



Assets Planning and Delivery Group
Engineering

DESIGN STANDARD DS 71-02

Fluorosilicic Acid 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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REVISION STATUS

The revision status of this standard is shown section by section below:

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Fluorosilicic Acid Storage and Dosing System

Control Functional Specification

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1 SYSTEM OVERVIEW

The Fluorosilicic Acid (FSA) system normally operates automatically but may also be operated manually from the local fluoride control panel (Fluoride Local Interface Panel or FLIP) located in the entry vestibule or viewing room of the FSA plant. Manual operation of the FSA system from the plant-wide supervisory control system (HMI) is not recommended as onsite observation would be required to minimize potential safety hazards. Most current FSA installations do permit remote manual operation but it is intended that changes will be made to restrict remote operation other than dose rate changes in future. Information provided on the HMI for the FSA system is also duplicated and displayed on the FLIP.

The 2 Tanks & 2 Panels standard FSA design consists of two complete and separate dosing systems that operate as duty and standby. Each system comprises of a tank and dosing panel including actuated valves, pump and flow meter. Should a device in the duty dosing system fail, prompting a changeover to the standby system, then the complete standby system will commence operation taking the place of the entire failed system, not just part of the standby system.

This control functional specification is written specifically for 2 Tanks & 2 Panels standard design systems. Refer to P&IDs GT36-60-83.1 through to 83.4 for valve and equipment numbers. Sections of the text have been highlighted in green to indicate the differences between systems using chlorine solution water as the FSA dilution water and systems using service water, or some other supply, as the FSA dilution water.

1.1 Process Description

The FSA is stored in two <volume> m³ <material> tanks inside a bund within a sealed room. The volume inside each tank is monitored by a pressure transmitter. A magnetic level indicator 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.

Fluorosilicic acid solution is loaded into the tanks through a load-in panel. Displays on the front of the load-in panel show the volume in each tank, level alarm lights and sirens.

The bund sump is equipped with a conductivity probe and high level switch to assist in the detection of acid leaks. The bund sump is connected to the load-in apron sump via an actuated isolation valve (located in an external pit). The load-in apron sump drains to the sludge drying beds or site drainage via a manual isolation valve. This valve is normally open to prevent rain water accumulating on the apron and in the sump. It is closed during a delivery to capture minor spills.

Each tank has a manual isolation valve, actuated isolation valve and a three-way actuated acid/water selector valve connected as close as possible to the process outlet. A flushing water line and actuated valve is also located in close proximity. The piping arrangement aims to maximise the effectiveness and efficiency of the automated pipework flushing system. Each tank is plumbed to a dedicated dosing panel which holds a calibration column, strainer, dosing pump, pulsation dampener, acid flow meter, dilution water and acid dosing pipework, along with other valves and equipment. These panels are mounted on the storage room walls and have transparent PVC screens or doors for additional protection from leaks and sprays.

Dosing systems for chemicals other than FSA often employ duty and standby equipment within a single dosing system to provide a high degree of continuity of dosing. However, it is desirable to minimise complexity in FSA dosing system designs so as to reduce the potential for leakage and the associated OSH hazards. In an effort to achieve a degree of simplicity, separate duty and standby dosing systems are provided with no cross-connections. This provides two main benefits:

- it minimises the number of connections, and thus the potential number of points that may leak; and
- it allows maintenance to be safely done on one dosing system, while the other dosing system is in operation, safely sealed in a separate dosing cabinet.

<If FSA and chlorine are dosed together ie chlorine solution is used as the dilution water>

FSA is conveyed to the dose point in solution water (dilution water with a minimum twenty-fold dilution at the maximum dose rate). FSA is added to the chlorine solution water (i.e. downstream of the addition of chlorine to the solution water) and thus chlorine and FSA are dosed together. The controlled addition of fluoride ions into the drinking water achieves a pre-set fluoride concentration in the drinking water.

<If FSA is dosed separate from chlorine ie service water or dedicated pumps provide dilution water>

FSA is conveyed to the dose point in service water (dilution water with a minimum twenty-fold dilution at the maximum dose rate). The controlled addition of fluoride ions into the drinking water achieves a preset fluoride concentration in the drinking water.

The FSA dose rate is flow-paced from a magflow meter installed in the recipient water main. A mini-magflow meter on the neat acid line on the dosing panel provides a signal used for feedback control of the dose pump speed to achieve the target dose rate.

An online fluoride ion analyser is used to monitor the fluoride ion concentration in the recipient water main. A continuous water sample is drawn from downstream of the dose point to supply this analyser. The signal from this analyser is not normally used to control the fluoride dose rate (no feedback trim from this analyser) but alarms generated from this analyser are used to alert the operator to high or low fluoride concentrations in the water supply and shutdown fluoride dosing on high-high concentration. However, at sites where the background fluoride concentration of the raw water or recipient water varies widely, feedback trim from the analyser could be considered.

Exhaust fans are located inside the storage room. Safety showers are located both inside and outside the FSA storage room. These are equipped with flow switches to indicate continuous operation and the external safety shower is equipped with a thermostatic bleed valve.

1.2 System Functionality

Fluoride dosing occurs when:

- the flow rate in the recipient water main exceeds a set point minimum value; and
- when dilution water is running through the duty dosing panel.

<For systems where chlorine solution is used as the dilution water>

- Dilution water is registered as running when the low flow switches¹ are not active in the lines carrying chlorinated water to the fluoride dosing system (i.e. when 'dose water flow established' signal is registered - refer to chlorine standard drawing EO28-60-8)

<For systems where service water or a dilution pump is used to supply the dilution water>

- Dilution water is registered as running when the low flow switches on the dosing panels (FSL 83205 for panel 1 and FSL 83305 for panel 2) are not active.

The FSA storage and dosing systems incorporate a number of different operations and these are summarised in the following table:

¹ Ordinarily, chlorination would only be operating when the minimum flow rate in the recipient water main had been achieved, but it is possible that the flow switches may also be active during system testing or flushing; hence, the FSA system requires both the establishment of the minimum flow rate and the chlorine solution water flow switches being active.

Operation	Interrelationship with Other FSA Operations
Bund sump discharge	No relationship with any other operation
Storage tank refilling	No relationship with any other operation
FSA Dosing System 1 FSA 1 Dosing FSA 1 Flushing FSA 1 Calibration FSA 1 Manual FSA 1 Stopped	Only one control mode per dosing system can be active at a time.
FSA Dosing System 2 FSA 2 Dosing FSA 2 Flushing FSA 2 Calibration FSA 2 Manual FSA 2 Stopped	Only one control mode per dosing system can be active at a time.

The following two manual operations can occur irrespective of the operational state of the FSA dosing systems.

- Sump Bund discharge
- Storage Tank filling

The sump bund contents can be discharged to the waste holding tank, sludge drying beds or site drainage via an automated sump drain valve (VA83137) located in an external valve pit. Providing the conductivity in the bund sump is not high, the operator can manually open and close this valve from the HMI or FLIP at any time. If the conductivity is 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 FLIP. 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 conductivity analyser are installed in the bund sump to detect high sump levels and acid 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 and the interlock with the sump drain valve described above will be triggered. These 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 inhibit the dosing systems from running.

The filling of the storage tanks is purely a manual operation. None of the valves involved with this procedure are automated and there are no interlocks. The level 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.

Each FSA dosing system can be in any one of the following operational states:

- Dosing – This mode doses FSA from the storage tanks through the dosing panel to the recipient water main, this is the normal operating mode.
- Flushing – This mode uses flushing water to displace FSA out of the system and directs it to the dose point, so that maintenance can be conducted on the system.

- Calibration – This mode is used to calibrate the dosing pump using service water from the calibration column and directs it to the dose point, this mode will be used predominantly during commissioning or after pump replacement.
- Manual – This mode allows the operator to open/close and stop/start any component of the FSA system. This is not a normal operating mode.
- Stopped – This mode stops the dosing, flushing or calibration systems and isolates the tanks. This mode is a safe state and is also used as a starting point for the selection of other modes.

Only one mode can be selected to be active at a time and this selection will only be permitted when there is no other control mode selected. This means the Operator can only select a mode when the system is in the ‘FSA <dosing system number> Stopped’ state.

Operators can manually de-activate a mode to return the system to the ‘FSA <dosing system number> Stopped’ state. Or the control system may abort a mode due to an interlock or trigger and return the system to a stopped state.

When a control mode is selected by the operator for dosing system 1 the corresponding actuated valve configuration and pump control selection is undertaken automatically:

- FSA 1 Dosing –
 - The actuated tank isolation valve (VA83117) will be opened.
 - The acid/water valve (VA83118) will be opened to the acid position.
 - The flushing isolation valve (VA83132) will be closed.
 - The dilution water valve (VA83202) will be opened.
 - The dose/drain valve (VA83224) will be opened to the dose position.
 - The dosing pump (PU83213) speed is set to automatic control. The manual control of the pump (speed control) is not permitted in dosing mode.
- FSA 1 Flushing –
 - The actuated tank isolation valve (VA83117) will be closed.
 - The acid/water valve (VA83118) will be closed (open in the water position).
 - The flushing isolation valve (VA83132) will be opened.
 - The dilution water valve (VA83202) will be opened.
 - The dose/drain valve (VA83224) will initially be opened to the dose position. After initial valve configuration, the dose/drain valve can be manually opened or closed to dose or drain.
 - The dosing pump (PU83213) speed is set to automatic control; manual control of the pump (speed control) is not permitted.
- FSA 1 Calibration –
 - The actuated tank isolation valve (VA83117) will be closed.
 - The acid/water valve (VA83118) will be closed (in the water position).
 - The flushing isolation valve (VA83132) will be closed.
 - The dilution water valve (VA83202) will be opened.
 - The dose/drain valve (VA83224) will be opened in the dose position.
 - The dosing pump (PU83213) speed is under manual control and the pump speed can be selected.

- The operator will normally close the manual supply valve (VA83209) and open the calibration tube downstream valve (VA83208) after filling the calibration tube from the site service water via valve (VA83206).
- FSA 1 Manual –
 - All valves can be positioned as required with the exception of one interlock (if the acid/water valve (VA83118) is open (in the acid position) then the dose/drain valve (VA83224) must be open (in the dose position). The dose drain valve cannot be opened to drain whilst the acid/water valve is open to acid).
 - The pump is under manual control and the pump speed can be manually set.
- FSA 1 Stopped –
 - The actuated tank isolation valve (VA83117) will be closed.
 - The acid/water valve (VA83118) will hold its last position.
 - The flushing isolation valve (VA83132) will be closed.
 - The dilution water valve (VA83202) will be closed.
 - The dose/drain valve (VA83224) will hold its last position.
 - The dosing pump (PU83213) speed control is set to off.

The same control modes exist for dosing system 2 – FSA 2 Dosing, FSA 2 Flushing, FSA 2 Calibration, FSA 2 Manual and FSA 2 Stopped. Similar automatic valve actuation occurs when each of these modes is initiated by the operator.

Each FSA dosing system is moved between each of these operational states by executing sequences initiated from the commands on the pop-up panel on the HMI/FLIP display, or by tripped interlocks and triggers. The commands available on the HMI/FLIP Sequence Controls pop-up panel for each system are:

- Dosing Mode Start
- Dosing Mode Stop
- Flushing Mode Start
- Flushing Mode Stop
- Calibration Mode Start
- Calibration Mode Stop
- Manual Mode Start
- Manual Mode Stop

The FSA <dosing system number> Dosing Pump can only commence running automatically when the system is in the 'FSA <dosing system number> Dosing Mode' operational state. Transition to the 'FSA <dosing system number> Dosing Mode' state can only occur from the 'FSA <dosing system number> Stopped' state by an Operator selecting 'FSA <dosing system number> Dosing Mode Start' command.

Once in the 'FSA <dosing system number> Dosing Mode' the FSA <dosing system number> Dosing Pump is automatically initiated by the control system when the minimum set point flow rate in the recipient water main is exceeded for at least 30 seconds. When this condition ceases (when recipient water flow drops below the minimum set point for at least 30 seconds) then the FSA dosing pump will automatically stop operating and the system will sit idle in the 'FSA <system> Dosing Mode' state.

The FSA dosing system can transition to the 'FSA Stopped' state by the Operator selecting any of the following commands from the Sequence Controls pop up panel,

- FSA <dosing system number> Dosing Mode Stop

- FSA <dosing system number> Flushing Mode Stop
- FSA <dosing system number> Calibration Mode Stop
- FSA <dosing system number> Manual Mode Stop

In the 'FSA Stopped' state, the dosing system cannot transition automatically to the 'FSA Dosing Mode' state and hence the dosing pump cannot run.

Transition to the 'FSA <system number> Flushing Mode' state can only occur from the 'FSA Stopped' state. This is achieved by the Operator selecting the 'FSA <system number> Flushing Mode Start' command. Once selected, the flushing operation will continue to run until the operator command 'FSA <dosing system number> Flushing Mode Stop' is activated or an interlock terminates the flushing operation and returns the system to the 'FSA <dosing system number> Stopped' state.

Transition to the 'FSA <dosing system number> Calibration Mode' state can only occur from the 'FSA Stopped' state. This is achieved by the Operator selecting the 'FSA <dosing system number> Calibration Mode Start' command. The 'FSA <dosing system number> Calibration Mode Stop' command will terminate the calibration operation and return the system to the 'FSA <dosing system number> Stopped' state.

The transition between the operating states is shown diagrammatically in Section 7.2. The pre-requisites for the 'FSA <dosing system number> Dosing', 'FSA <dosing system number> Flushing' and 'FSA <dosing system number> Calibration' control sequence and the interlocks associated with these sequences are described in detail in Sections 6.3, 6.4 and 6.5 respectively.

To facilitate the above control sequences, the PLC controlled valves, instruments and dosing pumps associated with each FSA dosing system are grouped together within the control system under a Group Controller identified as 'FSA <dosing system number>_GC'. The purpose of the group controller is to,

1. Monitor the 'Available' (health) status of each of the devices that will be controlled by the sequences,
2. Allow the operator to place all the affected FSA dosing system controllable field devices into an 'Automatic state', thereby ensuring that the control sequences that will actuate these devices will succeed.

The control sequences that rely on the response of these devices is prevented or stopped from executing if the group controller does not have the required list of 'Available' devices.

Group Controller FSA <dosing system number>_GC has two states that can be selected on the HMI and FLIP screen,

- AUTO** This state prohibits the Operator from initiating pump or individual valve operation from the HMI and FLIP screen.
- MANUAL** Control sequences cannot be initiated therefore only 'Manual Mode' can be selected. The Operator has control access to the individual items of equipment controllable from the FLIP or HMI display. Manual control is recommended to be carried out from the FLIP where the operator has full view of the FSA room.

Devices associated with Group Controller FSA 1_GC are:

Plant Device
Valve VA 83117 (tank isolation valve)
Valve VA 83118 (acid/water valve)
Valve VA 83132 (flushing water valve)
Valve VA 83202 (dilution water valve)
Valve VA 83224 (dose/drain valve)
Pump PU 83213

Devices associated with Group Controller FSA 2_GC are:

Plant Device
Valve VA 83127 (tank isolation valve)
Valve VA 83128 (acid/water valve)
Valve VA 83134 (flushing water valve)
Valve VA 83302 (dilution water valve)
Valve VA 83324 (dose/drain valve)
Pump PU 83313

Group Controller FSA<dosing system number>_GC has an ‘Available’ status that is the combined ‘Available’ status of all devices in the group. Therefore all devices must be ‘Available’ for the Group Controller to be ‘Available’.

Individual devices, if faulted, lost power, alarmed, electrically isolated or tagged as ‘Out of Service’, will present their status on the HMI, FLIP and to the Group Controller FSA<dosing system number>_GC as ‘Not Available’ after a delay of 30 seconds.

The Group Controller FSA<dosing system number>_GC can only be selected to MANUAL when that particular dosing system is in the ‘FSA Stopped’ operational state or a sequence is locked in an invalid state due to a sequence not finishing. An invalid state includes all of the following:

- Not dosing
- Not flushing
- Not calibrating
- Not stopped

The status of the FSA dosing systems is usually one of the pre-requisites for operation of a water treatment plant in automatic mode. Each FSA dosing system is considered to be ‘Available’ if the following conditions are current.

FSA Dosing System Status for AUTO Operation of a Water Treatment Plant
Dosing system is in the ‘FSA <dosing system number> Dosing’ operational state

Although full automatic and manual control of the FSA system is currently possible from the remote HMIs, it is recommended that ‘Flushing’, ‘Calibration’ and ‘Manual’ modes be selected and controlled at the FLIP as onsite observation is required during operation of these modes to minimise potential safety hazards. It is intended that changes will be made to place restrictions and controls over remote operation in future such as through the use of password, pop-up prompts or user designated privileges.

The controls of the FSA Storage and Dosing System are summarised in the Functional Description Overview provided in Appendix B.

1.3 Three Way Valves

The convention for labelling the status of the three way valves will be as follows:

1. Open state –
 - acid/water valve configured to allow acid from the tank to flow to the dosing panel; and
 - dose/drain valve configured to allow acid flow into the dilution water line which is dosed into the recipient water main.
2. Closed state –
 - acid/water valve configured to allow flushing water to flow to the dosing panel; and
 - dose/drain valve configured to allow flushing water to flow to the tundish on the dosing panel.

1.4 Plant Power Failure

A UPS provides continuous power to the Control system and the Fluoridation Control Cubicle for a minimum period of 30 minutes in the event when no input power supply is available. In addition to this the fluoride analyser is connected to this supply so fluoride levels can continue to be monitored and alarmed. 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 FSA 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 fluoride 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 shall be allowed for the fluoride residual to return to normal. However, if the system is in 'Manual' mode, it shall revert to the 'Stopped' (off) mode in the event of a power failure, and thus the equipment shall remain off when power is restored.

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 sized to provide continuous running on normal load for 3 days.

2 FSA STORAGE

2.1 Set Point and Alarm Configuration

The set point and alarm values listed in the following sections are all configured on the HMI and FLIP screens. The values can only be changed by personnel with supervisory log-on privileges.

2.2 Storage Tank No 1 - TA 83110

The storage tank incorporates the following instrumentation and automated valve.

The level/volume in this tank is measured by a pressure transmitter LT83113, calibrated to 0 – 100% with the following PLC set points. (0% is defined as the bottom of the tank, and 100% is defined as the invert level of the tank overflow)

Tag Number	Set Point	Functionality
LAH83113	80%	LAH 83113 is a local visual alarm to notify the delivery tanker operator to stop filling. An alarm condition is also displayed on the HMI and FLIP screens.
LAL 83113	40%	LAL 83113 is a low level alarm displayed on the HMI and FLIP screens to indicate the need to order more chemical.
LALL 83113	7%	LALL 83112 is a low level alarm displayed on the HMI and FLIP screens to indicate that the tank is nearing empty. This alarm will inhibit the selection of dosing mode for FSA system 1 and will shutdown dosing if it is already occurring when the this alarm is generated to prevent the dosing pump from running dry.

Note: The set point values listed above are provided as a guide only. They will need to be determined for each site based on tank volume, delivery volume and delivery turn around. Some notes on the determination of these set points are provided in appendix A.

A magnetic bar graph level indicator LI 83110 complete with a level switch LSHH 83110 is also installed on tank TA 83110 to provide visual indication of the tank level and to trigger the high-high level alarm.

Tag Number	Set Point	Functionality
LI 83110	Not applicable	LI 83110 is a visual indication of tank level only.
LSHH83110	85%	LAHH 83110 is a local visual and audible alarm on load-in panel to alert that the tank is close to overflowing. An alarm condition is also displayed on the HMI and FLIP screens.

Tank TA 83110 discharge valve VA 83117 is a motorised valve with limit switches to indicate valve position on the HMI and FLIP displays. Refer to the dosing section for the description of control for this valve.

Tag Number	Set Point	Functionality
ZSH 83117	Fully open	Indication to notify the control system that valve VA 83117 is open. This forms part an interlock to enable the dosing system to operate.
ZSL 83117	Fully closed	Indication to notify the control system that valve VA 83117 is closed. This forms part of an interlock to enable the flushing and calibration modes to operate.
ZA 83117	Valve fault	If VA 83117 fails an alarm is registered. This forms part of a pre-requisite and interlock to enable operating modes to be selected.

2.3 Storage Tank No 2 - TA 83120

The storage tank incorporates the following instrumentation and automated valve.

The level/volume in this tank is measured by a pressure transmitter LT83123, calibrated to 0 – 100% with the following PLC set points. (0% is defined as the bottom of the tank, and 100% is defined as the invert level of the tank overflow)

Tag Number	Set Point	Functionality
LAH 83123	80%	LAH 83123 is a local visual alarm to notify the delivery tanker operator to stop filling. An alarm condition is also displayed on the HMI and FLIP screens.
LAL 83123	40%	LAL 83123 is a low-low level alarm displayed on the HMI and FLIP screens to indicate the need to order more chemical.
LALL 83123	7%	LALL 83123 is a low-low level alarm displayed on the HMI and FLIP screens. This alarm will inhibit the selection of dosing mode for FSA system 1 and will shutdown dosing if it is already occurring when the this alarm is generated to prevent the dosing pump from running dry.

A magnetic bar graph level indicator LI 83120 complete with a level switch LSHH 83120 is also installed on tank TA 83120 to provide visual indication of the tank level.

Tag Number	Set Point	Functionality
LI83120	Not applicable	LI83120 is a visual indication of tank level only.
LSHH 83120	85%	LAHH 83120 is a local visual and audible alarm on the load-in panel to alert that the tank is close to overflowing. An alarm condition is also displayed on the HMI and FLIP screens.

Tank TA 83120 discharge valve VA 83127 is a motorised valve with limit switches to indicate valve position on the HMI and FLIP displays. Refer to the dosing section for the description of control for this valve.

Tag Number	Set Point	Functionality
ZSH 83127	Fully open	Indication to notify the control system that valve VA 83127 is open. This forms part of an interlock to enable the dosing system to operate.
ZSL 83127	Fully closed	Indication to notify the control system that valve VA 83127 is closed. This forms part of an interlock to enable the flushing and calibration modes to operate.
ZA 83127	Valve fault	If VA 83127 fails and an alarm is registered. This forms part of a pre-requisite and interlock to enable operating modes to be selected.

2.4 FSA Sump

The FSA sump incorporates the following instrumentation and automated valve.

2.4.1 Conductivity Transmitter AE 83136

Conductivity transmitter AE 83136 registers the conductivity of the water maintained in the drainage sump in the bund. Conductivity is indicated locally (with a display mounted on the wall above the bund sump) and on the HMI and FLIP screens.

Tag Number	Set Point	Functionality
AI 83136		Conductivity (in $\mu\text{S}/\text{cm}$) displayed on HMI and FLIP screens
ASHH 83136	5000 $\mu\text{S}/\text{cm}$	AAHH 83136 will raise an HMI/FLIP alarm to indicate the presence of a high-high concentration of FSA in the sump
ASH 83136	2500 $\mu\text{S}/\text{cm}$	AAH 83136 will raise an HMI/FLIP alarm to indicate the presence of FSA in the sump. This condition alone will initiate an interlock to prevent valve VA 83137 from opening. This condition when registered in conjunction with LAH83135 will initiate an interlock to close the tank outlet isolation valves (VA83117 & VA83127)

2.4.2 Drain Valve VA 83137

The sump discharge valve VA 83137 is a motorised valve with limit switches to indicate valve position on the HMI and FLIP displays. The position of the valve is selected by the Operator from the FLIP screen only.

Tag Number	Set Point	Functionality
ZSH 83137	Fully open	Indication to notify the control system that valve VA 83137 is open.
ZSL 83137	Fully closed	Indication to notify the control system that valve VA 83137 is closed.
ZA 83137	Valve fault	No control action is taken if VA 83137 fails but an alarm is registered

Level switch LSH 83135 is installed in the sump to register an alarm high level condition.

Tag Number	Set Point	Functionality
LSH 83135	Not applicable	LAH 83135 is a high level alarm to indicate a high level in the sump. No control action is taken when this alarm occurs individually, but if ASH83136 is raised at the same time an interlock to close both the tank outlet isolation valves is initiated.

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

Tag Number	Set Point	Functionality
HS 83137B		Override selector on/off switch at OIP
HS 83137A		Switch to open or close valve manually at OIP.
ZSH 83137	Fully open	ZIH 83137 notifies the control system that valve VA 83137 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.
ZIM 83137		Indicates that the valve is in transition.
ZSL 83137	Fully closed	ZIL 83137 notifies the control system that valve VA 83137 is closed.
ZA 83137	Valve fault	If VA 83137 fails to reach an open or closed state within a set time, a fault alarm is registered, no control action.

2.5 Load in Panel

The load in panel displays the level of FSA in the storage tanks and provides relevant information regarding the chemical bund to the chemical delivery operator. Its main purpose is to inform the delivery vehicle operator of a potential overflow condition and opening status indication of the apron sump’s 3-way drainage valve. The following alarm lights and sirens are located on the panel. The alarm status of the parent instrument is also shown in the table below.

Parent Instrument	Instrument alarm status	Load in panel indication
LT 83113	LI 83113	Displays volume in tank TA 83110
	LAH 83113	‘FSA Tank 1 High Level’ light illuminated
LSHH 83110	LAHH 83110	‘FSA Tank 1 High-high Level’ light illuminated and siren sounds
LT 83123	LI 83123	Displays volume in tank TA 83120
	LAH 83123	‘FSA Tank 2 High Level’ light illuminated
LSHH 83120	LAHH 83120	‘FSA Tank 2 High-high Level’ light illuminated and siren sounds
ZSH 83138	ZIH 83138	“Open to Drainage” light illuminated
ZSL 83138	ZIL 83138	“Open to Waste Tank” light illuminated

The sirens can be silenced by a local hand switches (HS83113/HS83123), these hand switches do not interface with the control system, they only mute the audible alarms. The alarms will not reset until the alarm conditions are removed.

For maintenance purposes the operation of these sirens and alarms can be tested by a local hand switch (HS83150).

2.6 Load-in Apron Sump

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

2.6.1 Drain Valve VA 83138

Under normal conditions, the load-in apron sump drains to the soakwell (or site stormwater drainage) through a motorised 3-way valve (VA 83138), preventing rainwater accumulating on the load-in apron. When a delivery load-in transfer to the storage tanks is to take place, the apron sump will have to be isolated from the soakwell/site drainage and open to the waste holding tank in anticipation of any potential chemical spillage.

At sites where the security system is not linked to the load-in system, this change in the 3-way valve opening position is triggered automatically by de-activation of a switch (YS 83106) 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 site drainage”.

The apron sump 3-way valve VA 83138 has limit switches to indicate valve position on the HMI and OIP displays.

Tag Number	Set Point	Functionality
YS 83106		Switch activated by closing of the load-in door <ul style="list-style-type: none"> • VA 83138 opens to site drainage (close to waste holding tank). Switch de-activated by the opening of the load-in door. HMI indication YI 83106 on HMI & FLIP screens “Load-in door open” <ul style="list-style-type: none"> • VA 83138 opens to waste holding tank (and close to drainage).
HS 83138A		Override selector Auto/Manual switch at OIP
HS 83138B		Switch to open (to site drainage) or close (to waste holding tank) valve manually at OIP.
ZIH 83138	Fully open	ZIH 83138 notifies the control system that valve VA 83138 is open to drainage (closed to waste holding tank) including a light indication on the load-in panel.
ZIL 83138	Fully closed	ZIL 83138 notifies the control system that valve VA 83138 is open to waste holding tank (closed to drainage) including a light indication on the load-in panel.
ZA 83138	Valve fault	If VA 83138 fails an alarm is registered. <ul style="list-style-type: none"> • VA 83138 to be requested to open to waste holding tank (and closed to drainage) on valve fault.

2.6.2 Level Switch LSH 83138

Level switch LSH 83138 is installed in the apron sump to register a high level alarm condition. Tag Number Set Point Functionality

Tag Number	Set Point	Functionality
LSH 83138	75%	HMI alarm LAH 83138 displayed on the HMI & OIP screens “LAH 83138 Apron Sump level high” including a light indication on the load-in panel.

2.7 Waste Holding Tank

The waste holding tank is an <X> m³ tank which is used to store FSA waste, spillage and contaminated washdown generated in the FSA storage room or from the load-in apron until sufficient volume has been collected to order a tanker for waste pump-out and disposal off- site.

The waste holding tank incorporates the following instrumentation:

Tag Number	Set Point	Functionality
LSH 83144	Not applicable	LAH 83144 is a high level alarm to indicate a high level in the waste holding tank. No control action is associated with this alarm.

3 FSA DOSING SYSTEM

3.1 FSA Dosing System Equipment

Each FSA dosing system consists of a dosing pump, a flow transmitter and five motorised valves. Apart from the tank isolation valves already covered in section 2.2 & 2.3, information on these items is given below.

3.1.1 FSA System 1

Flow transmitter FE 83218 is a magnetic flowmeter used in the process flow control loop FC 83231 for the addition of FSA.

Tag Number	Set Point	Functionality
FI 83218		FSA flow (in L/h) displayed locally on dosing panel and on HMI and FLIP screens.
FQI 83218A		Totalised FSA flow (in L) displayed on HMI and FLIP screens
FQI 83218B		FSA Daily flow (in L) displayed on HMI screen
FC 83231	Calculated set point	Flow control set point (L/h) for the flow control loop interfacing with the speed of the dosing pump
YA 83218	Set pt x0.9> FI >set pt x 1.1	YA83218 is a deviation alarm which is initiated when the FSA flow deviates from the calculated set point by more than 10% for longer than 1 minute. This is alarm is displayed on the HMI screen but has no control functionality.

Dosing pump PU 83213 is a diaphragm metering pump with manual stroke length adjustment and variable speed control. The speed of the pump is dictated by flow control loop FC 83231 for the addition of FSA. Minimum pump speed limit will be set in the control to prevent damage to the pump motor and prevent infrequent “slugs” of FSA dosage.

Although most installations will have only manual stroke length adjustment, automatic stroke length adjustment (“wedge” control) can be incorporated together with variable speed control for sites with wide range of plant flows. For automatic wedge control, once the maximum or minimum pump speed limit associated with a particular stroke length is reached, the next adjacent wedge position will automatically be set to give the next stroke length thereby allowing the pump to operate within the optimum pump speed range. The step changes shall be gradual to prevent drastic changes to the dosage. A HMI screen display example of automatic pump wedge control is shown in Appendix C.

Tag Number	Functionality
IY 83213	Pump motor run activated
YS 83213A	Diaphragm leak detection activated. Pump Diaphragm leak alarm YA83213A raised on HMI/FLIP. Pump shuts down, FSA 1 Dosing mode stops and changeover to standby system initiated.
YS 83213B	Motor running indication on the HMI and FLIP screens.
YS 83213C	Motor fault (YA83213B). Pump shuts down and changeover to standby system initiated.
SI 83213	Pump speed indication on the HMI and FLIP screens.

KQT 83213	Number of hours running will be totalised and displayed on the HMI and FLIP screens
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Valve VA 83118 is a three way motorised valve to allow either FSA or flushing (service) water to be directed to the dosing pump. When the Group Controller is in the AUTO mode, service water can be directed into the dosing pump suction line if the ‘FSA 1 Flushing Mode’ or ‘FSA 1 Calibration Mode’ operational state is initiated by the Operator from the commands in the sequence controls pop up box on the FLIP screen.

Tag Number	Set Point	Functionality
ZSH 83118	Fully open	Indication to notify the control system that valve VA 83118 is open to acid.
ZSL 83118	Fully closed	Indication to notify the control system that valve VA 83118 is closed (open to water).
ZA 83118	Valve fault	If VA 83118 fails it can cause shutdown of the FSA 1 dosing system.

Valve VA 83132 is a two way motorised isolation valve to allow flushing (service) water to enter the flushing circuit via the three way valve VA83118. When the Group Controller is in the AUTO mode, flushing water can only be activated when the ‘FSA 1 Flushing’ operational state is initiated by the Operator from the commands in the sequence controls pop up box on the FLIP screen.

Tag Number	Set Point	Functionality
ZSH 83132	Fully open	Indication to notify the control system that valve VA 83132 is open.
ZSL 83132	Fully closed	Indication to notify the control system that valve VA 83132 is closed.
ZA 83132	Valve fault	If VA 83132 fails it can cause a shutdown of the dosing system.

Valve VA 83224 is a three way motorised valve to discharge FSA into the process stream or to drain. The majority of the time this valve will be open to dose. However, when the Group Controller is in the AUTO mode, FSA can be directed to drain if the ‘FSA 1 Flushing Mode’ is initiated by the Operator from the commands in the controls pop up box on the FLIP screen and the operator manually selects the dose/drain valve to drain.

Tag Number	Set Point	Functionality
ZSH 83224	Fully open	Indication to notify the control system that valve VA 83224 is open to dose.
ZSL 83224	Fully closed	Indication to notify the control system that valve VA 83224 is closed (open to drain).
ZA 83224	Valve fault	If VA 83224 fails it can cause shutdown of the dosing system and changeover to the standby system.

Valve VA 83202 is a two way motorised valve to allow dilution water to enter the dosing panel. When the Group Controller is in the AUTO mode, valve VA 83202 will open if any of the operational states, except Manual, are initiated by the Operator from the commands in the sequence controls pop up box on the FLIP screen.

Tag Number	Set Point	Functionality
ZSH 83202	Fully open	Indication to notify the control system that valve VA 83202 is open.

ZSL 83202	Fully closed	Indication to notify the control system that valve VA 83202 is closed.
ZA 83202	Valve fault	If VA 83202 fails it can cause shutdown of the dosing system.

Note: For systems using chlorine solution as the FSA dilution water at least one dilution water valve (VA83202 for system 1 or VA83302 for system 2) must be open at all times. This is so chlorine dosing can continue even if FSA dosing is not required or halted.

For systems using service water or dedicated dilution pumps this additional control is not necessary.

For systems using service water or dilution pumps as the dilution water supply a variable area flow indicator with a flow switch FSL83205 is provided on the dosing panel to indicate when dilution water is not flowing.

Tag Number	Set Point	Functionality
FSL83205	Flow <15 x maximum pump flow (L/h)	Flow alarm low FAL 83205 is raised on HMI/FLIP indicating that dilution water is not flowing. If this alarm is active for 2 minutes when FSA 1 pump is running then it will shutdown dosing and initiate changeover to standby system.

Note: For systems using chlorine solution as the FSA dilution water, this FSL is not required as the flow switches on the solution water lines which form part of the standard chlorine design can be used for this purpose.

3.1.2 FSA System 2

Flow transmitter FE 83318 is a magnetic flow meter used in the process flow control loop FC 83331 for the addition of FSA.

Tag Number	Set Point	Functionality
FI 83318		FSA flow (in L/h) displayed locally on dosing panel and on HMI and FLIP screens.
FQI 83318A		Totalised FSA flow (in L) displayed on HMI and FLIP screens
FQI 83318B		FSA Daily flow (in L) displayed on HMI screen
FC 83331	Calculated set point	Flow control set point (L/h) for the flow control loop interfacing with the speed of the dosing pump
YA 83318	Set pt x0.9> FI >set pt x 1.1	YA83318 is a deviation alarm which is initiated when the FSA flow deviates from the calculated set point by more than 10% for longer than 1 minute. This is displayed on the HMI screen but has no control functionality.

Dosing pump PU 83313 is a diaphragm metering pump with manual stroke length adjustment and variable speed control. The speed of the pump is dictated by flow control loop FC 83331 for the addition of FSA. Minimum pump speed limit will be set in the control to prevent damage to the pump motor and prevent infrequent “slugs” of FSA dosage.

Although most installations will have only manual stroke length adjustment, automatic stroke length adjustment (“wedge” control) can be incorporated together with variable speed control for sites with wide range of plant flows. For automatic wedge control, once the maximum or minimum pump speed

limit associated with a particular stroke length is reached, the next adjacent wedge position will automatically be set to give the next stroke length thereby allowing the pump to operate within the optimum pump speed range. The step changes shall be gradual to prevent drastic changes to the dosage. A HMI screen display example of automatic pump wedge control is shown in Appendix C.

Tag Number	Functionality
IY 83313	Pump motor run activated
YS 83313A	Diaphragm leak detection activated. Pump Diaphragm leak alarm YA83313A raised on HMI/FLIP. Pump shuts down, FSA 1 Dosing mode stops and changeover to standby system initiated.
YS 83313B	Motor running indication on the HMI and FLIP screens.
YS 83313C	Motor fault (YA83313B). Pump shuts down and changeover to standby system.
SI 83313	Pump speed indication on the HMI and FLIP screens.
KQT 83313	Number of hours running will be totalised and displayed on the HMI and FLIP screens

Valve VA 83128 is a three way motorised valve to allow either FSA or flushing (service) water to be directed to the dosing pump. When the Group Controller is in the AUTO mode, service water can only be directed into the dosing pump suction line if the ‘FSA 2 Flushing Mode’ operational state initiated by the Operator from the commands in the sequence controls pop up box on the FLIP screen.

Tag Number	Set Point	Functionality
ZSH 83128	Fully open	Indication to notify the control system that valve VA 83128 is open to acid.
ZSL 83128	Fully closed	Indication to notify the control system that valve VA 83128 is closed (open to water).
ZA 83128	Valve fault	If VA 83128 fails it can cause shutdown of the FSA 2 dosing system.

Valve VA 83134 is a two way motorised isolation valve to allow flushing (service) water to enter the flushing circuit via the three way valve VA83128. When the Group Controller is in the AUTO mode, flushing water can only be activated when the ‘FSA 2 Flushing’ operational state is initiated by the Operator from the commands in the sequence controls pop up box on the FLIP screen.

Tag Number	Set Point	Functionality
ZSH 83134	Fully open	Indication to notify the control system that valve VA 83134 is open.
ZSL 83134	Fully closed	Indication to notify the control system that valve VA 83134 is closed.
ZA 83134	Valve fault	If VA 83134 fails it can cause a shutdown of the dosing system.

Valve VA 83324 is a three way motorised valve to discharge FSA into the process stream or to drain. The majority of the time this valve will be open to dose. However, when the Group Controller is in the AUTO mode, FSA can only be directed to drain if the ‘FSA 2 Flushing Mode’ is initiated by the Operator from the commands in the controls pop up box on the FLIP screen and the operator manually selects the dose/drain valve to drain.

Tag Number	Set Point	Functionality
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ZSH 83324	Fully open	Indication to notify the control system that valve VA 83324 is open to dose.
ZSL 83324	Fully closed	Indication to notify the control system that valve VA 83324 is closed (open to drain).
ZA 83324	Valve fault	If VA 83324 fails it can cause shutdown of the dosing system and changeover to the standby system.

Valve VA 83302 is a two way motorised valve to allow dilution water to enter the dosing panel. When the Group Controller is in the AUTO mode, valve VA 83302 will open if any of the operational states, except Manual, are initiated by the Operator from the commands in the sequence controls pop up box on the FLIP screen.

Tag Number	Set Point	Functionality
ZSH 83302	Fully open	Indication to notify the control system that valve VA 83302 is open.
ZSL 83302	Fully closed	Indication to notify the control system that valve VA 83302 is closed.
ZA 83302	Valve fault	If VA 83302 fails it can cause shutdown of the dosing system and changeover to the standby system.

Note: For systems using chlorine solution as the FSA dilution water at least one dilution water valve (VA83202 for system 1 or VA83302 for system 2) must be open at all times. This is so chlorine dosing can continue even if FSA dosing is not required or halted.

For systems using service water or dedicated dilution pumps this additional interlock is not necessary.

For systems using service water or dilution pumps as the dilution water supply a variable area flow indicator with a flow switch FSL83305 is provided on the dosing panel to indicate when dilution water is not flowing.

Tag Number	Set Point	Functionality
FSL83305	Flow <15 x maximum pump flow (L/h)	Flow alarm low FAL 83305 is raised on HMI/FLIP indicating that dilution water is not flowing. If this alarm is active for 2 minutes when FSA 2 pump is running then it will shutdown dosing and initiate changeover to standby system.

Note: For systems using chlorine solution as the FSA dilution water this FSL is not required as the flow switches on the solution water lines which form part of the standard chlorine design can be used for this purpose.

4 FSA SAMPLING, ANALYSING & MISCELLANEOUS SYSTEMS

4.1 FSA Sampling & Analysing System Equipment

Each FSA facility will have a sampling and analysing system which consists of at least a fluoride concentration analyser and a flow switch. Information on these items is given below.

Flow switch FSL 83410 is an inline flow switch used to raise alarm when the flow to the fluoride analyser is interrupted.

Tag Number	Set Point	Functionality
FSL83410	<Minimum fluoride analyser requirements> ~ 1 (L/h)	Flow alarm low FAL 83410 is raised on HMI indicating that sampling water is not flowing. If this alarm is active for 15 minutes when either dosing system is running then it will shutdown dosing.

Fluoride analyser AE83411 will continuously monitor the fluoride ion concentration in the recipient water main (downstream of the dose point).

Tag Number	Set Point	Functionality
AI 83411		Fluoride concentration in recipient water main (in mg/L) displayed on HMI and FLIP screens.
AAHH 83411	1.0 mg/L	High-high alarm displayed on HMI and FLIP screens to register unacceptable fluoride in drinking water. This high-high level has to be registered continuously for a period of 30 seconds before an alarm condition is initiated. This alarm will shutdown the duty dosing system in operation and initiates the standby system.
AAH 83411	0.9 mg/L	High alarm on HMI and FLIP screens to register unacceptable fluoride in drinking water. This high level has to be registered continuously for a period of 30 seconds before an alarm condition is initiated. There is no control action associated with this alarm condition.
AAL 83411	0.7 mg/L	Low alarm on HMI and FLIP screens to register unacceptable fluoride in drinking water. This low level has to be registered continuously for a period of 30 seconds before an alarm condition is initiated. There is no control action associated with this alarm condition.
AALL 83411	0.5 mg/L	Low-low alarm on HMI and FLIP screens to register unacceptable fluoride in drinking water. This low level has to be registered continuously for a period of 30 seconds before an alarm condition is initiated. This alarm condition will terminate operation of the duty FSA dosing system and initiate operation of the standby system.

4.2 Miscellaneous Equipment – Safety Showers, Hose Reels & Exhaust Systems

Each FSA facility will have at least 3 safety showers and 2 hose reels. Each safety shower shall be fitted with a flow switch to indicate operation.

Tag Number	Set Point	Functionality
FSH83401	1 (L/h)	Flow alarm high FAH 83401 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.
FSH83402	1 (L/h)	Flow alarm high FAH 83402 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.
FSH83403	1 (L/h)	Flow alarm high FAH 83403 is raised on HMI indicating that the safety shower at the load in apron area 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.

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

The exhaust fans in the FSA storage room will be activated by a hand switch located outside the storage room. There is no control associated with these units.

5 CONTROL LOOPS AND CALCULATIONS

Control loop FC 83231 associated with the FSA dosing system 1 and FC loop FC 83331 associated with FSA dosing system 2 are responsible for the introduction of a controlled addition of fluoride ion into the treated water. The control loop is flow paced from flow transmitter FIT XXXXX located in the Clearwater recipient pipeline.

The required flow rate (in L/h) from the dosing pumps is given by the following formula,

$$\frac{(\text{Flow rate registered by FIT XXXXX in m}^3/\text{h}) \times (\text{Set point fluoride conc in mg/L} - \text{Background fluoride conc in mg/L})}{7.91 \times \text{FSA Delivered conc in \%} \times \text{FSA specific gravity}}$$

For example,
 If:

FITXXXXX = 5000 m³/h
 SP F⁻ conc = 0.85mg/L
 Background F⁻ = 0.2mg/L
 FSA delivered concentration = 22%
 FSA SG (@ 22%) = 1.21

Then: FSA required flow rate = 15.4L/h

The factor of 7.91 relates to the active fluoride ion concentration in FSA. The specific gravity of the delivered FSA is automatically determined from the look-up table below once the operator has entered the delivered FSA concentration:

FSA Delivered Concentration (w/w)	FSA Specific Gravity ²
20 %	1.19
21 %	1.20
22 %	1.21
23%	1.22
24%	1.23

For system 1, the flow control loop FC 83231 is a direct acting PID loop that maintains the set point flow through flow transmitter FIT 83218 on the discharge of the dosing pumps. It incorporates a threshold value of X m³/h whereby the control loop does not exert any control action until the flow registered by FIT XXXXX exceeds X m³/h.

Similarly for system 2, the flow control loop FC 83331 is a direct acting PID loop that maintains the set point flow through flow transmitter FIT 83318 on the discharge of the dosing pumps. It incorporates a threshold value of X m³/h whereby the control loop does not exert any control action until the flow registered by FIT XXXXX exceeds X m³/h.

The target set point fluoride concentration, background fluoride concentration and delivered acid concentration can be changed on the HMI and FLIP screens by personnel with designated supervisor log-on privileges. These set point and other values that are monitored are given below.

² FSA Specific Gravity is based on samples tested by Wesfarmers CSBP in the last 5 years.

Tag Number	Set Point	Functionality
HC 83231A	0.2mg/L*	Raw water background fluoride ion concentration (mg/L)
HC 83231B	22%*	Delivered Acid Concentration (%)
HC 83231C	0.85 mg/L*	Treated water target fluoride concentration for flow control loop FC 83231
FI 83231A		Calculated actual fluoride dose rate (mg/L) dispatched into treated water, displayed on HMI and FLIP screens
FI 83231B		PID Controller fluoride dose rate set point (mg/L)
FAHH 83231	1.0 mg/L	High-high alarm to register unacceptable fluoride concentration dispatched into the drinking water distribution system. The high-high level has to be registered continuously for a period of 5 minutes before an alarm condition is initiated. This alarm condition will shutdown the duty dosing system in operation and initiates the standby system.
FAH 83231	0.9 mg/L	High alarm to register fluoride concentration above required set point dispatched into the drinking water. The high level has to be registered continuously for a period of 5 minutes before an alarm condition is initiated. There is no control action associated with this alarm condition.
FAL 83231	0.7 mg/L	Low alarm to register unacceptable fluoride concentration dispatched into the drinking water distribution system. The low level has to be registered continuously for a period of 5 minutes before an alarm condition is initiated. There is no control action associated with this alarm condition
FALL 83231	0.5 mg/L, inhibited if Clearwater flow FIT XXXXX is less than X m ³ /h (initiating set point)	Low-low alarm to register unacceptable dosing rate and thereby potential problems with the duty dosing pump. The low-low level has to be registered continuously for a period of 5 minutes before an alarm condition is initiated. This alarm condition will shutdown the duty dosing system in operation and initiates the standby system.

* denotes setpoint values that can be changed by authorized personnel according to site conditions.

The calculated actual fluoride dose rate FI 83231A is given by the following formula,

$$\frac{\text{Flow rate registered by FIT 83218 (L/h)} \times 7.91 \times \text{FSA Delivered conc in \%} \times \text{FSA specific gravity}}{\text{Flow rate registered by FIT XXXXX (m}^3\text{/h)}}$$

This value, after adding the raw water background fluoride ion concentration HC 83231A, is used to initiate alarms FAHH 83231, FAH 83231, FAL 83231 and FALL 83231 when the concentration strays outside of acceptable limits. The high-high and low-low alarms are also used to shut down the FSA dosing system completely and initiate changeover to the standby system.

The tag numbers, calculations and set points provided here are for FSA 1 dosing system. The tag numbers, calculations and set points for FSA 2 dosing system are similar.

6 PRE-REQUISITES, TRIGGERS & INTERLOCKS FOR START UP AND FOR SHUTDOWN

6.1 Storage Tank Refilling

There are no pre-requisites or interlocks associated with the tank refilling operation.

The delivery driver is expected to check that he/she is able to deliver the full 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.

The operator observing the delivery is expected to close the manual load-in apron sump isolation valve VA83138 prior to unloading.

However, these steps are covered by the delivery work instructions and procedures, there are no pre-requisites, interlocks or controls associated with these functions.

6.2 Bund Sump Discharge

The operation of the bund sump discharge valve VA 83137 is initiated from the FLIP screen.

Interlocks will apply to the valve position if a high conductivity is registered by AIT 83136. When a high conductivity is registered the following actions will take place,

- 1 Valve VA 83137 will automatically close if AIT 83136 registers a high conductivity, assuming that the valve is not closed at the time of the alarm
- 2 Valve VA 83137 will be prevented from opening if AIT 83136 registers a high conductivity

The operator can override these interlocks by selecting the 'sump drain override on' from the FLIP. 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.

6.3 FSA Dosing System Operational States

The following definitions have been applied,

Pre-requisite Requirements for a sequence to commence

Interlocks Conditions 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 'FSA Stopped' state

In the following sub-sections, references are made to FSA system 1 for convenience. FSA system 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 'FSA 1 Stopped' state to the 'FSA 1 Dosing' state:

Pre- requisites to transition system to ‘FSA 1 Dosing’ state
FSA Tank 1 Storage is not low-low (LALL 83113 is not active)
AND FSA 1 Dosing System is in the ‘FSA Stopped State’, so no other mode is selected (Dosing Mode, Flushing Mode, Calibration Mode is not active)
AND Group Controller FSA 1_GC is selected to the AUTO position on the HMI/FLIP display
AND Group Controller FSA 1_GC devices are ‘Available’ as defined in Section 1.2.

The following trigger will initiate the transition of the system from the ‘FSA 1 Stopped’ state to the ‘FSA 1 Dosing’ state:

Trigger to transition system from ‘FSA 1 Stopped’ state to ‘FSA 1 Dosing’ state
‘FSA 1 Dosing Start’ command activated from HMI/FLIP pop-up menu

The following triggers will transition the system from the ‘FSA 1 Dosing’ operational state to the ‘FSA 1 Stopped’ state:

Triggers to transition from ‘FSA 1 Dosing’ state to ‘FSA 1 Stopped’ state
FSA Tank Isolation Valve VA 83117 open and FSA Storage Tank 1 level LALL 83113 active
OR Group Controller FSA 1_GC devices are ‘Not Available’ as defined in Section 1.2.
OR ‘FSA 1 Dosing Stop’ command activated from HMI/FLIP pop-up menu
OR Sequence timer expired during ‘FSA 1 Dosing’ sequence

When in the ‘FSA 1 Dosing’ state, the following trigger will initiate the start-up sequence, ‘FSA 1 Pump Run’, for the FSA 1 Dosing Pump:

Triggers to initiate ‘FSA 1 Pump Run’ sequence
Clearwater Flow meter FITXXXXX > Xm3/h for 30 seconds

The pre-requisite for this transition is:

Pre- requisites to transition system from ‘FSA 1 Dosing’ state with pump idle to ‘FSA 1 Dosing’ state with pump running
FSA 1 Dosing System is in the ‘FSA 1 Dosing’ state, so no other mode is selected (Flushing Mode, Calibration Mode is not active)

When in the ‘FSA 1 Pump Run’ state, the following trigger will initiate the pump stop sequence, ‘FSA 1 Pump Stop’ (the system will remain in the ‘FSA 1 Dosing’ mode):

Triggers to initiate ‘FSA 1 Pump Stop’ sequence (Halt)
Clear water FITXXXXX < Xm3/h for 30 seconds
OR FSA 1 Pump Speed < Min. Pump Speed HC 83213C

During the FSA 1 Dosing Pump start up sequence any of the following interlocks will abort the ‘FSA 1 Pump Run’ starting sequence and return the system to the ‘FSA 1 Stopped’ state:

FSA 1 Pump Run Start Up Sequence Abort Interlocks
FSA Tank Isolation Valve VA 83117 open and FSA Storage Tank 1 level LALL 83113 active
OR Dilution Water Low Flow switch FSL 83205 active <for systems using service water for dilution supply>
OR Chlorine Dilution Water Low Flow switch FSL81XXX or FSL81XXX active <for systems using chlorine solution water as dilution supply>
OR Group Controller FSA 1_ GC devices are ‘Not Available’ as defined in Section 1.2.
OR Sequence timer expired

If the FSA 1 Dosing Pump is running, the following triggers will initiate a shutdown of the FSA 1 Dosing Pump and will transition the system directly to the ‘FSA 1 Stopped’ state using the ‘FSA 1 Auto Shutdown’ sequence:

Triggers to transition from Pump Running to ‘FSA 1 Stopped’ state (Fault)
FSA Tank Isolation Valve VA 83117 open and FSA Storage Tank 1 level LALL 83113 active
OR Group Controller FSA 1_ GC devices are ‘Not Available’ as defined in Section 1.2.
OR Dilution Water Low Flow switch FSL 83205 active <for service water dilution systems>
OR Chlorine Dilution Water Low Flow switch FSL81XXX or FSL81XXX active <for chlorine solution dilution systems>
OR FSA 1 pump diaphragm leak detection active (YA83213A)
OR FSA 1 pump motor protection fault active (YA83213B)
OR Recipient water fluoride low-low alarm (AALL 83411) active
OR Recipient water fluoride high-high alarm (AAHH83411) active
OR Calculated actual fluoride low-low alarm (FALL83231) active
OR Calculated actual fluoride high-high alarm (FAHH83231) active
OR Operator changes Sequence Controls command to ‘FSA 1 Dosing Stop’

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

Triggers for changeover to Standby system operation
FSA Tank Isolation Valve VA 83117 open and FSA Storage Tank 1 level LALL 83113 active
OR Group Controller FSA 1_ GC devices are ‘Not Available’ as defined in Section 1.2.
OR Dilution Water Low Flow switch FSL 83205 active <for service water dilution systems>
OR Chlorine Dilution Water Low Flow switch FSL81XXX or FSL81XXX active <for chlorine solution dilution systems>
OR FSA 1 pump diaphragm leak detection active (YA83213A)
OR FSA 1 pump motor protection fault active (YA83213B)

OR Recipient water fluoride low-low alarm (AALL 83411) active
OR Recipient water fluoride high-high alarm (AAHH83411) active
OR Calculated actual fluoride low-low alarm (FALL83231) active
OR Calculated actual fluoride high-high alarm (FAHH83231) active
OR When FSA 1 Dosing system is transitioned to the 'FSA 1 Stopped' state by the control system executing the 'FSA 1 Auto shutdown' sequence (not operator selected).

The prerequisite for this transition to occur is that the FSA 2 dosing system must already have been placed in the mode 'FSA 2 Dosing' by the Operator and selected as the standby system (not selected as the duty system).

Pre- requisites to Transition from 'FSA 1 Dosing' state to 'FSA 2 Dosing' state
FSA 2 Dosing System is in the 'FSA 2 Dosing' state, so no other mode is selected (Flushing Mode, Calibration Mode, Manual Mode is not active)

When a dosing system is selected to be in dosing mode, 'FSA <dosing system number> Dosing', but not selected as the duty system then the tank outlet isolation valve (VA83117 or VA83127) and the dilution water valve (VA83202 or VA83302) will remain closed. It will not open until the standby system is requested to operate by one of the changeover triggers.

6.4 FSA Flushing Operational State

The following pre-requisites are required for the start-up of the 'FSA 1 Flushing' sequence:

Pre- requisites to transition system to 'FSA 1 Flushing' state
Group Controller FSA 1_GC is selected to the AUTO position on the HMI/FLIP display
AND FSA 1 Dosing System is in the 'FSA Stopped' operational state, so no other mode is selected (Dosing Mode, Flushing Mode and Calibration Mode is not active)
AND Acid/Water Selector Valve VA 83118 is 'Available'
AND Flushing (Service Water) Isolation Valve VA 83132 is 'Available'
AND Dilution Water Isolation Valve VA 83202 is 'Available'
AND Dose/Drain Selector Valve VA 83224 is 'Available'
AND FSA 1 Dosing Pump PU83213 is 'Available'

The Tank Outlet Valve VA83118 does not need to be available as this is already closed in the 'FSA Stopped' State and is not required to open as part of the flushing sequence.

The trigger to transition the system to the flushing state is:

Triggers to initiate 'FSA 1 Flushing Start' Sequence
'FSA 1 Flushing Start' command activated on the FLIP Pop up menu

The following interlocks will abort the ‘FSA 1 Flushing’ sequence and return the system to the ‘FSA Stopped’ state:

Interlocks to abort ‘FSA 1 Flushing’
Acid/Water Selector Valve VA 83118 ‘Not Available’
OR Flushing (Service Water) Valve VA 83132 ‘Not Available’
OR Dose/Drain Selector Valve VA 83224 ‘Not Available’
OR FSA 1 Dosing Pump PU83213 is ‘ Not Available’
OR Recipient water fluoride high-high alarm (AAHH83411) active
OR Operator changes Sequence Controls command to ‘FSA 1 Flushing Stop’
OR Sequence timer expired

6.5 FSA Calibration Operational State

The following pre-requisites are required for the start-up of the ‘FSA 1 Calibration’ sequence:

Pre-requisites to transition system to ‘FSA 1 Calibration’ state
Group Controller FSA 1_GC is selected to the AUTO position on the HMI/FLIP display
AND FSA 1 Dosing System is in the ‘FSA Stopped’ operational state, so no other mode is selected (Dosing Mode, Flushing Mode and Calibration Mode is not active)
AND Acid/Water Selector Valve VA 83118 is ‘Available’
AND Dilution Water Valve VA 83202 is ‘Available’
AND Dose/Drain Selector Valve VA 83224 is ‘Available’
AND FSA 1 Dosing Pump PU83213 is ‘Available’

The trigger to transition the system to the calibration state is:

Triggers to initiate ‘FSA 1 Calibration Start’ Sequence
‘FSA 1 Calibration Start’ command activated on the FLIP Pop up menu

The following interlocks will abort the ‘FSA 1 Calibration’ sequence and return the system to the ‘FSA Stopped’ state:

Interlocks to abort ‘FSA 1 Calibration’
Acid/Water Selector Valve VA 83118 ‘Not Available’
OR Dose/Drain Selector Valve VA 83224 ‘Not Available’
OR FSA 1 Dosing Pump PU83213 is ‘ Not Available’
OR Operator changes Sequence Controls command to ‘FSA 1 Calibration Stop’
OR Sequence timer expired

6.6 Pre-requisites and Interlocks Associated with Manual Operation

The only pre-requisite associated with operation of the FSA dosing system when Group Controller FSA GC is in MANUAL is that the dosing pumps will not be allowed to commence operation if a pump diaphragm leak detection alarm is active or if there is a pump motor fault.

An interlock will terminate pump operation if a pump diaphragm leak detection alarm is registered when the pump is in operation.

Also, in manual mode an interlock will prevent the dose/drain valve, VA83224 or VA83324, being selected to drain (closed) if the acid/water selector valve, VA83118 or VA83128, is open to acid (open).

7 SEQUENCES

7.1 Dosing System Selection

The two dosing systems installed operate in a duty/standby arrangement. The control system incorporates a toggle button on the HMI/FLIP display to enable the Operator to manually select the duty dosing system. When a changeover is initiated, the complete dosing system (tank, valves, panel, pump and flowmeter) will changeover, not just parts of the system. For example, there is no flexibility in this arrangement to have the tank from system 1 supply the dosing panel from system 2.

If the selected duty system is 'Not Available' or failed then the standby system will automatically commence operation, providing it is in the 'Dosing mode' 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).

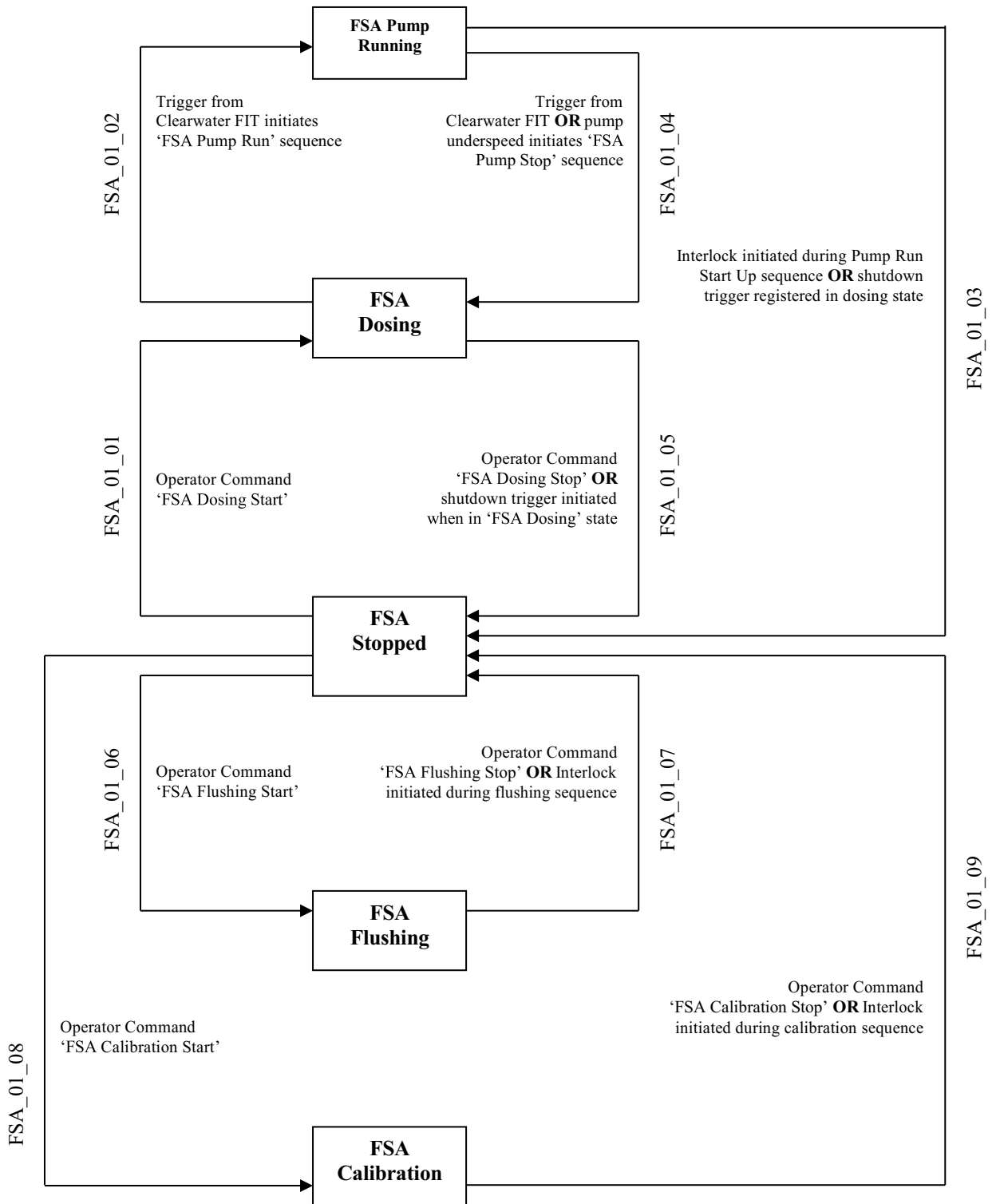
In the following sub-sections, references are made to FSA system 1 for convenience. FSA system 2 has similar sequences with its associated sequence, equipment and instrumentation tag numbers.

7.2 FSA Dosing Plant States

The following sequences are associated with the FSA 1 dosing system:

FSA Sequence No.	Description
FSA_01_01	'FSA 1 Dosing Start' Sequence
FSA_01_02	'FSA 1 Pump Run' Sequence
FSA_01_03	'FSA 1 Dosing Auto Shutdown' Sequence
FSA_01_04	'FSA 1 Pump Stop' Sequence
FSA_01_05	'FSA 1 Dosing Stop' Sequence
FSA_01_06	'FSA 1 Flushing Start' Sequence
FSA_01_07	'FSA 1 Flushing Stop' Sequence
FSA_01_08	'FSA 1 Calibration Start' Sequence
FSA_01_09	'FSA 1 Calibration Stop' Sequence

The transition and sequence between the operating states is shown schematically in the diagram below.



The following valve and equipment states are associated with each sequence.

Device	Tank Outlet Valve	Acid/Water Valve	Flushing Water Valve	Dilution Water Valve	Dose/Drain Valve	Duty Pump	Control Loop
State	VA83117 or VA83127	VA83118 or VA83128	VA83132 or VA83134	VA83202 or VA83302	VA83224 or VA83324	PU83213 or PU83313	FC83231 or FC83331
Out of Service	One or more devices OOS Tagged						x
All Stopped	Closed	x	Closed	Closed	x	Off	Off
Dosing Start	Open	Open	Closed	Open	Open	Running	Auto
Flushing Start	Closed	Closed	Open	Open	Open (initially)	Running	Auto
Calibration Start	Closed	Closed	Closed	Open	Open	Manual	Manual
Manual Start	x	x*	x	x	x*	Manual	Manual

The symbol (x) refers to the device being in any state (holding their last position). * Interlock in manual mode prevents the dose/drain valve from selecting to drain (closed) if the acid/water valve is selected to acid (open).

7.3 FSA Dosing Sequences

When the Operator selects the ‘FSA 1 Dosing Start’ command on the Sequence Control pop up, the following sequence is executed,

‘FSA 1 Dosing’ Sequence (FSA_01_01)

Step Description	Step Action	Step Number	Transition Condition	Minimum Step Time (sec)
‘FSA 1 Dosing’ system permissive check listed in Section 6.3	Wait	10	‘FSA 1 Dosing’ system start permissive healthy	
Initiate ‘Sequence Delay Timer’	Set ‘Sequence Delay Timer’ and run timer	20	Timer = 40	40
Open Tank 1 Isolation Valve VA 83117	Wait	30	Valve VA83117 limit switch registers valve in correct position	5
Open valve VA 83118 to port FSA from tanks to dosing pumps	Wait	40	Valve VA 83118 limit switch registers valve in correct position	5
Open valve VA 83224 to port FSA from dosing pumps to dilution line	Wait	50	Valve VA 83224 limit switch registers valve in correct position	5
Close Flushing (service water) isolation valve VA 83132	Wait	60	Valve VA 83132 limit switch registers a closed condition	5
Open Dilution water valve VA83202	Wait	70	Valve VA 83202 limit switch registers valve in correct position	5

Set Dosing Controller FC 83231 to Auto	Loopmode =Auto, SP = 0	80	Loopmode =Auto	
Cancel 'Sequence Delay Timer'	Clear Timer	90	Clear 'Sequence Delay Timer'	
Change Operational state to 'FSA 1 Dosing'		100	Operational state = 'FSA 1 Dosing'	

When the duty FSA 1 dosing system is in the 'FSA 1 dosing' state, the following flow trigger will initiate execution of the 'FSA 1 Pump Run' control sequence.

Triggers for FSA Dosing Pump Start Up
FITXXXX registers a recipient water flow > Xm3/h for 30 seconds.

This trigger is indicative of the plant flow being above a minimum flow to require FSA dosing.

The start-up sequence steps are shown below. The interlocks associated with the execution of this sequence were discussed in section 6.3

'FSA 1 Pump Run' Sequence (FSA_01_02)

Step Description	Step Action	Step Number	Transition Condition	Min. Step Time (sec)
'FSA 1 Pump Run' permissive check listed in Section 6.3	Wait	10	'FSA 1 Pump Run' start permissive healthy	
Initiate 'Sequence Delay Timer'	Set 'Sequence Delay Timer' and run timer	20	Timer = 60	60
Start operation of FSA 1 Dosing Pump PU83213		30	FSA 1 Dosing pump = 'running'	
FC 83231 set point calculated	Loopmode =Auto, SP calculated	40	Loopmode =Auto	
Cancel 'Sequence Delay Timer'	Clear timer	50	Clear 'Sequence Delay Timer'	
Indicate 'FSA 1 Dosing Pump Running'	Wait	60	Operational state = 'FSA 1 Dosing' Indication = 'FSA 1 Dosing Pump Running'	

When this sequence is complete the FSA dosing system will still be in the 'FSA 1 Dosing' operational state, but now with the dosing pump running as indicated on the HMI screen. The dosing controller FC 83231 will respond to changes in flow rate registered by Clearwater flow meter FIT XXXXX and adjust the pump speed accordingly.

The 'FSA 1 Pump Run' start up sequence will abort to the 'FSA 1 Stopped' state, by executing the 'FSA 1 Auto Shutdown' sequence, if any of the interlocks listed in Section 6.3 are registered.

Similarly, if the dosing pump is running and any of the shutdown triggers listed in Section 6.3 occur the system will transition to the 'FSA 1 Stopped' state by executing the 'FSA 1 Auto Shutdown' sequence. These sequence steps are shown below.

‘FSA 1 Auto Shutdown’ Sequence (FSA_01_03)

Step Description	Step Action	Step Number	Transition Condition	Min. Step Time (sec)
Stop operation of FSA 1 dosing pump PU83231		10	FSA 1 Dosing pump = ‘not running’	
FC 83231 to Off	CV = 0	20	Loopmode = Off, CV = 0	
Close FSA Tank 1 Isolation Valve VA83117	Wait	30	Valve VA83117 limit switch registers valve in correct position	5
Close Dilution Water Isolation valve VA83202	Wait	40	Valve VA83202 limit switch registers valve in correct position	5
Change Operational state to ‘FSA 1 Stopped’	Wait	50	Operational state = ‘FSA 1 Stopped’	

The FSA 1 Dosing Pump will stop running, but will remain in the ‘FSA 1 Dosing’ state if the following flow trigger is registered.

Triggers for FSA Dosing Pump Stop
FITXXXX registers a recipient water flow < Xm3/h for 30 seconds.
OR FSA 1 Pump Speed < Min. Pump Speed HC 83213C

The above indicates the requirements of the plant flow to be above a minimum flow before FSA dosing and the FSA dosing pump to be above a minimum speed to prevent infrequent “slugs” of FSA and damage to the pump.

The pump stop sequence steps are shown below.

‘FSA 1 Pump Stop’ Sequence (FSA_01_04)

Step Description	Step Action	Step Number	Transition Condition	Min. Step Time (sec)
Stop operation of duty dosing pump		10	Dosing pump = ‘not running’	
FC 83231 set point held at zero	Loopmode = Auto SP = 0	20	Loopmode = Auto, SP = 0	
Change Indication to ‘FSA 1 Dosing Pump Stop’		30	Operational state = ‘FSA 1 Dosing’ Indication = FSA 1 Dosing Pump Stopped	

The Operator may terminate operation of the FSA dosing pump, or change the system from the ‘FSA 1 Dosing’ state to the ‘FSA 1 Stopped’ state (whether the pump is running or not) by issuing a ‘FSA 1 Dosing Stop’ command. In this situation the FSA_01_05 sequence will execute and the FSA will return to the ‘FSA Stopped’ State.

‘FSA 1 Dosing Stop’ Sequence (FSA_01_05)

Step Description	Step Action	Step Number	Transition Condition	Min. Step Time (sec)
Stop operation of duty dosing pump		10	Dosing pump = 'not running'	
FC 83231 to Off	CV = 0	20	Loopmode = Off CV = 0	
Close FSA Tank 1 Isolation Valve VA83117	Wait	30	Valve VA83117 limit switch registers valve in correct position	5
Close Dilution Water Isolation Valve VA83202	Wait	40	Valve VA83202 limit switch registers valve in correct position	5
Change Operational state to 'FSA Stopped'	Wait	50	Operational state = 'FSA Stopped'	

Even though sequence FSA-01-05 is the same as FSA-01-03, the triggers are different.

FSA 1 Dosing Stop sequence, FSA_01_05, is initiated only by an operator command and FSA Shutdown 1 sequence, FSA_01_03, is triggered automatically by process conditions and interlocks. Differentiation between the two sequences allows the completion of the shutdown sequence FSA_01_03 to be used as a trigger to initiate automatic changeover to the standby system.

7.4 FSA Dosing Pump Flushing Sequences

Commencement of the 'FSA 1 Flushing Start' sequence can only be initiated by the Operator from the 'FSA 1 Stopped' state. The sequence steps are shown below.

The pre-requisites and interlocks associated with this running state are described in Section 6.4.

'FSA Flushing Start Sequence (FSA_01_06)

Step Description	Step Action	Step Number	Transition Condition	Minimum Step Time (sec)
FSA Pump Flushing system permissive check as listed in Section 5.4	Wait	10	FSA flushing system start permissive healthy	
Initiate 'Sequence Delay Timer'	Set 'Sequence Delay Timer' and run timer	20	Timer = 40	40
Close Valve VA 83118 to port flushing water to dosing pumps	Wait	30	Valve VA 83118 limit switch registers valve in closed position	5
Open Valve VA 83224 to port to dose	Wait	40	Valve VA 83224 limit switch registers valve in open position	5
Open Dilution Water Valve VA 83202	Wait	50	Valve VA 83202 limit switch registers valve in open position	5
Open flushing water isolation valve VA 83132	Wait	60	Limit switch on valve VA 83132 registers an open condition	5
Start operation of FSA 1 Dosing Pump PU83213		70	FSA 1 Dosing pump = running	

FC 83231 set point calculated	Loopmode=Auto, SP calculated	80	Loopmode = Auto	
Cancel 'Sequence Delay Timer'	Clear timer	90	Clear 'Sequence Delay Timer'	
Change Operational state to 'FSA 1 Flushing'		100	Operational state = 'FSA 1 Flushing'	

Once this sequence has been successfully executed the FSA dosing system will be in the 'FSA 1 Flushing' state and the dosing pump will be running with its speed automatically controlled by the flow controller. The operator is able to manually change the position of the dose/drain valve VA83224 (via the HMI) to check the pH of the flushing water at the tundish on the dosing panel (using Litmus paper or a portable pH meter) to determine if flushing needs to continue or can be stopped. Changing the dose/drain valve position will not stop the flushing sequence.

The system will remain in the 'FSA 1 flushing' operational state unless it is terminated by an interlock (as defined in section 6.4) or an Operator selects the 'FSA 1 Flushing Stop' command, in either of these situations the following sequence will take place,

'FAS 1 Flushing Stop' Sequence (FSA_01_07)

Step Description	Step Action	Step Number	Transition Condition	Minimum Step Time (sec)
Stop operation of FSA 1 dosing pump PU83213		10	Dosing pump = 'not running'	
FC 83231 to Off	CV = 0	20	Loopmode = off, CV = 0	
Close flushing water valve VA 83132	Wait	30	Limit switch on valve VA 83132 registers a closed condition	5
Close dilution water valve VA 83202	Wait	40	Limit switch on valve VA 83202 registers a closed condition	5
Change Operational state to 'FSA Stopped'	Wait	50	Operational state = 'FSA Stopped'	

7.5 FSA Dosing Pump Calibration Sequences

Commencement of the 'FSA 1 Calibration Start' sequence can only be initiated by the Operator from the 'FSA 1 Stopped' state. The sequence steps are shown below.

The pre-requisites and interlocks associated with this running state are described in Section 6.5.

‘FSA Calibration Start Sequence (FSA_01_08)

Step Description	Step Action	Step Number	Transition Condition	Minimum Step Time (sec)
FSA Pump Calibration system permissive check as listed in Section 5.4	Wait	10	FSA flushing system start permissive healthy	
Initiate ‘Sequence Delay Timer’	Set ‘Sequence Delay Timer’ and run timer	20	Timer = 40	40
Close Valve VA 83118 to port flushing water to dosing pumps	Wait	30	Valve VA 83118 limit switch registers valve in closed position	5
Open Valve VA 83224 to port to dose	Wait	40	Valve VA 83224 limit switch registers valve in open position	5
Open dilution water isolation valve VA 83202	Wait	50	Limit switch on valve VA 83202 registers an open condition	5
Set operation of FSA 1 Dosing Pump PU83213 to manual		60	FSA 1 Dosing pump = manual	
Set FC 83231 to off	Loopmode= Manual	70	Loopmode = Manual	
Cancel ‘Sequence Delay Timer’	Clear timer	80	Clear ‘Sequence Delay Timer’	
Change Operational state to ‘FSA 1 Calibration’		90	Operational state = ‘FSA 1 Calibration’	

Once this sequence has been successfully executed the FSA dosing system will be in the ‘FSA 1 calibration’ state. The dosing pump will be under manual control and the pump speed will be able to be entered by the operator at the HMI. The pump will not start running until the operator initiates operation by selecting the “manual start” button on the HMI.

The system will remain in the ‘FSA 1 calibration’ operational state unless it is terminated by an interlock (as defined in section 6.5) or an Operator selects the ‘FSA 1 calibration Stop’ command, in either of these situations the following sequence will take place,

‘FAS 1 Calibration Stop’ Sequence (FSA_01_09)

Step Description	Step Action	Step Number	Transition Condition	Minimum Step Time (sec)
Stop operation of FSA 1 dosing pump PU83231		10	Dosing pump = ‘not running’	
FC 83231 to Off	CV = 0	20	Loopmode = off, CV = 0	
Close dilution water isolation valve VA 83202	Wait	30	Limit switch on valve VA 83202 registers a closed condition	5
Change Operational state to ‘FSA Stopped’	Wait	40	Operational state = ‘FSA Stopped’	

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 (less than an hour). 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 following alarms are associated with the FSA storage and dosing system:

Instrument Tag Number	Alarm Message	Delay	Control System Action	Alarm Status
LSHH83110	LAHH 83110 FSA Storage Tank TA 83110 High-high level	10 seconds	Activates high-high level light and siren on load-in panel	Critical
LT 83113	LAL 83113 FSA Storage Tank TA 83110 Low level – re-order chemical	10 seconds	None	Warning
	LALL 83113 FSA Storage Tank TA 83110 Low-low level	10 seconds	Terminates operation of FSA 1 dosing mode if VA 83117 is open	Critical
	LAH 83113 FSA Storage Tank TA 83110 High level	10 seconds	Activates high level light on load-in panel	Urgent
LSHH83120	LAHH 83120 FSA Storage Tank TA 83120 High-high level	10 seconds	Activates high-high level light and siren on load-in panel	Critical
LT 83123	LAL 83123 FSA Storage Tank TA 83120 Low level – re-order chemical	10 seconds	None	Warning
	LALL 83123 FSA Storage Tank TA 83120 Low-low level	10 seconds	Terminates operation of FSA 2 dosing mode if VA 83127 is open	Critical
	LAH 83123 FSA Storage Tank TA 83120 High level	10 seconds	Activates high level light on load-in panel	Urgent
VA 83117	ZA 83117 Tank 1 outlet valve VA 83117 fault	10 seconds	Aborts mode start up sequences.	Warning
	VA 83117 Tank 1 outlet valve VA 83117 ‘Not Available’	10 seconds	Pre-requisite for start-up as part of group equipment availability	Warning
VA 83127	ZA 83127 Tank 2 outlet valve VA 83127 fault	10 seconds	Aborts mode start up sequences.	Warning
	VA 83127 Tank 1 outlet valve VA 83127 ‘Not Available’	10 seconds	Pre-requisite for start-up as part of	Warning

Instrument Tag Number	Alarm Message	Delay	Control System Action	Alarm Status
			group equipment availability	
VA 83118	ZA 83118 Acid/Water selector valve VA 83118 fault	10 seconds	Aborts mode start up sequences.	Warning
	VA 83118 Acid/Water selector valve VA83118 'Not Available'	10 seconds	Pre-requisite for start-up as part of group equipment availability	Warning
VA 83128	ZA 83128 Acid/Water selector valve VA 83128 fault	10 seconds	Aborts mode start up sequences.	Warning
	VA 83128 Acid/Water selector valve VA83128 'Not Available'	10 seconds	Pre-requisite for start-up as part of group equipment availability	Warning
VA 83132	ZA 83132 Flushing water valve VA 83132 fault	10 seconds	Aborts mode start up sequences.	Warning
	VA 83132 Flushing water valve VA83132 'Not Available'	10 seconds	Pre-requisite for start-up as part of group equipment availability	Warning
VA 83134	ZA 83134 Flushing water valve VA 83134 fault	10 seconds	Aborts mode start up sequences.	Warning
	VA 83134 Flushing water valve VA83134 'Not Available'	10 seconds	Pre-requisite for start-up as part of group equipment availability	Warning
LSH 83135	LAH 83135 Bund water high level	10 seconds	None - if only alarm. Initiates tank isolation valves closure if it occurs in conjunction with AAH 83136	Urgent
AE 83136	AAHH 83136 Bund water high-high conductivity	10 seconds	None	Critical
	AAH 83136 Bund water high conductivity	10 seconds	Interlock to prevent Valve VA 83137 opening. Initiates tank isolation valves closure if it occurs in conjunction with LSH 83135	Urgent
LSH83144	LAH83144 Waste Holding Tank High Level	10 seconds	None	Warning
VA 83137	ZA 83137 Drain sump valve VA 83102 fault	10 seconds	None	Warning
	VA 83137 Drain sump valve VA 83137 'Not Available'	10 seconds	None	Warning

Instrument Tag Number	Alarm Message	Delay	Control System Action	Alarm Status
VA 83202	ZA 83202 Dilution water valve VA 83202 fault	10 seconds	Aborts mode start up sequences.	Warning
	VA 83202 Dilution water valve VA 83202 'Not Available'	10 seconds	Pre-requisite for start-up as part of group equipment availability	Warning
VA 83302	ZA 83302 Dilution water valve VA 83302 fault	10 seconds	Aborts mode start up sequences.	Warning
	VA 83302 Dilution water valve VA 83302 'Not Available'	10 seconds	Pre-requisite for start-up as part of group equipment availability	Warning
VA 83224	ZA 83228 Dose/drain valve VA 83224 fault	10 seconds	Aborts mode start up sequences.	Warning
	VA 83224 Discharge valve VA 83224 'Not Available'	10 seconds	Pre-requisite for start-up as part of group equipment availability	Warning
VA 83324	ZA 83324 Dose/drain valve VA 83324 fault	10 seconds	Aborts mode start up sequences.	Warning
	VA 83324 Discharge valve VA 83324 'Not Available'	10 seconds	Pre-requisite for start-up as part of group equipment availability	Warning
PU 83213	YA 83213A Dosing Pump PU 83213 Diaphragm leak detection active	2 seconds	Terminates dosing system operation and initiates operation of standby system, if available	Urgent
	YA 83213B Dosing Pump PU 83213 motor fault	2 seconds	Terminates dosing system operation and initiates operation of standby system, if available	Urgent
PU 83313	YA 83313A Dosing Pump PU 83313 Diaphragm leak detection active	2 seconds	Terminates dosing system operation and initiates operation of standby system, if available	Urgent
	YA 83313B Dosing Pump PU 83313 motor fault	2 seconds	Terminates dosing system operation and initiates operation of standby system, if available	Urgent
FE83218	YA83218 Flow meter deviation flow alarm	60 seconds	None	Critical
FE83318	YA83318 Flow meter deviation flow alarm	60 seconds	None	Critical

Instrument Tag Number	Alarm Message	Delay	Control System Action	Alarm Status
FC 83231	FAHH 83231 Fluoride Dose Rate High-high	5 minutes	Shuts down dosing and initiates standby system if available.	Critical
	FAH 83231 Fluoride Dose Rate High	5 minutes	None	Urgent
	FAL 83231 Fluoride Dose Rate Low	5 minutes	None	Urgent
	FALL 83231 Fluoride Dose Rate Low-low	5 minutes	Shuts down dosing and initiates standby system if available.	Critical
FC 83331	FAHH 83331 Fluoride Dose Rate High-high	5 minutes	Shuts down dosing and initiates standby system if available.	Critical
	FAH 83331 Fluoride Dose Rate High	5 minutes	None	Urgent
	FAL 83331 Fluoride Dose Rate Low	5 minutes	None	Urgent
	FALL 83331 Fluoride Dose Rate Low-low	5 minutes	Shuts down dosing and initiates standby system if available.	Critical
FSL 83205	FAL 83205 FSA 1 Dilution Water Low Flow	2 minutes	Shuts down dosing and initiates standby system if available.	Warning
FSL 83305	FAL 83305 FSA 2 Dilution Water Low Flow	2 minutes	Shuts down dosing and initiates standby system if available.	Warning
FSH 83401	FAH 83401 Shower in Use	60 seconds	None	Warning
FSH 83402	FAH 83402 Shower in Use	60 seconds	None	Warning
FSH 83403	FAH 83403 Shower in Use	60 seconds	None	Warning
FSL 83410	FAL 83410 Sample Flow-low	15 minutes	Shutdown dosing systems	Critical
AE 83411	AALL 83411 Fluoride Level Low-low	30 seconds	Shuts down dosing and initiates standby system if available.	Critical
	AAL 83411 Fluoride Level Low	30 seconds	None	Warning
	AAH 83411 Fluoride Level High	30 seconds	None	Warning
	AAHH 83411 Fluoride Level High-high	30 seconds	Shuts down dosing and initiates standby system if available.	Critical

9 TRENDS

The following trends will be recorded on the HMI system

Instrument Tag Number	Information	Data sampling interval
LT 83113	FSA Storage Tank TA 83110 level	10 seconds
LT 83123	FSA Storage Tank TA 83120 level	10 seconds
FIT 83218	FSA 1 dosing Rate	10 seconds
FIT 83318	FSA 2 dosing Rate	10 seconds
AE 83136	Bund water conductivity	10 seconds
FI 83231	FSA 1 Dosing concentration	10 seconds
FI 83331	FSA 2 Dosing concentration	10 seconds
AI83411	Fluoride Concentration	10 seconds

10 REPORTS

The following reports will be created on a daily basis.

The reporting period will be from 0.00 hours to 0.00 hrs, namely from midnight to midnight.

Instrument Tag Number	Information	Units
LT 83113	FSA Storage Tank TA 83110 volume	m ³
LT 83123	FSA Storage Tank TA 83120 volume	m ³
FQT 83213	FSA 1 dosing volume	L
FQT 83313	FSA 1 dosing volume	L
PU 83213	Pump 1 Operational time	h
PU 83313	Pump 2 Operational time	h

Alarms will be captured on an alarm and event log

11 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 before tank overflow.

The following formulae should be used to calculate this level:

$$H_{hha} = \frac{250\pi D^2 H_o - 0.33Q_f}{250\pi D^2}$$

where

H_{hha} = Height of high high alarm above tank bottom in meters

D = Inside diameter of tank in metres

H_o = Height of tank overflow invert level above tank bottom in metres

Q_f = Fill rate of tank in litres per minute

This level can be converted to a percentage by calculating $H_{hha} / H_o \times 100$.

High Level Alarm Set Point (LAH)

The high level alarm should be initiated at a level which corresponds to 1 minute before tank overflow during the filling operation.

The following formulae should be used to calculate this level :

$$H_{ha} = \frac{250\pi D^2 H_o - Q_f}{250\pi D^2}$$

where

H_{ha} = Height of high alarm above tank bottom in metres

D = Inside diameter of tank in metres

H_o = Height of tank overflow invert level above tank bottom in metres

Q_f = Fill rate of tank in litres per minute

This level can be converted to a percentage by calculating $H_{ha} / H_o \times 100$.

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 FSA at the end of the delivery turnaround period. For most metro sites the delivery turnaround is 24 hours, so at this level there should be at least one day's supply of acid remaining in the tank.

Low-low Level Alarm (LALL)

The low-low level alarm is essentially to protect the pump from running dry, so its set point should be just above the invert level of the outlet to prevent air from being entrained in the pump suction line and pump. 3 minutes of dosing at the maximum flow should be adequate.

The following formulae can be used to calculate this level:

$$H_{la} = \frac{250\pi D^2 H_i + 3Q_m}{250\pi D^2}$$

where

H_{la} = Height of low alarm above tank bottom in meters

D = Inside diameter of tank in metres

H_i = Height of tank process outlet level above tank bottom in meters

Q_m = Maximum FSA dosing pump rate in litres per minute

This level can be converted to a percentage by calculating $H_{la} / H_0 \times 100$.

12 APPENDIX B: FUNCTIONAL DESCRIPTION OVERVIEW

The controls and interlocks of the Fluorosilicic Acid Storage and Dosing System are summarised in the Functional Description Overview provided in this Appendix.

13 APPENDIX C: DOSING PUMP WEDGE CONTROL EXAMPLE

This Appendix presents a HMI screen display of automatic dosing pump stroke length adjustment (wedge) control taken from an existing FSA dosing plant. It provides an idea of how the pump wedge control is set out for sites where the plant flow varies widely. Once the maximum or minimum pump speed limit associated with a particular stroke length is reached, the next adjacent wedge position will automatically be set to give the next stroke length thereby allowing the pump to operate within the optimum pump speed range. The step changes will have to be gradual to prevent drastic changes to the dosage.

FSA Dosing Pump 1 Wedge Control				
	Wedge %	Max Output	Min Speed	Max Speed
Wedge Position 1	5.0%	13.20 L/h	3.30 L/h	12.54 L/h
Wedge Position 2	10.0%	18.50 L/h	4.62 L/h	17.57 L/h
Wedge Position 3	20.0%	24.50 L/h	6.12 L/h	23.27 L/h
Wedge Position 4	35.0%	39.00 L/h	9.75 L/h	37.05 L/h
Wedge Position 5	50.0%	50.00 L/h	12.50 L/h	47.50 L/h
Wedge Position 6	75.0%	75.00 L/h	18.75 L/h	71.25 L/h
Wedge Position 7	100.0%	98.00 L/h	24.50 L/h	93.10 L/h
Pump Speed Low Deadband				25.00%
Pump Speed High Deadband				95.00%
Actual Pump Speed				0.00%
Wedge Position Requested				5.00%
Wedge Position Feedback				73.31%
Acid Flow Required				-0.03 L/hr
Wedge Increase			Wedge Decrease	
Menu	Pump			

HMI SCREEN DISPLAY OF FSA DOSING PUMP AUTOMATIC STROKE LENGTH ADJUSTMENT (WEDGE) CONTROL

END OF DOCUMENT