FIT82224/FIT82324 monitors the Hypo dosing pump discharge flow rate against the required flow. A low Hypo flow rate (lower than 50% of required hypo flow rate) indicates a hydraulic fault in the dosing line e.g. a blocked dosing spear. When a low flow is detected, an alarm is raised on the OIP/HMI and a changeover to the standby dosing panel is initiated.

The controller incorporates a threshold flow rate value of X m³/h whereby the control loop does not exert any control action until the measured flow registered by FIT XXXXX exceeds the setpoint X m³/h. Similarly, the dosing pump will stop running and will not be called to run while the flow rate in the recipient water main is below X m³/h setpoint. The control loop can be in ‘Automatic Trim’ or ‘Fixed’ mode.

In ‘Fixed’ control mode, there is no chlorine residual feedback and the dosing controller FC 82426 adjusts the chlorine dose rate to the fixed dose rate value HC 82426 entered on the HMI using only feed forward ratio control (flow pacing) from the recipient water flow. This control mode is used if there are problems with the chlorine analyser or sample water system. The required Sodium Hypochlorite dose flow rate (in L/h) from the dosing pumps is given by the following formula,

$$\text{Required Sodium Hypochlorite Dosing Flow Rate (L/h)} = \frac{\text{Recipient water flow rate FIT XXXXX in m}^3/\text{h} \times \text{Fixed Chlorine dose rate HC 82426 in mg/L}}{\text{Hypo strength (w/v) in \%} \times 10}$$

Hypo strength (w/v) in % is typically fixed at 10%.

The ‘Automatic Trim’ control mode is the normal operating control mode. In this mode, the required Hypo dosing flow rate, flow paced to the recipient water flow, is adjusted (trimmed) continuously by PID control loop AC 82419 monitoring the chlorine residual downstream of the Sodium Hypochlorite dosing point; to achieve the target chlorine residual setpoint (mg/L) value HC 82419A entered on the OIP/HMI. In the event of low sample water flow or a failure in the chlorine analyser, the dosing pump will continue to operate under flow paced control based on AC 82419 output (in mg/L) at the last recorded healthy chlorine residual. The required Sodium Hypochlorite dose flow rate for the Automatic Trim mode is given by the following formula,

$$\text{Required Sodium Hypochlorite Dosing Flow Rate (L/h)} = \frac{\text{Recipient water flow rate FIT XXXXX in m}^3/\text{h} \times \text{Chlorine dose rate output from PID trim control loop AC 82419 in mg/L}}{\text{Hypo strength (w/v) in \%} \times 10}$$

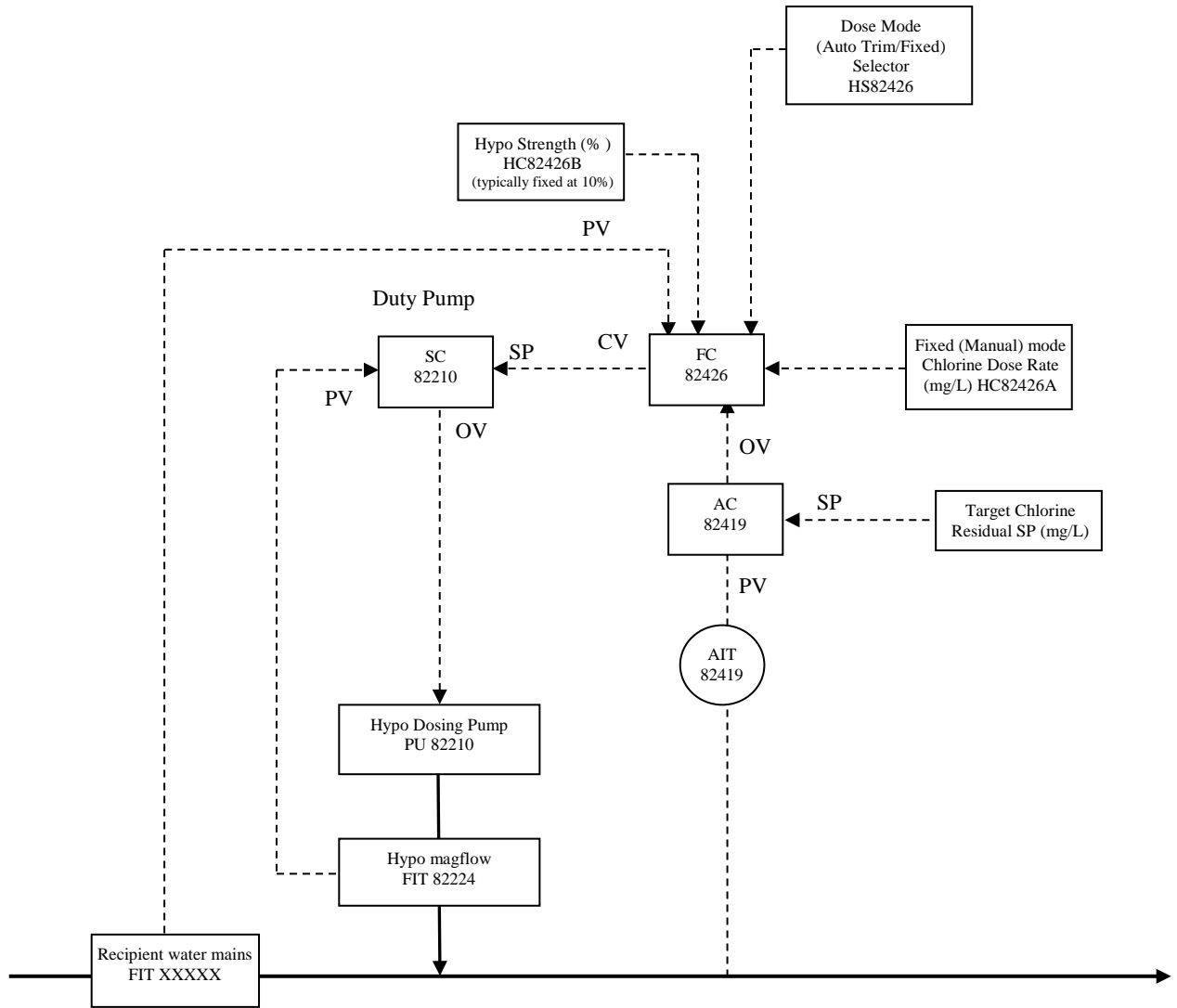
Hypo strength (w/v) in % is typically fixed at 10%.

A configurable delay (default 10 minutes) is usually set for the PID loop to start a short period after chlorination is initiated to allow for the system to stabilize after dosing startup.

Upper and lower chlorine dose rate limits are set in the AC 82419 controller to flag potential problem with the dosing process such as abnormal chlorine demand, or chlorine analyser malfunction. If the required hypo dose rate is greater than the upper dose rate limit a high warning alarm is activated on the local OIP, conversely if the required dose rate is less than the lower dose rate limit a low warning alarm is activated on the local OIP. Both these conditions will limit the Hypochlorite dosing to the upper or lower dose rate limits. Should either of these conditions remain continuously active for thirty minutes, a high (or low) alarm will be activated on both the local OIP and SCADA. There is no

interlock or control action when these limits are breached; the alarm should prompt the operator to investigate further. Typical dose rate limit setpoints are indicated in section 4.2.

A schematic of the control loop for Sodium Hypochlorite dosing system 1 is shown in the figure below. The control loop for dosing system 2 is similar.



7 PRE-REQUISITES, TRIGGERS & INTERLOCKS CONDITIONS

7.1 Definitions

The following definitions have been applied,

| | |
|---------------|---|
| Pre-requisite | Requirement for a sequence to commence |
| Interlock | Condition that will prevent an undesirable activation or outcome |
| Trigger | An event when the system is in an operational state that will initiate another sequence |
| Abort | A sequence resulting from an interlock that will return the system to the 'Stopped' state |

7.2 Storage Tank Refilling

For the storage tank refilling operation, the opening of the door to the load-in panel will trigger the operation of the 3-way valve VA 82105 of the load-in apron sump to open to the waste holding tank and closed to the soakwell/site drainage in anticipation of a chemical delivery. After delivery, the valve will revert back to open to the soakwell/site drainage and closed to the waste tank when the door is shut again. Light indication on the load-in panel provides a confirmation on which way the valve is open.

The delivery driver is also expected to check that he/she is able to deliver the contents of his tanker into the tanks prior to unloading by checking the level indication of each tank on the load-in panel and the maximum full level labels.

These steps are covered by the delivery work instructions and procedures; there are no other control pre-requisites or interlocks associated with these functions.

7.3 Bund Sump Discharge

The operation of the bund sump drain valve VA 82106 is initiated from the OIP screen.

Interlocks will apply to the valve position if a high conductivity is registered by AIT 82153. When a high conductivity is registered, drain valve VA 82106 will automatically close if it is open at the time of the alarm, or if it is already closed, it will be prevented from opening.

The operator can override these interlocks by selecting the sump drain valve 'Override On' locally near the valve pit or from the OIP. However if the valve is left open for longer than 5 minutes continuously then control system will automatically close the valve whether override is selected or not.

7.4 Sodium Hypochlorite Dosing System Operational States

In the following sub-sections, references are made to Sodium Hypochlorite Dosing System 1 (Hypo 1) for convenience. Sodium Hypochlorite Dosing System 2 (Hypo 2) has similar operational states with its associated equipment and instrumentation tag numbers.

The following pre-requisites are required to transition the system from the ‘Stopped’ state to the ‘Running’ state:

| Pre-requisites to transition system from ‘Stopped’ to the ‘Running’ State |
|--|
| Recipient water flow meter FIT XXXXX registers flow > X m3/h |
| AND Dosing System SH1 is CSS is on Normal (PLC) position |
| AND Dosing System SH1 devices are ‘Available’ as defined in Section 1.6. |
| AND (Outlet valve VA 82137 ‘Open’ OR Outlet valve VA 82147 ‘Open’) |
| AND 2 minute stop timer has expired |

The following trigger will initiate the transition of the system from the ‘Stopped’ state to the ‘Running’ operational state (Disinfection Initiated):

| Triggers to transition system from ‘Stopped’ state to ‘Running’ state |
|--|
| PU 82210 Running feedback on “Running” (Run relay) |

The following triggers will transition the system from the ‘Running’ operational state to the ‘Stopped’ state:

| Triggers to transition system from ‘Running’ state to ‘Stopped’ state |
|---|
| Any Dosing System SH1 devices are ‘Not Available’ or in fault state as defined in Section 1.6. |
| OR Both Hypo Tank outlet valves VA 82137 and VA 82147 are closed or ‘Not Available’ |
| OR Flowrate drops below initiate chlorination AND 2 minute run timer has expired. |
| OR Alternate Duty changeover time occurs (Daily or Weekly) IF duty is selected as Alternative |

If the Hypo 1 Dosing Pump is running, the following fault triggers will initiate a shutdown of the Hypo 1 Dosing and will transition the system directly to the ‘Stopped’ state:

| Triggers to abort Dosing to ‘Stopped’ state (Fault) |
|---|
| Any Dosing System SH1 devices become ‘Not Available’ as defined in Section 1.6. |
| OR Both Hypo Tank outlet valves VA 82137 and VA 82147 are closed or ‘Not Available’ |
| OR Hypo 1 pump motor protection fault (YA 82210A) active |
| OR Hypo 1 pump fault (YA 82210B) active |
| OR Hypo 1 de-gassing valve fault (ZA 82221) active |
| OR Hypo 1 hydraulic fault (flow rate low) (FAL 82224) active |
| OR Recipient water chlorine low low alarm (AALL 82419) active IF other dosing system is not unavailable or in fault state |
| OR Recipient water chlorine high high alarm (AAHH 82419) active |
| OR Operator disables ‘Chlorination’ OIP/HMI |

In the Hypo 1 ‘Dosing’ state, the following triggers will terminate operation of the Hypo 1 dosing system and initiate operation of the standby Hypo 2 dosing system.

| Triggers for changeover to Standby system operation |
|---|
| Any Dosing System SH1 devices are 'Not Available' as defined in Section 1.6 |
| OR Hypo 1 pump motor protection fault (YA 82210A) active |
| OR Hypo 1 pump fault (YA 82210B) active |
| OR Hypo 1 de-gassing valve fault (ZA 82221) active |
| OR Hypo 1 hydraulic fault (flow rate low) (FAL 82224) active |
| OR Recipient water chlorine residual low alarm (AAL 82419) active |
| OR Recipient water chlorine residual high alarm (AAH 82419) active |
| OR Recipient water chlorine low low alarm (AALL 82419) active |
| OR Alternate Duty changeover time occurs (Daily or Weekly) IF duty is selected as Alternative |

The prerequisite for this transition to occur is that the Hypo 2 dosing system must be available and selected as the standby system (not selected as the duty system).

| Pre-requisites to Transition from Hypo 1 Dosing to Hypo 2 Dosing |
|---|
| Hypo 2 Dosing System is Available |

8 ALARMS

Alarming is divided into three priority categories:

- A ‘Critical’ level alarm is an alarm which will require immediate site operator actions. A ‘Critical’ level alarm will be transferred to telemetry provided RTU COMMS ENABLE is “on”.
- An ‘Urgent’ level alarm will require the operator to address the issue within a limited time period (within 24 hours). An urgent level alarm may also be transferred to telemetry in some cases.
- A ‘Warning’ level alarm is an event logged in the alarm history for review at some appropriate time.

Critical, Urgent and Warning alarms are indicated on the HMI display in flashing red. Once these alarms have been accepted the alarm will stop flashing. If an alarm is no longer in an alarmed state, but has not been acknowledged then it will flash green.

The “Water Quality Breached” alarm shall initiate shutdown of recipient water source to prevent delivery of poor quality water to consumers. Refer to Section 1.12 for more details.

The following alarms are associated with the Hypo storage and dosing system:

| Instrument Tag Number | Alarm Message | Control System Action | Alarm Status |
|-----------------------|--|---|--------------|
| LSH 82104 | LAH 82104 Load-in apron sump level high | No control action, annunciates on load-in panel to alert tanker driver. | Critical |
| VA 82105 | ZA 82105 Load-in apron sump drain valve VA 82105 fault. | Upon failure, load-in apron sump drain valve VA 82105 opens to Waste Holding Tank (closed to site drainage) | Urgent |
| LIT 82115 | LAH 82115 Sodium Hypo Tank TA 82110 level high (tank full). | No control action, annunciates on load-in panel to alert tanker driver to stop filling. | Urgent |
| | LAL 82115 Sodium Hypo Tank TA 82110 level low (re-order Hypo). | No control action, notifies operator to re-order Hypo. | Warning |
| | LALL 82115 Sodium Hypo Tank TA 82110 level low low (tank empty). | Close tank isolation valve VA82137 and shut down operation of duty dosing pump, preventing it from running dry. | Critical |
| LIT 82125 | LAH 82125 Sodium Hypo Tank TA 82120 level high (tank full). | No control action, annunciates on load-in panel to alert tanker driver to stop filling. | Urgent |
| | LAL 82125 Sodium Hypo Tank TA 82120 level low (re-order Hypo). | No control action, notifies operator to re-order Hypo. | Warning |
| | LALL 82125 Sodium Hypo Tank TA 82120 level low low (tank empty). | Close tank isolation valve VA82147 and shut down operation of duty dosing pump, preventing it from running dry. | Critical |
| LSHH82134 | LAHH 82134 Sodium Hypo Tank TA 82110 level high high (overflow). | No control action, annunciates visually and audibly on load-in panel to alert tank near overflowing. | Critical |
| LSHH82144 | LAHH 82144 Sodium Hypo Tank TA 82120 level high high (overflow). | No control action, annunciates visually and audibly on load-in panel to alert tank near overflowing. | Critical |
| VA 82137 | ZA 82137 Tank TA 82110 outlet | No control action if VA82147 is open. | Urgent |

| Instrument Tag Number | Alarm Message | Control System Action | Alarm Status |
|-----------------------|---|---|--------------|
| | valve VA 82137 fault. | If Tank TA 82120 valve VA 82147 is also closed, initiates system shutdown and triggers 'Water Quality Breached' alarm and peer inhibit is activated for the water source/s | Critical |
| VA 82147 | ZA 82147 Tank TA 82120 outlet valve VA 82147 fault. | No control action if VA82137 is open. | Urgent |
| | | If Tank TA 82110 valve VA 82137 is also closed, initiates system shutdown and triggers 'Water Quality Breached' alarm and peer inhibit is activated for the water source/s | Critical |
| LSH 82152 | LAH 82152 Bund sump level high | No control action if only high level alarm. | Warning |
| | | If it occurs in conjunction with AAH 82153, interlock to close tank outlet valves, which will initiate system shutdown and triggers 'Water Quality Breached' alarm and peer inhibit is activated for the water source/s | Critical |
| AIT 82153 | AAH 82153 Bund sump conductivity high | Interlock to close Valve VA 82106 or prevent it from opening. | Urgent |
| | AAHH 82153 Bund sump conductivity high high | If it occurs in conjunction with LAH 82152, interlock to close tank outlet valves, which will initiate system shutdown and triggers 'Water Quality Breached' alarm and peer inhibit is activated for the water source/s | Critical |
| VA 82106 | ZA 82106 Bund sump drain valve VA 82106 failed | Valve to be fail-close. | Warning |
| LSH82107 | LAH82107 Waste Holding Tank level high | No control action, alerts operator to arrange for tank pump out. | Warning |
| PU 82210 | YA 82210A Dosing Pump PU 82210 motor fault. | Shuts down dosing system 1 operation and initiates standby system | Urgent |
| | YA 82210B Dosing Pump PU 82210 pump fault | Shuts down dosing system 1 operation and initiates standby system | Urgent |
| PU 82310 | YA 82310A Dosing Pump PU 82310 motor fault | Shuts down dosing system 2 operation and initiates standby system | Urgent |
| | YA 82310B Dosing Pump PU 82310 pump fault | Shuts down dosing system 2 operation and initiates standby system | Urgent |
| VA 82221 | ZA 82221 De-gassing valve VA 82221 fault | Shuts down dosing system 1 operation and initiates standby system | Urgent |
| VA 82321 | ZA 82321 De-gassing valve VA 82321 fault | Shuts down dosing system 2 operation and initiates standby system | Urgent |
| FIT 82224 | FAL 82224 Hypo dosing flow low (hydraulic fault) | Shuts down dosing system 1 operation and initiates standby system | Urgent |
| FIT 82324 | FAL 82324 Hypo dosing flow low (hydraulic fault) | Shuts down dosing system 2 operation and initiates standby system | Urgent |

| Instrument Tag Number | Alarm Message | Control System Action | Alarm Status |
|-----------------------|---|--|--------------|
| PU 82406 | YA 82406 Sample Water Pump PU 82406 motor fault | Halt PID loop auto trim, dosing control continues with flow pacing based on last recorded chlorine residual. | Critical |
| FSL 82418 | FAL 82418 Sample water flow low | When sample water low flow detected, dosing control continues with flow pacing based on last recorded chlorine residual. FAL 82418 raised if flow not restored after 15 min. | Critical |
| AIT 82419 | AAL 82419 Chlorine residual level low | If low level registered continuously for 6 min (configurable), triggers alarm and shuts down duty dosing system operation and initiates standby system. | Warning |
| | AALL 82419 Chlorine residual level low low – Dosing fault | If low low level registered continuously for 1 min after changeover, triggers alarm (alarm latched) and triggers ‘Water Quality Breached’ alarm and peer inhibit is activated for the water source/s. System continues to run. | Critical |
| | AAH 82419 Chlorine residual level high | If high level registered continuously for 6 min (configurable), triggers alarm and shuts down duty dosing system operation and initiates standby system. | Warning |
| | AAHH 82419 Chlorine residual level high high – Dosing fault | If high high level registered continuously for 1 min after changeover, triggers alarm (alarm latched) and triggers ‘Water Quality Breached’ alarm. | Critical |
| | YA 82419 Chlorine residual analyser instrument failure | Halt PID loop auto trim, dosing control continues with flow pacing based on last recorded chlorine residual. | Critical |
| | QAH 82419 Required dose rate high | Flags problem with dosing process and limits the dose rate. | Urgent |
| | QAL 82419 Required dose rate low | Flags problem with dosing process and limits the dose rate. | Urgent |
| FSH 82428 | FAH 82428 Shower in Use | No control action. | Critical |
| FSH 82431 | FAH 82431 Shower in Use | No control action. | Critical |

9 TRENDS

The following trends will be recorded on the OIP

| Instrument Tag Number | Information |
|------------------------------|---|
| FIT XXXXX | Recipient water mains flow rate |
| LIT 82115 | Sodium Hypochlorite Storage Tank TA 82110 level |
| LIT 82125 | Sodium Hypochlorite Storage Tank TA 82120 level |
| FIT 82224 | Sodium Hypochlorite 1 flow rate |
| FIT 82324 | Sodium Hypochlorite 2 flow rate |
| AIT 82153 | Bund water conductivity |
| AIT 82419 | Chlorine residual |
| CL00809_RES1SC | Chlorine Setpoint |
| CL00809_F1 | Dose Rate |

10 APPENDIX A: STORAGE TANK LEVEL SET POINTS CALCULATION

This appendix provides some guidance on determining the storage tank level set points.

High-High Level Alarm Set Point (LAHH)

The high-high level alarm should be set at a level which corresponds to 20 seconds (= 0.33 minutes) before tank overflow. is generated when the tank level reaches 50mm below the bottom of the overflow. This alarm is also interlocked to isolate power to the filling pump GPO.

High Level Alarm Set Point (LAH)

The high level alarm should be initiated before the high-high level and is set no less than 1000L or 3% (whichever is greater) below the overflow. The 1000L figure is based on a response time of 2 minutes at the typical filling pump rate for bulk tankers (i.e. 500 L/min). This volume may be reviewed is lower rate filling pumps are to always be used.

The tank volume at the high level alarm setting shall be defined as the maximum fill volume and shall be clearly denoted on the tank and on the load-in panel (1 label per tank on the load-in panel).

Low Level Alarm (LAL)

The low level alarm or re-order alarm should be triggered at a level which corresponds to the tank being sufficiently empty to receive a full load of Sodium Hypochlorite at the end of the delivery turnaround period. However, at this level there should also be at least a supply of chemical remaining in the tank to last the period from the re-ordering till the actual delivery.

Low Low Level Alarm (LALL)

The low low level alarm is essentially to protect the pump from running dry, so its set point is 50mm above the top of the outlet nozzle.

11 APPENDIX B: FUNCTIONAL DESCRIPTION OVERVIEW

The controls and interlocks of the Bulk Sodium Hypochlorite Storage and Dosing System are summarised in the Functional Description Overview in Excel spreadsheet format which can be found as standard document *DS 73-02 Appendix B – Functional Description Overview*.

END OF DOCUMENT