



Assets Planning and Delivery Group
Engineering

DESIGN STANDARD DS 71-01

Fluorosilicic Acid Storage and Dosing System - Basis of Design

VERSION 2
REVISION 5

MARCH 2024

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.

Design Standards draw on the asset design, management and field operational experience gained and documented by the Corporation and by the water industry generally over time. They are intended for application by Corporation staff, designers, constructors and land developers to the planning, design, construction and commissioning of Corporation infrastructure including water services provided by land developers for takeover by the Corporation.

Nothing in this Design Standard diminishes the responsibility of designers and constructors for applying the requirements of the Western Australia's Work Health and Safety (General) Regulations 2022 to the delivery of Corporation assets. Information on these statutory requirements may be viewed at the following web site location:

[Overview of Western Australia's Work Health and Safety \(General\) Regulations 2022 \(dmirs.wa.gov.au\)](https://dmirs.wa.gov.au)

Enquiries relating to the technical content of a Design Standard should be directed to the Senior Principal Engineer, Water Treatment Section, Engineering. Future Design Standard changes, if any, will be issued to registered Design Standard users as and when published.

Head of Engineering

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REVISION STATUS

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

REVISION STATUS						
SECT.	VER./REV.	DATE	PAGES REVISED	REVISION DESCRIPTION (Section, Clause, Sub-Clause)	RVWD.	APRV.
1	2/0	30.06.08	All	New Version	ST	NH
1	2/1	03.01.12	12	Standards and regulation updated	ST	NH
1	2/2	28.02.14	10	1.2 Outdated background info removed	ST	NH
1	2/2	28.02.14	12-14	1.6 List of standards updated	ST	NH
1	2/2	28.02.14	14	1.6 Standards and Regulations updated	ST	NH
1	2/2	28.02.14	15	1.7 References updated 1.8 Terminology & Abbrev. updated	ST	NH
1	2/3	06.09.17	16-17	List of standards updated	NH	DH
1	2/4	15.01.21	13, 15-18	1.4, 1.5.2, 1.6 and 1.8 Updated. New definitions added.	NH	DH
1	2/5	10.08.23	16	1.6.1 Stds references updated	NH	BM

2	2/0	30.06.08	All	New Version	ST	NH
2	2/1	03.01.12	13	Reference to 1992 DG Regulations removed	ST	NH
2	2/1	03.01.12	14	Reference to DS100 added	ST	NH
2	2/2	28.02.14	16	2 Reference to DG Regulations replaced with ref to AS3780	ST	NH
2	2/2	28.02.14	17	2.3 Amended to include PPE storage in Entry Vestibule	ST	NH
2	2/2	28.02.14	18-19	2.5 Amended paragraph on FRP grating cut-out	ST	NH
2	2/3	06.09.17	19-20	Sections 2.3 and 2.4 revised – ventilation modified in line with AS2927 and requirement for vestibule revised.	NH	DH
2	2/4	15.01.21	20-22	2.2, 2.3, 2.4, 2.5 Updated and new 2.7 added	NH	DH
2	2/5	10.08.23	18-22	2, 2.2, 2.4, 2.6, 2.7; Reworded to align with DS73. Vent area calculation changed to match AS1668. New requirements added.	NH	BM

3	2/0	30.06.08	All	New Version	ST	NH
3	2/1	03.01.12	25	Reference to SPS 499 added	ST	NH
3	2/1	03.01.12	26	Reference to 1992 DG Regulations removed	ST	NH
3	2/2	28.02.14	20	3.1 Reference to DG Regulations 1992 removed. Updated to latest AS3780 reference.	ST	NH
3	2/2	28.02.14	20-21	3.2 SiD Report Info for bund leak test added. 3.3 Description of float valve requirement added.	ST	NH
3	2/2	28.02.14	21	3.3 Amended valve handles to be located just below grid mesh	ST	NH
3	2/2	28.02.14	23	3.5 Access road to waste tank added, waste tank pump out camlock connection deleted	ST	NH
3	2/3	06.09.17	22-24	3.1 Bund grade for transportable buildings added. 3.2 More detail added on coating requirements 3.3 Valve requirements enhanced	NH	DH
3	2/4	15.01.21	23-26	3.1, 3.2, 3.3 and 3.5 Updated	NH	DH
3	2/5	10.08.23	24,26	3.3, 3.5; Rationale for wet sump added. Dwg references changed.	NH	BM

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4	2/2	28.02.14	24	4.2 Updated latest AS3780 ref in footnote	ST	NH
4	2/2	28.02.14	25-26	4.2, 4.3 Updated latest AS3780 ref in footnote 4.3 Fitting for transfer point to be flanged jointed to load-in pipe. Added thermal insulation to roller shutter door	ST	NH
4	2/2	28.02.14	26	4.3 Added testing of alarms before load in, large digital display of tank level indicators on load-in panel	ST	NH
4	2/3	06.09.17	27-29	Sections revised to include valve control as per DS73.	NH	DH
4	2/4	15.01.21	27-30	All sections Updated	NH	DH
4	2/5	10.08.23	29	S4.3 Connection changed to horizontal.		

5	2/0	30.06.08	All	New Version	ST	NH
5	2/2	28.02.14	28	5.1.2 Amended list of tank nozzles description	ST	NH
5	2/2	28.02.14	28-29	5.1.2 Tank top entry manhole deleted, side inspection port and vent nozzle size added. List of tank compliance plate info amended	ST	NH
5	2/2	28.02.14	28-31	5.1.2 List of tank compliance plate info amended 5.1.3.1 Heading numbering added, minor changes	ST	NH
5	2/2	28.02.14	31-32	5.1.3.2 Heading numbering added, strength of roof structure and side man way removed 5.1.3.3 Heading numbering added 5.1.4 Cabling to install above plinth level added.	ST	NH
5	2/2	28.02.14	32	5.2 Added new heading	ST	NH
5	2/2	28.02.14	33	5.2.2 Clause on tank inspection deleted 5.3.1 SiD Report Info for Filling Line added	ST	NH
5	2/2	28.02.14	33-34	5.3.2 Vent line size increased 5.3.3 Incorrect scour line valves description removed, tank to allow complete draining.	ST	NH
5	2/2	28.02.14	35	5.3.5 Overflow line clause amended.	ST	NH
5	2/3	06.09.17	38	Fume mitigation requirements enhanced	NH	DH
5	2/4	15.01.21	31-40	5.1, 5.2 and 5.3 Updated with new definitions	NH	DH
5	2/5	10.08.23	37	5.2.1 Note regarding use of radar transmitters added.	NH	BM

6	2/0	30.06.08	All	New Section	ST	NH
6	2/2	28.02.14	38	6.1 Amended	ST	NH
6	2/2	28.02.14	39	6.1.2 SiD Report Info for PRV added	ST	NH
6	2/2	28.02.14	40-41	6.1.8 SiD Report Info for pressure sustaining valve added	ST	NH
6	2/2	28.02.14	43	6.3.2 Heading amended	ST	NH
6	2/2	28.02.14	43-44	6.3.2 Ref to DS78 added 6.3.3 Calgon SHMP Dosing clause added	ST	NH
6	2/3	06.09.17	41,47	6.1 Dosing panel enclosure requirements enhanced	NH	DH

REVISION STATUS						
SECT.	VER./REV.	DATE	PAGES REVISED	REVISION DESCRIPTION (Section, Clause, Sub-Clause)	RVWD.	APRV.
				6.4 New section added on safety shower requirements around dosing panels.		
6	2/4	15.01.21	41-47	6.1, 6.2, 6.3 and 6.4 Updated	NH	DH
6	2/5	10.08.23	43	6.1.2 Clarification that external relief valves are only required for pumps without internal relief.	NH	BM
7	2/0	30.06.08	All	New Section	ST	NH
7	2/2	28.02.14	45	7.2 Updated paragraph on fluoride analyser, added footnote	ST	NH
7	2/4	15.01.21	48	7.2 updated	NH	DH
8	2/0	30.06.08	All	New Section	ST	NH
8	2/2	28.02.14	46	8.1 Changed PVC pipe to Schedule 80, paragraph on flexible hose removed 8.2 Amended paragraph on solvent cement	ST	NH
8	2/2	28.02.14	47	8.5 SiD Report Info for Pipework Identification added	ST	NH
8	2/4	15.01.21	49-50	8.1, 8.2, 8.4 and 8.5 Updated	NH	DH
8	2/5	10.08.23	50	8.5 New section “Hoses and Tubing” added.	NH	BM
9	2/0	30.06.08	All	New Section	ST	NH
9	2/2	28.02.14	48	9.3.1 Ref to Safety Shower std updated, provision of thermal relief bleed valve amended to all showers 9.3.2 Removed service water usage for safety shower.	ST	NH
9	2/4	15.01.21	51	9.1 Updated	NH	DH
9	2/5	10.08.23	52	9.3.1 New requirement for safety showers to be risk assessed added.	NH	BM
10	2/0	30.06.08	All	New Section	ST	NH
10	2/2	28.02.14	51	10.3 Amended clause and added footnote	ST	NH
10	2/3	06.09.17	51	10.1 Requirement for Design Manager approval for implementing fluoride feedback control added.	NH	DH
10	2/4	15.01.21	52-54	10.4 Updated	NH	DH
11	2/0	30.06.08	All	New Section	ST	NH
11	2/2	28.02.14	53	11.1 Units of conductivity amended	ST	NH
12	2/0	30.06.08	All	New Section	ST	NH
12	2/2	28.02.14	55	12 Ref to Signs & Placards std updated, FSA waste tank sign description added, SiD Report Info for Signs & Placards added	ST	NH
12	2/4	15.01.21	58	Updated with standard reference	NH	DH
13	2/0	30.06.08	All	New Section	ST	NH

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14	2/2	28.02.14	58	Amended the Heading	ST	NH
14	2/4	15.01.21	61-63	Updated with standard reference	NH	DH
15	2/0	30.06.08	All	New Section	ST	NH
15	2/2	28.02.14	59	Amended clause and added hyperlink	ST	NH
15	2/5	03.08.23	67	Collated all equipment schedule appendices into this section. Added new hyperlink	BY	BM
16	2/0	30.06.08	All	New Section	ST	NH
16	2/2	28.02.14	60	Amended clause and added hyperlink	ST	NH
16	2/5	03.08.23	68	Removal of section. Collated equipment schedules in section 15.	BY	BM
17	2/0	30.06.08	All	New Section	ST	NH
17	2/2	28.02.14	61	Amended clause and added hyperlink	ST	NH
17	2/5	03.08.23	69	Removal of section. Collated equipment schedules in section 15.	BY	BM

DESIGN STANDARD DS 71-01

Fluorosilicic Acid Storage and Dosing System – Basis of Design

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1 INTRODUCTION

1.1 Purpose

The purpose of this document is to explain the reasoning behind the Water Corporation's design and installation requirements for its Fluorosilicic Acid Storage and Dosing facilities and to provide specific information relating to the Corporation's preferences and best practices that have evolved over years of experience.

1.2 Background Information

Fluoride is dosed to maintain optimal fluoride levels in drinking water to reduce tooth decay.

The three most commonly used Fluoride compounds for drinking water treatment are:

- Fluorosilicic Acid (also known as FSA) - H_2SiF_6
- Sodium Fluorosilicate - Na_2SiF_6
- Sodium Fluoride – NaF

The Corporation's preferred Fluoridation system for water treatment plants requiring a peak fluoride (F-) feed rate greater than 25kg/day is a Fluorosilicic Acid (FSA) storage and dosing system.

FSA, being a liquid, has multiple advantages over bulk powdered sodium fluorosilicate or sodium fluoride. These advantages are:

- It is easier to manage the OSH exposure risks of a liquid (FSA) through barrier protection/containment than to manage the inhalation risks posed by a powder (bulk Na_2SiF_6 or NaF);
- A liquid is easier to dose as the powder requires a weigh-feeder and is not easily dissolved;
- The liquid does not have the dusting problems associated with use of the powder. This is significant as the dust is toxic and requires use of a ventilator for all handling operations; and
- The powdered material has a tendency to flow irregularly and occasionally blocks during humid weather. This causes poor control of dosing rates compared to the use of liquid FSA.

This basis of design document applies solely to the Corporation's FSA dosing systems. The process and instrumentation drawings and the general arrangements associated with this document can be found in the Corporation's Drawing Management System (DMS) and have the following drawing numbers:

- GT36-060-083-01 through to GT36-060-083-04; and
- GT36-070-083-01 through to GT36-070-083-09

1.3 Governance

In Western Australia, fluoridation is regulated by the Fluoridation of Public Water Supplies Act 1966 which is administered by the WA Department of Health. An Advisory Committee oversees fluoridation and makes recommendations to the Minister for Health who may issue or rescind directives as appropriate.

The Water Corporation may only fluoridate the water in towns where the Minister for Health has given direction to do so. This would typically occur where the population exceeds 3000 people but may also occur for smaller towns, where a specific request has been made or where it is anticipated that the population will rapidly grow to exceed 3000.

Fluoride dose rates have been set to provide consumers with a prescribed amount of fluoride based on water consumption. As average water consumption is proportional to ambient temperatures, different dose rates have been set for various parts of the State.

A maximum dose rate of 1.0 mg/L is prescribed in the Act. Notwithstanding the provisions of the Fluoridation of Public Water Supplies Act the maximum health criteria for fluoride is 1.5 mg/L in the Australian Drinking Water Guidelines. The target residual is 0.85 mg/L.

Fluoridation performance is reported monthly to the Department of Health (DoH) and periodically to the Fluoridation Advisory Committee.

1.4 Water Corporation's Level of Service (LOS)

The Water Corporation level of service for Fluoridation systems is as listed below:

1. 90% of all weekly samples shall meet the required range.
2. Faulty fluoridation systems are to return to service within 2 business days for Metro sites and within 4 business days for regional sites.
3. No exceedance of fluoride residual greater than 1.0 mg/L¹ at point of dosing (after mixing). The fluoride dosing should fail safe “stop” if high residual occurs (i.e. Water supply is to continue without fluoridation).

Setting aside the above levels of service, this standard design is aimed at engineering FSA facilities to achieve better than this on a regular basis. High reliability and availability of FSA dosing and storage facilities is viewed as practically and readily achievable.

1.5 Standard Design Philosophy

1.5.1 Continuity of Dosing

Fluoride is not critical to the water treatment process. Fluoride is dosed for its long-term health effect (based on an assumed average consumption). Therefore, a temporary interruption to fluoride dosing does not present any significant public health risks. However, to achieve 90% compliance with the targets set by the FAC, interruptions to fluoride dosing shall now be avoided by providing duty and standby dosing systems.

Formerly, FSA dosing systems had no standby equipment because it was considered more important to maximise simplicity of the dosing system, and thus minimise the potential for leakage of hazardous FSA.

In an effort to maintain 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 performed on one dosing system, while the other dosing system is in operation, safely sealed in a separate dosing cabinet.

This approach to design achieves our occupational safety objectives, and achieves our regulator's continuity of dosing objective, but it does so at a higher capital cost.

1.5.2 Dilution Before Dosing

This standard design is based on dosing concentrated FSA into a dilution water stream (also known as carrier water), at a minimum dilution ratio of 20 parts water to 1 part of concentrated acid solution, before conveyance to the dose point. This is to provide rapid mixing at the dose point into the recipient water main. Also, a dilute acid solution is less hazardous than a concentrated acid solution, so this avoids the need for containment piping along the pipe run from the dosing room to the dose point in the field. Above ground sections of such pipework, however, shall be chemical barrier protected in accordance with the spray protection requirements of DS79-03.

¹ Note: This value is lower in the north of state so the fluoridation directive for the scheme shall be checked.

If the use of a concentrated acid line outside the dosing room is unavoidable, then the dose line shall be enclosed within containment piping. This containment piping shall have an open end that drains to the FSA bund sump or viewing catch pots at low points.

1.5.3 Modes of Operation

This standard design is based on the FSA storage and dosing system being operated in one of four distinct modes. These are:

- Dosing Mode – This is the normal operation mode and is used to dose FSA from the storage tanks through the dosing panel to the recipient water main.
- Flushing Mode – This mode uses flushing water to remove FSA out of the system so that maintenance can be conducted on the system.
- Calibration Mode – This mode is used to calibrate the dosing pump using service water, this mode will be used predominantly during commissioning or after pump replacement.
- Manual Mode – This mode allows the operator to open/close and stop/start any component of the FSA system. This is not a normal operating mode.

A number of actuated two-way and three-way valves have been included in the standard design to ensure that when one of these modes is selected by the operator the control system will automatically configure the necessary valves to ensure acid, dilution water and flushing water are directed to the correct location or isolated. By having these distinct modes and this level of automation it reduces the degree of manual operator involvement required and the potential for human error, thus making the FSA system safer to operate.

These modes and configurations are discussed further in the following sections and in the FSA Control Functional Specification DS71-02.

1.6 Standards

This design standard makes reference (directly or indirectly) to the following standards and regulations:

1.6.1 Australian & International Standards:

AS 1170.1	Structural design actions – Permanent, imposed and other actions
AS 1158.3.1	Lighting for roads and public spaces – Pedestrian area (Category P) lighting – Performance and design requirements
AS 1318	SAA Industrial safety colour code
AS 1319	Safety signs for the occupational environment
AS 1345	Identification of the contents of pipes, conduits and ducts
AS 1657	Fixed platforms, walkways, stairways and ladders – Design, construction and installation
AS 1680.2.4	Interior Lighting – Industrial tasks and processes
AS 1668.2	The use of ventilation and air-conditioning in buildings – Part 2: Ventilation design for indoor air contaminant control
AS 2032	Installation of PVC pipe systems
AS 2293.1	Emergency escape lighting and exit signs for buildings – System design, installation and operation
AS 2634	Chemical plant equipment made from Glass-fibre Reinforced Plastics (GRP) based on thermosetting resins
AS 3500	National plumbing and drainage code (provision of backflow prevention devices)

AS 3780	The storage & handling of corrosive substances (2008)
AS 3879	Solvent cements and priming fluids for PVC (PVC-U and PVC-M) and ABS pipes and fittings
AS 4041	Pressure piping
AS 4087	Metallic flanges for waterworks purposes
AS 4775	Emergency eyewash & shower equipment

Water Corporation Standards:

DS 20	Electrical Design Process
DS 22	Ancillary Plant & Small Pump Stations – Electrical
DS 24	Electrical Drafting
DS 26	Type Specifications - Electrical
DS 28	Water and Wastewater Treatment Plants - Electrical
DS 30	Mechanical General Design Criteria & Glossary
DS 31-01	Pipework
DS 31-02	Valves & Appurtenances
DS 32	Pump stations
DS 33	Water Treatment Mechanical Design Standards
DS 35	Ancillary Plant Mechanical Design Standards
DS 40	(suite of) SCADA Standards
DS 40-07	Electrically Actuated Valve Control
DS 40-09	Field Instrumentation
DS 62	Site Security Treatments
DS 78	Chemical Dosing
DS 79-01	Design of Chemical Systems – Legislative Requirements and General Principles
DS 79-02	Emergency Safety Showers and Eyewash Stations
DS 79-03	Chemical Barrier Protection
DS 79-04	Chemical Safety Signage, Labels and Markers
DS 80	WCX CAD Standard
DS 81	Process Engineering
DS 95	Standard for the Selection, Preparation, Application, Inspection and Testing of Protective Coatings on Water Corporation Assets
DS 100	Suspended Flooring (Grid Mesh and Chequer Plate)
S395	Dangerous Goods Safety - Site Requirements Strategic Products Register

1.6.2 Regulations

Fluoridation of Public Water Supplies Act 1966 (Western Australia)

Dangerous Goods Safety Act 2004 (Western Australia)

Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations 2007 (Western Australia)
Memorandum of Understanding (MOU) for Drinking Water
<https://nexus.watercorporation.com.au/otcs/cs.exe/link/58586927>
Schedule 7 of MOU - Chemicals Approved for Addition to Drinking Water
<http://ww2.health.wa.gov.au/~media/Files/Corporate/general%20documents/water/PDF/MaterialsSubstancesDrinkingWater.pdf>

1.7 References

Water Fluoridation Principles and Practices, Manual of Water Supply Practices – M4, Fifth Edition, American Water Works Association, 2004
Criteria for Regulated Water Supply
Australian Drinking Water Guidelines
Fluorosilicic Acid Dosing Facilities – Design Standards Review Discussion Paper, Infrastructure Development Branch, December 1997.

1.8 Terminology & Abbreviations

ADWG	Australian Drinking Water Guidelines
Corporation	The Water Corporation
DG Regulations	Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations 2007 (Western Australia)
FAC	Fluoride Advisory Committee
FSA	Fluorosilicic Acid
FRP	Fibre Reinforced Plastic
GRP	Glass-Fibre Reinforced Plastic
HMI	Human Machine Interface
FLIP	Fluoride Local Interface Panel
PCV	Pressure Control Valve (pressure reducing and / or pressure sustaining)
PSV	Pressure Safety (Relief) Valve
Tank working volume	The volume of the tank between the low-low alarm and the high alarm
Tank design capacity	The volume of the tank from its base to the invert of the overflow
Transfer Point ²	The point where the filling pipework of a bulk container terminates and where the hose from the delivery truck connects during load in (transfer) of chemical into the container.

2 CHEMICAL BUILDING

The storage and dosing system shall be constructed within a building. The function of the building is:

- to exclude rainfall from the bund, this eliminates the need to size the bund with additional capacity for rainwater and makes it easier to distinguish between rainfall ingress and leaks of the FSA system.

² Transfer point is defined in a broader sense in AS3780 Clause 5.5.7 as “the point where the pipework from a bulk container terminates” and where a vehicle can transfer product into or receiving product from the container.

As FSA is a colourless liquid which visibly resembles plain water, any liquid within the bund shall be treated as acid until proven otherwise;

- to provide an additional level of separation of this hazardous chemical from staff and visitors to site;
- to safeguard the assets in line with the Corporation's key security principles; and
- to protect the equipment inside from UV degradation.

The internal walls of the room shall be designed to minimise the number of protrusions and thereby provide as much flush wall space as possible to facilitate wall mounted equipment, instruments, and simplify the running of piping and cable trays. The piping shall also be appropriately located to allow easy access to equipment and valves and facilitate unobstructed cleaning of the work areas. Ramps over the drops in floor levels should be included at appropriate locations for easy and ergonomic moving of equipment in and out of the building.

The design and layout of the facility shall include consideration of provisions as laid out in section 7.9.2.1 of AS 3780. This shall include sufficient space between bund walls, storage areas and other structures that will allow access for maintenance and during emergencies. Specifically for maintenance access, an unobstructed clearance of not less than 1.0 m shall be provided in front of the dosing pump/panel and other equipment, with a minimum 2.1 m head clearance.

The building, inclusive of doors, windows and ventilation openings shall be designed to withstand bushfire attack in accordance with AS3959.

The building shall be designed to exclude wildlife, insects and vermin. Measures shall include door seals, tropical midge mesh on ventilation openings, and brush ware around the edges of any roller shutter door to impede ingress of insects through the doorway when the roller shutter is in the closed position.

Internal lighting, external entry lighting and lighting on internal roads shall be provided, all with easy and safe access for lamp maintenance. These lighting levels and other characteristics shall be designed so as to conform to the requirements of DS28.

The building shall be designed so that storage tanks can be removed and replaced, by using either removable wall panels, or having a roof specially designed with a lift-out section such that the structure retains integrity when the roof section is removed. For facilities with two or more storage tanks, the design shall allow for replacement of any tank while the others remain in operation.

The general arrangement drawing GT36-070-083-01 gives an overview of the main features of the FSA building.

2.1 Materials of Construction

Various materials of construction may be appropriate for the FSA room – metal clad, concrete or masonry walls. Choice of building materials will need to consider the corrosive nature of FSA vapour, as well as architectural and security requirements that apply to the particular site.

2.2 Ventilation

The FSA room shall be adequately ventilated in accordance with the Water Corporation's mechanical standards (refer DS30-02) which references AS 1668. Natural ventilation is preferred over mechanical ventilation as it does not require redundancy considerations nor does it incur running costs. However, FSA fumes are considered Type A effluent so the minimum requirement is natural ventilation combined with mechanical exhaust³.

The ventilation system design shall comply with the requirements of AS 1668 and should incorporate the following key features:

³ AS1668.2-2012 C.3.3 defines a Type A effluent & Figure 3.1 provides general guide for the application of exhaust systems.

- i. The temperature rise in the building shall be limited to 6°C above ambient,
- ii. The minimum total area of natural ventilation openings shall be 5% of the floor area.
- iii. Openings for natural ventilation should be positioned on opposite sides of the room to maximise cross-draught.
- iv. Openings for natural ventilation should be provided at high and low levels to maximise the benefits of thermal effects.
- v. Velocity of the air as it enters exhaust hood shall be not less than 0.5m/s averaged across the opening.
- vi. The exhaust fans shall be located up high, unlike fans for chlorine, and air shall be discharged vertically at a high level above the building (because FSA fumes are lighter than air⁴) with a discharge velocity not less than 5m/s to prevent further contamination of the storage areas.

The exhaust system shall be activated by an external switch or deactivation of building security.

2.3 PPE and First Aid Storage

The fluoridation facility shall include generous room to store the PPE and first aid equipment that is required for use in the fluoridation room (Note: Calcium gluconate gel is used for treating FSA exposure/contact and requires storage below 25oC, but, is not to be refrigerated). This space may be provided in a room such as a control or switchroom, but, it shall be in close proximity to the FSA store room to facilitate ready access to PPE by personnel.

If a room is provided adjacent to the FSA storage and dosing room, then that room shall incorporate a door between the rooms and a large PVC⁵ viewing window that allows the Operator to view the FSA storage and dosing room (particularly the dosing panels).

2.4 Personnel Doors

The location of access doors to the room shall be selected to maintain the required separation and segregation distances outlined in the Western Australian Dangerous Goods Safety Act 2004 and its associated regulations and AS780. Consideration should be given to the potential inclusion of exit only doors where personnel undertaking activities may not be able to access the usual route of entry/exit. If the floor area is greater than 25m² then two means of access are required.

Any internal door into the storage tank area shall be fitted with a PVC window in the top section to allow visibility prior to opening. If the room layout warrants it, a one-way door between the FSA storage area and the external of the building may be required specifically as an emergency exit. Access through this door shall be possible from inside the FSA storage room only, no handle is to be provided on the outside and it shall be signed appropriately. Refer to section 12 for appropriate signage.

Personnel doors shall be designed to meet the required fire rating and shall be fitted with crash bars to allow for emergency exit. They shall open outwards, and the travel path of the doors shall not be restricted by external features on the building or any other structure. External doors shall be metal-faced to meet security requirements and to provide weather resistance. They shall have pull handles and retaining hooks for holding in the open position. Hydraulic operated door anti-slam closer/damper shall be provided for each door leaf. Appropriate signs shall be fitted on the doors.

⁴ Information obtained from Water Fluoridation Principles and Practices pg 53.

⁵ PVC is recommended for its chemical resistance and durability. Glass shall not be used as it will eventually turn opaque with continuous exposure to vapour from the fluorosilicic acid.

2.5 Roller Door to Storage/Dosing Room

Roller door access shall be provided to allow chemical deliveries to the storage/dosing room (via a load-in panel – see section 4.3). The doorway width shall be sufficient (2.5m minimum) to also allow movement of equipment into and out of the storage/dosing room.

Roller shutters (rather than single curtain sheet roller doors) shall have thermal insulation in the interlocking slats. The operation of these doors shall be automated using heavy duty motors and they shall be equipped with manual override. These doors shall be industrial strength with galvanised fixtures and guides.

2.6 Platforms and Stairways

An FRP grid mesh platform is to be provided over the bund to give access around the tank. Cut-out sections with removable covers shall be provided to allow easy access for likely operational activities (e.g. to allow removal of valves, neutralisation activities, etc.) and to comply with DS100 (s3.5.2 is particularly relevant).

Sufficient grid mesh area is required to accommodate the load-in and dosing panel(s) and associated equipment. The height of the platform is to suit the height of the load-in connection (refer to section 4.3 for further detail) but, shall be above the flood level of the bund. All platforms and stairways shall be designed in accordance with DS30-02, DS100, and AS 1170.1 & AS 1657 and shall have the necessary kickplate and handrails. All structural components of the floor, stairs and handrail system shall also be FRP.

There shall be a stairway from the platform down to the bund floor for access to the bund sump. All stairways shall be equipped with automatic self-closing gates. The gates shall close in such a way as to prevent people from falling downstairs. Stairs and platforms shall be sized to accommodate the movement of personnel wearing fully encapsulated protective suits and SCBA sets.

The FRP grating selected for the platform shall:

1. be resistant to FSA;
2. be moulded type with square mesh pattern to provide bi-directional strength;
3. have a non-slip grit top surface;
4. have a layout which enables access to pipework, valves and equipment by incorporating readily removable sections;
5. be fastened in place using 316 SS clips to prevent sliding and overturning; and
6. have any shop or field cuts coated with resin to provide maximum corrosion resistance.

Various grades of FRP grating are available, so it is important to ensure that the FRP grating selected and supplied for a FSA storage room is acid resistant and more specifically, suitable for FSA applications. Each manufacturer has its own means of designating grating types, whether it is specific colours to indicate acid resistance or cast-in identification threads, so suitability will need to be confirmed with the individual FRP manufacturer when a grating is being considered for use.

The design should minimise the number of valve spindles to be extended above grating level and provide cutouts to allow use of a tool to operate below the grating valves (operators shall not be required to have to kneel and/or extend their hands below grating level. **Cutouts shall not create a tripping hazard or obstruct access/egress ways.** Where cut outs are required in the FRP grating, for raised valve spindles or to accommodate equipment, then proper strengthening and support of the modified grating shall be carried out by qualified designers and installers to ensure its integrity is not compromised. The open hole in the grating that results from the cut out shall be covered with a removable cut-to-shape FRP grating panel securely supported and clipped. All modification work to the grating shall comply with the prevalent OSH requirements for safe access of Grid Mesh Landings.

Equipment and valve spindle ends shall not protrude out of the FRP grating where it could pose a tripping hazard.

The design of the FRP platform supports shall:

1. meet the design loading requirements ;
2. allow for access to pipework and equipment;
3. take into account the direction of fall across bund floor; and
4. keep the number of concrete embedments to a minimum.

Structural FRP members shall be secured to the concrete floors and walls using 316 SS chemical anchors. The concrete to baseplate interface shall be grouted (30mm nominal) to prevent liquids and debris collecting underneath. Unless chemically resistant to FSA, the grout shall be coated to the same standard as the bund.

2.7 Accessibility

A minimum clearance of 1m shall be provided around all sides of equipment that require maintenance access, with consideration given to a greater clearance where maintenance activities require it.

All valves, pumps, ancillary equipment, and instruments shall be accessible without having to enter the bund and located above bund wall height. This requirement has an additional benefit of allowing the bund integrity to be tested through filling of the bund to wall height.

3 CHEMICAL STORAGE BUNDING

A bund, designed and constructed in accordance with the D.G. Regulations and AS 3780, shall extend beneath the storage tank, the load-in panel and all dosing equipment. There shall not be any piping or equipment which may contain concentrated fluorosilicic acid outside the bund area.

No incompatible dangerous goods shall be kept within the same bund as FSA.

3.1 Bund Volume and Geometry

Bund volume shall be at least 110% of the tank design capacity of the largest tank in the bund (not to be confused with tank working volume). This calculated volume shall not include the volume occupied by foundations and other items within the bund. Note that there is no cross-connection between the outlet pipework of the two tanks⁶ in the standard design. If tanks are cross connected and operated together, rather than as duty and standby, then the bund shall be sized to hold the contents of both tanks.

The bund wall height and position relative to the FSA storage tanks shall be such that:

- i. the bund wall is at least 1 meter from any storage tank containing FSA or other dangerous goods to allow for clear access; and
- ii. no portion of the tank lies outside of any line drawn from the top inside edge of the bund wall at an angle of 26.5 degrees to the vertical (this is equivalent to a rise of 2 metres for every one horizontal metre). This is to prevent liquid squirting over and outside the bund wall.

The above bund design requirements have been taken from the AS 3780 (Clause 5.4). These regulations and standards are specific with regards to chemical storage bund design. These and all other requirements of the regulations shall be complied with for a dangerous goods license to be granted.

For facilities with more than one tank, the minimum separation distance between the tanks is 600mm (AS 3780 5.3.2.2), however for ease of access for maintenance and operation 1000mm is preferred.

The bund floor shall have a minimum slope of 1 in 50 falling towards the sump. Note that this grade has been deliberately selected to be greater than typical tolerances for unformed surfaces because it is important to avoid ponding. Ponding is especially undesirable in FSA storage rooms because of the difficulty in visually distinguishing between colourless acid and water.

Note: For transportable modules, a minimum slope of 5 in 1000 is acceptable due to the smaller floor areas.

Commissioning Plan Information

As part of construction quality assurance or Factory Acceptance (in the case of modules), the slope shall be checked to confirm that requirements have been satisfied. A test shall be conducted for ponding.

3.2 Bund Linings and Coating

An FSA proof (or resistant) lining or coating shall be provided for the bund – refer DS95 and Specification CR 5. The bund floor, sump, walls (and building walls where these are within the crest locus limit of the tank) and tank plinths shall be coated. The grouting at the interface between supports or equipment shall also be coated to the same standard as the rest of the bund. The floor coating system shall incorporate a non-slip finish.

⁶ This has the advantage that the bund then only needs to be sized based on the volume of a single tank rather than the combined volume of both tanks, which results in cost savings due to lower building height. However, this has the disadvantage of slightly reducing flexibility of operation. The probability of a failure of a storage tank is low, and similarly the probability of failure of the other dosing system is also low; hence, the probability of both these failures coinciding is extremely low, and does not justify the additional cost for a taller building i.e. incremental improvements at high cost are not justified because the proposed design already easily achieves our goal of at least 95% compliance with the targets set by the FAC.

Full PVC lining with joined PVC sheet is very expensive and not believed necessary given the vast array of relatively inexpensive polymer and epoxy-based acid resistant surface coatings now available.

To achieve effective water-tight sealing of the bund, proper application of coatings is essential especially around the bund drain pipe which passes through the bund wall- no other bund penetrations shall be made. Strict specifications for products to be used and the methods of application should be in place to ensure that this is achieved.

Commissioning Plan Information
A 24-hour hydrostatic leak test shall be conducted on a bund prior to the filling of its associated storage tank(s) with chemical.

Water that has been used for the hydrostatic test on the storage tanks can be discharged onto the bund for this hydrostatic leak test.

3.3 Bund Sump & Valves

The FSA bund shall have a wet sump for collection of spills and leaks. Although the toroidal type of conductivity analysers is suited to normally dry operation, a wet sump is required to minimise fume generation and so that the conductivity analyser is able to detect small amounts of acid leakage (rather than having to accumulate a significant volume in the sump before the liquid level reaches the conductivity analyser) so that an Operator can take action to neutralise the acid before it degrades the bund coating. A float operated water supply valve (VA83105) shall maintain a fixed water level in the sump. As this valve is crucial for the effective functioning of the wet sump, the float operated valve must be of durable, high quality construction. The robust, heavy duty type valve shall have a reliable control mechanism that requires minimal maintenance. Valve components shall be constructed with materials that are corrosion-resistant and suitable for the chemical environment.

This bund sump serves multiple functions:

- It collects any spillage or tank overflow where it can then be pumped out or drained away;
- It provides a location for detection of high level and/or high conductivity in the event of a leak;
- It provides a location for the neutralization of minor spills.

The sump shall be adequately sized to house all necessary equipment and pipe entries. From past project experience the recommended minimum sump dimensions are: 1200 long x 800 wide x 300 deep. This arrangement provides adequate volume for spill neutralisation and sufficient water depth for operation of the float valve and immersion of the conductivity sensor. Clear access for maintenance of the valves and equipment located in and adjacent to the sump shall be provided.

A DN50 PVC drain outlet pipe positioned flush with the floor of the sump shall lead to an exterior valve pit outside the FSA building where a DN50 manual bund outlet isolation valve (VA83137) and motorised 3-way isolation valve (VA83140) is located. The recommended minimum valve pit dimensions are 1200 long x 800 wide to enable easy access for the installation and maintenance of these valves. The motorised valve shall be operated from the FLIP, and shall be interlocked with sump conductivity to prevent inadvertent discharge of fluorosilicic acid from the bund. An override will be available from the FLIP to allow this interlock to be overridden by the operator on site, only once they have confirmed that the contents of the sump are safe for disposal to the sludge drying beds/drainage or transferred to the waste handling tank. However, to prevent accidental release of bund sump content the motorised valve shall be programmed to automatically close if it is left open for longer than 30 minutes continuously, whether override is selected or not. When there is a valve fault, VA83140 shall also automatically close (fail-closed).

The manual isolation valve VA83137 is an additional protection measure against accidental discharge and allows isolation of the three-way valve for maintenance.

The exterior valve pit shall have a removable FRP grid mesh cover, allowing ready access to the valves inside. These valves shall be supplied with securely-supported extension spindles and handles located just below the FRP grid mesh cover to allow manual operation without sump entry. The valve tag numbers along

with open and close positions shall be clearly marked on each valve. A simple and concise description outlining the purpose of each valve shall be mounted on a small sign adjacent to each handle to assist with correct valve identification and operation.

Any rainwater collected in this external sump will be directed to the load-in apron sump by a DN100 PVC drain line. An additional collection chamber, sump pump and delivery line shall be provided if gravity flow to the drying beds and waste holding tank cannot be achieved. This system can be common with other compatible chemical bund sump drains.

3.4 Bund Sump Instruments

The following instruments will be installed in the internal bund sump to assist the operators with the identification of possible FSA leaks.

3.4.1 High Level Switch

A high level float switch (LSH83135) shall be fitted to detect a high fluid level in the internal bund sump and is used to generate a high FSA bund sump level alarm. This switch shall be linked to the plant control system to alert of an acid or water spillage. The level switch shall be set to activate an alarm at the lowest practical level in the sump.

The float and cable insulation shall be fabricated from FSA resistant components such as Polypropylene, Polyethylene or PVC. The junction box shall be mounted on the wall or the grating platform, above the bund height, so that it can be easily accessed for maintenance without having to reach across the sump.

3.4.2 Conductivity Analyser

The bund sump shall have a toroidal type conductivity probe (AE83136) to detect leakage of a highly conductive solution (e.g. acid) as opposed to water. A high conductivity shall generate alarms in the plant control system and shall be interlocked with the operation of the sump outlet valve and the tank outlet valves.

A conductivity (toroidal) analyser is deemed required over a pH analyser for the detection of FSA spills for the following reasons:

- It is considered more robust than pH probes.
- They do not normally require calibration.
- The toroidal probe has a very long life whereas pH analysers have high life cycle costs for routine pH probe replacement due to limited probe life (typically 2 years).
- It is suited to being maintained in pH neutral solutions most of the time.
- Failure of a pH probe may result in a low pH signal, thus erroneously initiating an alarm indicating an acid leak.
- Failure of a pH probe may also result in a constant pH reading near neutral (pH 7.00). When this occurs, the probe failure is not immediately obvious to the operator and may go unnoticed, thus an actual FSA leak at this time may not be detected.

The conductivity probe, seal and cable shall be fabricated from components suitable for FSA.

The conductivity analyser transmitter shall be mounted on the wall adjacent to the sump above the bund height. It is preferable that it be located so the display can be read without entering the bunded area and so it can be maintained without reaching across the sump.

3.5 Waste Holding Tank

A waste holding tank based on drawings FQ18-6-17,-6-24.1, 6-24.2, -6-27 and 6-28, and with a minimum storage capacity of 1000L⁷ shall be provided at each site for the collection of FSA waste. A larger tank should be provided if the tanker pump rate is greater than 7 L/s or where other site specific considerations or risks exist – e.g. location is near a river or other water body. The main purpose of this tank is to stockpile the small quantities of FSA waste and neutralised waste generated from either the storage room or load-in apron during normal operational duties. When sufficient waste is collected in the tank, a tanker truck can be arranged to pump out and transport the waste off-site for proper disposal. If the waste holding tank is not located near the load-in apron, road access to the tank shall be provided for the tanker.

This tank shall be fabricated from a material suitable for the long term storage of FSA, such as HDPE or, GRP, as it may be expected to hold FSA waste for well over a year depending on the waste production volumes. The tank is to be located at a level lower than the bund sump and load-in apron sump so waste FSA can gravitate to this tank. The tank shall be housed within a concrete liner to protect it from ground forces and to allow its easy removal at end of life. Joins in the concrete liner shall be sealed with Sika Tank to ensure that the concrete liner can act as secondary containment if FSA were to leak from the waste holding tank.

The tank shall be fitted with a float type level switch (LSH83144) to warn the operator when waste in the tank has reached a high level so as he/she can arrange for a disposal tanker. The design shall ensure that the switch can be easily accessed without the use of special equipment (e.g. cranes, scaffolding, etc.).

⁷ A 1000L tank capacity would be sufficient to contain a load-in chemical spillage volume of 840L calculated from pumping at a rate of 7L/s for two minutes before emergency shutoff. As a side note, requirement of AS3780 Clause 7.8.4.2 for capacity of spillage control system to be the greater of 9000L or largest tanker compartment is only intended for loading of chemical into tankers, not unloading from tankers as is the case at load-in facility. This was clarified by DMIRS in 2010 (ref Meeting minutes dated 3 June 2010 Nexus ID #53022606).

4 DELIVERY REQUIREMENTS

4.1 Delivery Sizes

FSA is typically delivered in two sizes of loads. For smaller sites a multi-pod flat-top bed truck with 3 pods of 3 tonne each (approximately 2,500L per pod) is used. The truck is fitted with its own unloading pump and 6m long flexible hose for unloading. Power is not required to be provided for unloading.

Where there is a possibility of a 16 tonne (approximately 13,400L) semi-trailer tanker being used to undertake deliveries, a permanently mounted, external weatherproof electrical power outlet conforming to the following specifications shall be provided:

- 1) Power supply required is 3-phase 440 volt, IP-56, 32 amp.
- 2) The power socket must be 4 pin all-weather.
- 3) The power socket must be fitted not closer than 5 metres to, but not more than 20 metres from, the chemical road tanker unloading coupling, and must be in full view of the road vehicle operator during the road tanker unloading operation.
- 4) The power socket and cabling must be in good condition and well supported.
- 5) The power socket must be of the type:

CLIPSAL WILCO – Industrial Switchgear Hi-Impact 32 amp, Triple Pole 4 Pin Socket, Catalogue No WICM 432.

- 6) The power socket must be protected against earth leakage current by means of a residual current device (RCD).

Early in the design phase the designers shall confirm what type of deliveries will be received and design the necessary load-in facilities accordingly.

4.2 Load-in Apron

A 200mm thick concrete load-in apron with the minimum dimensions of:

- 15m long and 4.5m wide for flat top multi-pod deliveries
- 25m long and 4.5m wide for standard trailer deliveries

shall be provided adjacent to the FSA storage room. The load-in apron shall be located nearest to the load-in panel platform door opening as the maximum allowable length of flexible transfer hose is 6m⁸. The apron shall be graded to a sump from where its contents drain to either a soakwell/site stormwater drainage or the waste holding tank via an actuated 3-way valve (VA83138). Under normal conditions, this valve is opened to discharge to the soakwell/site drainage so that rainwater is not collected on the apron or in the waste holding tank. During a delivery it is part of the tanker truck driver's procedures to open the door in front of the load-in panel. The opening of this door shall automatically initiate the 3-way valve to open to the waste holding tank (and close to site drainage) in anticipation of any potential spillage. 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'.

The actuated 3-way valve (VA83138) shall have limit switches to indicate valve position on the HMI, OIP and load-in panel displays. It shall have manual override with securely-supported extended spindles all housed in a valve pit with removable cover. In the event of valve failure or power outage, the valve shall automatically open to the waste holding tank and close to site drainage.

⁸ AS3780 Clause 5.8.3 (a) requirement.

The sump shall be fitted with a suitable level switch (LSH83138) to provide warning when the content in the sump has reached a set high level due to either a pipe blockage or valve fault. The sump high level alarm shall be enunciated on the load-in panel and on the OIP/HMI.

The apron shall have a small ramped trafficable lip 30-50mm in height above the roadway (around the perimeter for the containment of spills).

Road access to the load-in apron shall be designed to include a drive through route. If this is not possible, as may be the case on brown field sites, a turning circle with a minimum radius of 12.5m shall need to be incorporated. This is to enable the FSA delivery truck to be driven clear of the facility without the need to reverse⁹.

4.3 Load-in Panel and Transfer Point

The FSA is transferred from the delivery truck into the storage tanks via a transfer connection point on the load-in panel. This load-in connection shall meet the following requirements:

- It is to be located 2.2m above road level; this is so the flexible hose will drain back to the delivery tanker.
- It is to be located at a safe and ergonomic height for connection and disconnection - 1m above floor/platform level is recommended (this normally requires the inclusion of a platform to achieve this).
- It shall be located at least 5m from any protected places or the plant boundary¹⁰.
- It shall be DN50 Polypropylene male camlock coupling with matching dust cover. The camlock coupling must be pre-approved and of reputable make.
- It shall be positioned horizontal for ease of connection (refer GT36-70-83.9). The connection fitting and camlock are high wear components that often get damaged. For ease of replacement, a flanged joint shall be used to connect the connection fitting to the piping instead of solvent welding. The flanged joint shall be enclosed in a removable Perspex box to minimise the impact of a gasket failure. Screw fittings shall not be employed in accordance with AS3780.
- It shall have a spring to close valved (VA83130) drip leg, which is used to check that the delivery line has drained completely prior to disconnection of the hose. The spring-to-close valve automatically shuts when the Operator releases grip on the manual actuator, thereby preventing risk that the drip leg valve mistakenly gets left open during chemical deliveries.
- A safety shower and eyewash shall be provided at apron level between 2 and 7m from the transfer point, or the use of the delivery driver. A 600mm wide clear access route to this shower shall be maintained at all times. Any platform or stairs projecting onto the load-in apron shall be designed so that access to the safety shower is not restricted or impeded, especially when the truck is parked up for unloading. A safety shower shall also be provided at platform level.

The photo below shows an example of a raised platform configuration:

⁹ AS 3780 Clause 5.5.7 (d) iii requirement.

¹⁰ AS 3780 Clause 5.5.7 (c) requirement.



The load-in panel shall be located inside the FSA building so it is over the bunded area. Where possible the FRP grid mesh covering the bund within the FSA room shall also be at the same level as the elevated platform. A roller shutter door shall be provided to gain access to the load-in panel for the tanker hoses. Outside the building, there shall be a continuation of the platform in front of the roller shutter door, and a stairway shall give access to this external platform from ground level. Drawing GT36-070-083-1 provides an illustration of this arrangement.

The load-in panel shall be constructed from PVC sheeting (nominally 12mm thick) with FRP frame and supports. It shall have a drip tray which runs the full length of the panel and extends well clear of the valves and transfer point mounted on the panel to collect any drips. The tray shall have additional side and bottom supports to prevent cracking of PVC welds due to the weight of hose and operator. The front of the tray shall have a rolled over reinforced edge to act as an intermediate support for the transfer hose. The drip tray shall be graded towards a drain that is piped to the bund sump. From operator experience, the small amount of acid left over after a normal delivery is not enough to trigger a high conductivity alarm in the bund sump.

Along with the camlock, the load-in panel shall have the following valves and equipment mounted on it:

- tank filling line isolation valves (VA83110/83120);
- drip leg valve (VA83130);
- tank level indicators (LI83113/83123);
- high level visual alarms (LAH83113/83123);
- high high level visual and audible alarms (LAHH83113/83123);
- alarm acknowledge pushbuttons (HS83113/83123);
- manual alarm (light/siren) test pushbutton (HS83150); and
- a tank/bund pump-out connection point with isolation valve.

The tank/bund pump-out connection point is a DN50 female polypropylene camlock coupling with matching dust plug which is used to remove FSA from the bund sump or directly from the tanks in the event of a significant spill or for maintenance. A valved water inlet point for flushing and priming of the pump-out piping shall be also provided.

The displays, lights and sirens shall be mounted on the load-in panel so as to be as far apart as is practical from the load-in point in order to minimise corrosion of the instrumentation. The manual alarm (light/siren) test pushbutton is provided so operators and maintainers can simply and routinely check alarm light and siren operation without having to first generate or simulate an alarm condition. Similar to the safety showers, the alarm light and siren should be tested every time before unloading FSA into the tanks.

The digital readout display of the tank level indicators shall be clearly legible to the delivery driver during unloading. The driver would likely be standing next to the transfer pump control on his truck a few metres away. The digital readout display shall therefore have a minimum character height of 38 mm with a sunshade fitted on top to prevent glare.

All valves and equipment mounted on the panel shall be mounted at an easily accessible level (no higher than 1.8m above floor level is preferred) and shall be clearly labelled with an engraved traffolyte tag number (red tags for critical equipment, white tags for all other equipment) and functional description e.g. VA83110 FSA TANK 1 FILL VALVE. Other signage which shall appear on the load-in panel includes the maximum fill level label as described in section 12, Placarding, Labelling & Signage.

The purpose of the maximum fill level label is so the Operator and Delivery Driver can check that there is sufficient storage space in the tanks to accept a whole delivery load prior to commencement of the unloading. The units used on the maximum fill level label shall be in litres. This will eliminate the need to provide a conversion chart on the load-in panel.

All pipework and connections shall be rigidly fixed by pipe supports fastened to the load-in panel. All fixings on the panel shall be 316 SS.

An example of a load-in panel arrangement illustrating these requirements is shown in drawing GT36-070-083-09.

5 STORAGE SYSTEM

5.1 Tank(s)

5.1.1 Tank Number and Sizing

The bulk storage volume required at an FSA dosing facility is generally a compromise between sufficient operational storage and the volume of the delivery tanker¹¹. Safety regulations dictate that FSA loads are fully emptied at delivery and shelf-life is not normally a concern.

Sufficient working volume storage (not to be confused with tank design capacity) in the metropolitan area is 7 days' supply at peak flow or 14 days' supply at average flow, whichever is the greater of these two figures. In remote areas additional storage may need to be kept on site to ensure the frequency of deliveries is manageable. Possible disruption of FSA supply due to recent changes to FSA production¹² may require additional storage of up to 2 months' supply for large plants and plants at remote sites.

Note that in the case of the pod tanker, it is only necessary to completely empty an individual pod, which results in delivery sizes of 2,500 or 5,000 or 7,500 litres. Based on the minimum delivery volume of 2,500 litres, then the total storage volume at a facility is required to be approximately 4,000 litres. Similarly for sites where standard trailer tanker deliveries will be received the minimum storage volume required would be approximately 20,000L. Some common tank sizes are 10,000 & 14,000 litres; hence, a single tank facility would typically consist of a single 14,000 litre tank, so that it can store 1.5x a 7,500L delivery and a two tank facility would typically have two 10,000 litre tanks, so it can store 1.5x a 13,400L delivery (Note: the 1.5 times multiplier is simply a rule of thumb which can be optimized for a specific site).

With regards to the number of bulk storage tanks required, provision of two smaller bulk tanks improves the reliability and flexibility of the plant. The costs for two smaller tanks are less than that for one larger tank due to the ability to use a thinner tank wall while retaining structural integrity. Provision of two bulk storage tanks will increase the required building size and cost. The decision of whether to provide one or two bulk storage tanks will need to be made on a site by site basis taking into account both the facility capital cost and the degree of reliability and flexibility desired.

5.1.2 Tank Design

Each tank shall include as a minimum the following fittings:

- one (1) flanged tank fill point inlet nozzle on the tank roof;
- one (1) flanged process outlet nozzle on the side of the tank;
- one (1) flanged tank overflow nozzle with overflow pipework supports. The invert level of this outlet shall be specified;
- one (1) flanged tank vent nozzle on the tank lid;
- one (1) flanged scour outlet nozzle on the bottom of the tank, or on the side if provision is made to ensure that the scour can drain the entire tank – e.g. inclusion of a sloping false floor;
- two (2) flanged nozzles, one vertically in line with the other, on the side of the tank for mounting of a magnetic level gauge;
- one (1) flanged nozzle on the side of the tank for connecting to a pressure transmitter;

¹¹ A CSBP delivery requirement is that the storage tank is required to hold a minimum of 1.5 times the capacity of the chemical road tanker.

¹² CSBP has indicated possible disruption of FSA production each year due to a reduction in the production of fertilizer.

- one (1) flanged side inspection port of diameter 300 mm, to allow camera-based inspection of the tank interior or entry of a hose for flushing purposes¹³. The inspection port needs to be airtight when closed; and
- sufficient lifting lugs.

Previously FSA tanks were designed and constructed with an additional flanged nozzle on the tank lid for an ultrasonic level detector to be mounted. The level of the FSA in the tank shall now be monitored using a pressure transmitter installed on side mounted nozzles as discussed in section 5.2.1 below.

Each tank shall have an integral non-removable roof. The floor of the storage tank shall be graded towards the scour outlet to ensure the tank can be drained completely. A false floor may be required to achieve this requirement.

Each tank shall be designed for the following criteria:

- Contents: 20% to 24% fluorosilicic acid solution.
- Operating & Design Temperature: <select a design temperature and operating temperature range appropriate to the site>
- Operating & Design Pressure: atmospheric and hydrostatic
- Roof Live Loading: 1.25kPa

Adequate fixings at the base of each tank shall be provided to resist all seismic and wind loads as appropriate for the area.

All nozzles shall be flanged, adequately reinforced and of size DN50 minimum. The overflow and vent nozzles shall be at least 1.5 times the filling line diameter of the inlet line, usually DN8014.

In accordance with DS31-02 all flanges shall be Class 14/16 to AS 4087, unless a different flange standard has been adopted for the site for consistency. All flange bolt holes shall straddle the centre line.

The designer should provide drawings to the tank supplier which clearly shows the desired location and size of all connections and fittings on the tank(s).

A permanently affixed corrosion resistant compliance plate shall be provided on the outside of the tank¹⁵. This plate is best located at eye level and positioned so it can be read without stepping down into the bunded area. The characters shall be at least 5mm high and it shall contain the following information:

- Manufacturer's name or Registered Trademark
- Date of Manufacture (month and year)
- Serial Number
- Tag Number
- Design Capacity (Volume in Litres)
- Maximum design service pressure and temperature
- Maximum specific gravity of contents
- Material of manufacture and grade
- Design Code/Standard

¹³ Current philosophy of Safety and Asset Management with regards to CSE (confined space entry) is to totally preclude personnel entry into chemical storage tanks.

¹⁴ AS 3780 Clause 5.7.7 (b) requirement.

¹⁵ AS3780 Clause 5.7 requires certain information concerning tank details to be available to a DMIRS inspector.

Commissioning Plan Information

<p>Prior to delivery to site, all tanks shall be hydrostatically tested using clean water filled to the overflow level at the workshop. The full static head is to be held for a minimum of 12 hours. Once installed, the tanks should be hydrostatically tested to the full static head again to check for any damage which may have occurred during transportation or installation¹⁶. Testing, transportation, quality assurance and other design and manufacturing requirements for GRP tanks are specified in SPS 498.</p>

All tanks shall be transported to site with blind flanges fixed to all nozzles to prevent dust and vermin entering vessels.

If a crane is required to install HDPE or GRP tanks then soft sling rigs shall be used on the shackles so as not to damage the lifting lugs.

5.1.3 Tank Materials

FSA storage tanks shall be constructed of a material that is resistant to FSA in concentrations between 20% and 25%. The Corporation has used black high density polyethylene (HDPE) or glass-fibre reinforced plastic (GRP) to meet this requirement. The specific design and construction requirements associated with each material are listed below.

The Corporation has experienced satisfactory performance from both HDPE and GRP tanks in FSA service, so either material is deemed acceptable for use with FSA. The selection of tank materials should be based on tendered price and the tank life offered / warranted (which may vary based on storage temperature range for HDPE tanks).

5.1.3.1 HDPE Tanks:

- HDPE tanks shall be designed and constructed to DVS 2205.
- Rotationally-moulded type polyethylene tanks are not permitted due to issues with past installations.
- All extrusion welding shall be carried out by qualified welding technicians to DVS 2207-4
- All vertical welds in tanks shall be butt welds. Butt welds have a material rating factor of 0.8 compared to the 0.4 rating of extrusion welding, so the tank can be lighter and stronger.
- HDPE tanks shall have a design life of at least 20 years. Manufacturers may offer / warrant a longer life which may be taken into consideration during tender evaluation. Note design temperature above 40°C will limit the design life of HDPE tanks significantly.

Some of the benefits HDPE tanks are thought to offer are:

- Better impact damage resistance than GRP;
- Higher scratch resistance than GRP;
- Homogeneous material so no chemical attack points even when scratched; and
- Easily repaired, both internally and externally

Water Corporation strategic product specification “SPS 497 HDPE Storage Tanks for Chemicals” shall be used for specifying FSA HDPE storage tanks.

5.1.3.2 GRP Tanks:

- GRP tanks shall be designed and constructed to AS 2634/ASME RPT-1 or BS 4994.

¹⁶ Water used for testing tanks at site can then be discharged through the scour valves to test the bund as well.

- GRP tanks shall be fabricated with a laminate comprising of chopped strand glass mat and woven roving backing a double synthetic fabric reinforced internal chemical barrier all impregnated with a vinyl ester resin (Derakane 411-350 or approved equivalent).
- The outside will be finished with a layer of surface tissue and pigmented flowcoat.
- GRP tanks shall have a design life of at least 20 years. Manufacturers may offer / warrant a longer life which may be taken into consideration during tender evaluation.

Many of the recently constructed plants have adopted GRP tanks for the following reasons:

- GRP tanks are stiffer than PE tanks, so they have a decreased thickness for the same application which makes them lighter;
- Their maximum life is not adversely affected by high temperature;
- Their design life tends to be longer than PE tanks for chemical storage applications;
- They are not prone to leaking at the nozzle welds;

Water Corporation strategic product specification “SPS 498 GRP Chemical Storage Tanks” shall be used for specifying FSA storage tanks in glass fibre reinforced materials.

5.1.4 Tank Plinth

A concrete plinth or tank stand shall be provided for each storage tank so that its base is at least above the 110% bund fill level. The bund floor shall be designed to support the tank plinth or stand with a tank full to the top of its wall. Electrical and control cabling to tank valves and instruments shall be installed above the plinth level so that they shall be precluded from any inundation of the bund.

5.2 Tank Instrumentation

5.2.1 Tank Pressure Transmitter LT83113/83123

An externally mounted pressure transmitter shall be provided to measure fluorosilicic acid in each storage tank. The signal from the pressure transmitter shall be used to calculate the amount of FSA in the tank and to generate high level and low level alarms. This quantity shall be displayed locally at the load-in panel (in litres) as well as on the FLIP and HMI. The tank level indication on the FLIP and HMI shall be % and litres. The load-in panel digital read-out shall show litres. The maximum fill level shall also be shown as text on the load-in panel, magnetic level gauge, FLIP and HMI in litres.

The high level alarm generated by the pressure transmitter shall isolate the GPO used by the delivery tanker transfer pump (if provided) and activate a flashing light on the load-in panel to alert personnel that a high level in the tank has been reached and there is the potential for a tank overflow if the unloading operation is not terminated. The high level alarm is termed the “Maximum Fill Level” and shall be set at a level which corresponds to 2 minutes (~1000L depending on the transfer pump) before a tank would commence overflowing during a filling operation.

The low level alarm generated from this instrument is used to notify the operator that the FSA re-order level has been reached and should be set at a level which corresponds to the tank being sufficiently empty to receive a full delivery of chemical.

The low low level alarm shall be set at just above the invert level of the tank process outlet and is used as a trigger to shut down the FSA dosing system and changeover to the standby dosing system to prevent the dosing pump from running dry. These alarms and their set points are discussed further in section 10.4 of this document and in the control functional specification (DS71-02).

The pressure transmitter shall be installed on side mounted tank connections, complete with isolation valves, scour valve and flushing facilities to permit safe calibration and testing if required. The pipework which connects the pressure transmitter to the tank shall be as short as practicable to minimise the amount of FSA which needs to be drained away and flushed to gain access to the transmitter for maintenance. A diaphragm

seal shall be incorporated in the pressure transmitter installation to protect the transmitter components from contact with FSA.

Pressure transmitters are preferred to ultrasonic level detectors because:

- they minimise access requirements to top of tank, thereby avoiding occupational safety and health issues associated with working at heights;
- have lower capital cost because no stairway and platform on top of tank are required; and
- calibration is simple using simulated injection of pressure, whereas calibration of an ultrasonic level device requires either manual handling of the sensor or raising levels in the tanks to known levels.

Since pressure transmitters are being used to derive a level in the tank it is important that the specific gravity of the FSA is known when setting up and calibrating the pressure transmitters and level indicator. The specific gravity of 22% FSA is approximately 1.1817; this will vary based on the delivered concentration, however using 1.18 as the default specific gravity value for pressure transmitter calibration will result in an accuracy of approximately +/-2% which is considered acceptable for tank level monitoring.

Commissioning Plan Information
Confirm accurate calibration of the tank level indication from the pressure transmitter for the specific gravity of the chemical to be stored in the tank.
Confirm high and high high level alarms initiate well before the tank overflows.

Note: The Corporation is currently assessing the use of radar level transmitters in place of pressure transmitters. Subject to acceptance by the client Region's Asset Delivery Representative, an alternative is a radar level sensor mounted above a blank flange on top of the tank. Although installed at height, the requirement to access the top of the tank for maintenance of the radar level sensor is expected to be minimal because corrosion-related deterioration of the sensor is avoided because it is not exposed to FSA fumes.

5.2.2 Tank Magnetic Coupled Level Gauge LI83110/83120

In addition to the pressure transmitters, each storage tank shall be fitted with a magnetic coupled level gauge. The magnetic coupled level gauge provides a simple, continuous and positive indication of the tank contents and thus a cross-check of the electronic transmitter. This eliminates the need to periodically spot check the electronic indicator. It also provides a back-up level measurement device in the event of power failure.

Each tank magnetic coupled level gauge shall be of bar graph indicator type with a red/white (flip/flop) display that is visible from the tanker unloading apron. Shuttle types are not acceptable as they can lose linkage to the float. A level of float positive buoyancy shall be acquired against the lowest possible specific gravity to ensure the float remains in position for all normal and abnormal operations. A high high magnetic sensing level switch shall be added to the magnetic coupled level gauge to provide additional protection against tank overflow, independent of the pressure transmitter generated alarms. The high high level switch shall initiate an alarm on SCADA as well as audible and visual alarms on the load-in panel. It shall also be interlocked to isolate power to the chemical load-in GPO. The high-high level switch shall be set at a level which corresponds to 20 secs before tank overflow.

Each magnetic coupled level gauge shall be plumbed to side connections on the storage tanks complete with isolation, scour and flushing facilities as shown on the standard drawings. The float chamber shall be constructed of materials suitable for contact with FSA. Glass material shall not be used as the FSA fumes will etch this over time.

¹⁷ FSA concentration and specific gravity information obtained from Wesfarmers CSBP Chem Alert.

5.3 Storage System Pipework

5.3.1 Filling Line

The FSA storage tank filling lines shall be DN50 minimum. The fill line into the tank shall be located diametrically opposite the outlet pipe to minimise the possibility of any air entrainment during filling from interfering with the operation of the dosing pump. The fill line shall enter the tank above the overflow level.

Apart from a small section of fill pipework which is mounted on the load-in panel, the filling line shall be sloped to drain back to the tank. The onboard tanker pumps used for delivery are capable of pumping up to a 10 metre head typically; therefore the height of the filling line should not exceed this height.

Commissioning Plan Information
Prior to the first delivery of chemical, the filling line shall be hydrostatically pressure tested in accordance with AS 4041 to 1.5 times the maximum operating pressure of the tanker pump and held for a minimum of 30 mins. Written proof of this test will be requested by the chemical supplier and shall be made available to them. Note: The tank shall not be subject to the test pressure as it is only rated for static head up to the overflow level.

5.3.2 Vent Line

Each tank shall have a vent line to allow venting of fumes during tank filling and vacuum relief during tank emptying. The vent line shall be sized to ensure adequate air flow out of the tank during a filling operation and adequate air flow into the tank whilst the dosing pump is operating or the tank is being drained. As a minimum, the vent size shall be at least 1.5 times the diameter of the fill or scour line (whichever is the largest).

The vent line shall discharge outside the building at about 500 mm above the site finished surface level, which is high enough to observe any potential dripping, but low enough that it is unlikely that any drips will fall on personnel. The vent discharge point shall be weather-proofed and shall be fitted with a “tropical midge wire” insect screen.

The vent outlet shall be located so that it is possible to gain access to it for maintenance purposes, and shall be located at least 4m away (greater preferably) from the location where the load-in operator and driver stand during tank filling. The vent pipework shall be configured so that condensation of vapours is directed back into the tank.

5.3.3 Scour Line

There shall be a DN50 minimum scour outlet from the bottom of each tank which is plumbed to the bund sump to allow complete emptying of the tank. The scour piping shall be interconnected to the bund sump pump-out line to enable the contents of the tank to be directly loaded to a truck without firstly dumping it into the bund sump.

A DN50 manual isolation valve (VA83114/VA83124) shall be installed as close to the nozzle flange as possible to isolate the tank in the event of an emergency or downstream leak. The instrument drain line shall tee into the scour line in accordance with Section A on drawing GT36-070-083-05.

The scour valves are required to be operated without the operator entering the bund, and so the scour outlet should be located at the edge of the FRP grating or removable cut outs shall be provided in the grating to access these valves. Securely supported extension spindles to bring the valve handles to a comfortable height for ergonomic operation shall be provided.

Tanks shall be fabricated to allow the entire tank including any sludge that may have settled on the tank floor to be drained out completely. Provision of a sloping false floor inside the tank is one way to ensure complete emptying of the tank.

5.3.4 Process Line

This pipework supplies FSA from the tank to the dosing panel, or flushing water to the dosing panel. This pipework shall be arranged to keep the suction line to the dosing pump as short as possible. The diameter of this pipe should be at least equal to, or larger than, the pump suction and discharge port diameters.

The manual tank outlet valves (VA83116/VA83126) shall be easily accessible, either on the FRP grating, or adjacent to the edge of the grating or via removable grating cut outs. This is so that in the event of failure of the automatic tank isolation valves (VA83117/VA83127) the manual tank isolation valve can be operated. It is not considered to be critical for the actuated isolation valves to be specified to fail-closed as the chance of a major leak during a power failure is low, and even if it had occurred, the spillage would still be contained in the bund,

The manual isolation valves shall be flanged directly to the tank outlet nozzles. The actuated isolation valves (VA83117/VA83127) and the acid/water selector valves (VA83118/VA83128) shall be installed as close to the manual isolation valves as possible to minimise the length of pipework which cannot be flushed by the automated flushing system. Detail 1 on drawing GT36-070-083-05 gives an indication of this arrangement.

As the process line is likely to have a low section between the tank and the dosing panel, where it runs beneath the grid mesh, it is necessary to provide a manual drain valve along this line to facilitate the complete emptying of this line prior to maintenance. These drain valves shall be DN15 ball valves with securely-supported extension spindles so their handles are located just below the grid mesh grating for ease of operation (using an extension spindle). As these valves have the potential to drain the FSA storage tanks, their open/close position along with their purpose shall be clearly marked with appropriate signage and their handles shall be lockable to prevent accidental or inadvertent incorrect operation. These valves shall be located at the lowest point along the process line and close to the acid/water selector valves. Detail 1 on the Sections and Details drawing GT36-70-83-05 provides an example of this preferred location. Having them located in this position also means that they can form part of the tank outlet valve arrangement which is normally protected from accidental impact damage and regular thoroughfare traffic by a permanently erected barrier.

5.3.5 Overflow Line

Each tank shall have an overflow pipe sized at not less than 1.5 times the filling line, which shall discharge 200 mm above the bund sump. The overflow line shall have a fillable seal bend to prevent fumes from releasing into the dosing room and a sight tube that is visible from the tanker. Sturdy supports must be provided for the overflow piping to avoid excessive loading on the tank nozzle. No valves or equipment which could potentially cause blockages shall be installed in the overflow lines. Care shall be taken on the design to ensure that the sump water cannot be drawn into the tank under any conditions.

5.4 Storage System Valves

5.4.1 Outlet Isolation Valve (VA83117/83127)

To minimise the potential for chemical leakage, the actuated tank outlet isolation valve(s) (VA83117/83127) shall only be opened when required. In automatic mode, this would occur whenever the duty dosing system is in 'Dosing' mode. Whenever the dosing system reverts to the 'Stopped' state the tank outlet isolation valve(s) shall automatically close. For duty/standby dosing systems if a system is selected to be in 'Dosing' mode, but also selected as 'Standby', the actuated tank outlet isolation valve will also remain closed.

In the event of high sump level alarm occurring in conjunction with a high sump conductivity alarm this shall trigger an automatic closure of the tank outlet isolation valve(s) which will subsequently shutdown the FSA dosing systems.

5.4.2 Acid/Water Selector Valve (VA83118/83128)

The acid/water selector valve as the name suggests is a motorised three-way ball valve which directs either FSA from the tank or flushing water to the dosing panel. In 'Dosing' mode this valve will automatically be configured to direct acid from the tank to the dosing panel. In 'Flushing' mode this valve will automatically be configured to direct flushing water to the dosing panel.

The acid/water valve shall be connected immediately downstream of the tank motorised isolation valve. This arrangement minimises the length of pipework that is unable to be flushed prior to dismantling.

Care shall be taken when specifying this valve to ensure that the correct port type is selected to avoid the potential for flushing water to be routed to the FSA storage tanks. Both T or L ports are generally available and depending on the arrangement of the pipework, and whether the flushing water is located in the branch of the tee (or not), one particular port type will be suitable and the other will not.

5.4.3 Valve Materials

All valves selected for use in the FSA room shall be constructed of materials suitable for contact with FSA. This includes the handles, actuators, balls, ball seals and o-rings.

Plastic valves made of PVC-U, PE or polypropylene with Teflon ball seals and EPDM o-rings such as the Georg Fischer Type 546 PVC-U ball valves satisfy this requirement.

5.5 Flushing Water System

The fluorosilicic acid dosing system shall incorporate an automated flushing system to enable service water to flush FSA from the majority of the storage and dosing system pipework prior to equipment removal and/or maintenance. The objective of flushing is to achieve a pH>5 at the drain point, or downstream of where the maintenance is to be carried out.

The acid/water selector valve and the flushing water valves, which make up part of the flushing system are best located over the bunded storage area, as close to the tank outlet valves as possible, rather than on the dosing panels. This enables practically all of the FSA lines, right back to the tank, to be flushed.

Flushing should only take place in preparation for maintenance. It should not necessarily occur simply when changing over from one dosing system (duty) to another (standby) or when changing from one operating mode on a system to another (e.g. Dosing Mode to Stopped Mode). Routine or excessive flushing of the FSA system can cause scaling in the pipelines, so it should be avoided.

When flushing the FSA system, the flush water should be directed to the dose point under control of the dosing pump at normal dosing rates as this is the safest and easiest disposal route. When the 'Flushing' mode is selected on the FLIP (or HMI) the actuated acid/water selector valve and the dose/drain valves will automatically be configured such that this is the case.

For FSA systems with duty/standby dosing panels during the initial flushing period operation of the standby system should be inhibited by the control system to ensure over dosing does not occur.

5.5.1 Flushing Water Supply

Site service water is generally used as the flushing water supply. If the site service water supply has insufficient flow or pressure to carry out flushing then a dedicated flushing pump will be required as part of the FSA system. Alternatively, if the site water supply has excessive flow and pressure, which could cause overdosing during the initial flushing period or damage to valves and equipment then a pressure reducing valve may be required to limit the flushing flow and pressure. In all cases, the flushing water pressure must not exceed the setting of the dosing pump pressure sustaining valves.

If the same site service water supply is used to supply safety showers then the flushing water off-take shall be located downstream of a reduced pressure zone device (RPZD).

5.5.2 Flushing Water Valve (VA83132/83134)

A motorised flushing water valve shall be provided on each system to enable flushing to occur automatically. A permanent water supply for flushing shall be plumbed to this valve from either the site services water supply or flushing pump with sufficient head to flush water through both the fluorosilicic acid dosing pump and pressure sustaining valve of the dosing system.

The flushing valve is automatically configured, along with the acid/water selector valve and dose/drain valve, when the 'Flushing' mode is selected from the FLIP. As mentioned above, the initial flushing waste stream will be directed to the dose point, so the dose/drain valve will be configured open to dose, as this is the most convenient disposal route.

6 Dosing System

The standard FSA design calls for separate duty and standby dosing systems to be provided. They shall operate independently and automatically.

6.1 Dosing Panels

Dosing panels shall be provided for the fluorosilicic acid dosing equipment and pipework. It is recommended that independent duty and standby panel be provided for:

- Reliable continuous operation
- Increased process capability
- Decrease average variation from FSA target set point
- Reduce the risk of injury during duty system changeover and maintenance

Each entire dosing panel shall be enclosed within a spacious cabinet (with transparent doors) that complies with DS79-03. Enclosure of the dosing system such a cabinet reduces the hazard of undertaking maintenance work and enables the dosing system to be viewed during operation, at the same time providing protection of personnel from any acid leak or spray. Integral with the dosing panel is a drip tray at its base, which is graded to a drain that is piped to the bund sump. The drip tray shall extend well clear of the panel so that all chemical leaks are captured by the tray.

The dosing panel shall consist of a minimum 12mm thick PVC board and drip tray all mounted on a stainless steel or suitably surface protected steel frame. The steel frame shall incorporate lifting lug(s) to enable easy placement and future removal of the entire panel. The dosing panel shall be wall mounted, with a minimum clear space of 500mm between the wall and the back of the panel for the passage of piping, cabling and services. Equipment and piping shall be neatly arranged on the dosing panel. Different pipe sections shall not cross each other unless unavoidable.

6.1.1 Fluorosilicic Acid Dosing Pumps (PU83213 & PU83313)

There shall be a dosing pump for each dosing panel.

Each pump shall comply with the requirements of the Water Corporation's Mechanical standard DS32 Clause 10.8.6. It shall be a positive displacement diaphragm dosing pump, and shall include a double diaphragm, diaphragm leak alarming, integral over pressure protection and it shall be suitable for automatic speed control via a variable speed drive. There will be a provision in the control to set a minimum pump speed limit to prevent damage to the pump motor and at the same time prevent infrequent "slugs" of FSA dosage.

Dosing pump stroke length adjustment when required is normally carried out manually. However, for sites with wide range of plant flow, automatic stroke length adjustment ("wedge" control) can be incorporated in the control. When 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 speed range. The step changes shall be gradual to prevent drastic changes to the dosage.

Each pump shall be mounted on a PVC plinth attached to the dosing panel, so that the pump can be adequately accessed from all sides for adjustment and servicing.

6.1.2 Pressure Safety (Relief) Valves (VA83213/83313)

A separate external pressure safety (relief) valve shall be installed in a bypass arrangement around the dosing pump (i.e. pressure shall relieve to the suction side of the pump) unless the dosing has an internal pressure relief system and relief alarming, The pressure relief valve shall be set to open on failure (fail open).

Commissioning Plan Information

The pressure setting of all pressure safety valves (PSVs) shall be recorded on their (red) valve tags.
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6.1.3 Calibration Tubes (CC83208/83308)

The calibration tube on the dosing panel is used for fault finding and for establishing the performance of new and replaced pumps during commissioning/re-commissioning. The calibration tube shall have sufficient capacity to allow a single calibrating run of at least two minutes duration when operating the dosing pump at full design flow rate. However, it should not be oversized either because then it will take a long time to achieve an accurate estimate of pumping rate. The calibration tube shall be constructed out of PVC or a similar plastic, but it cannot be glass.

The calibration tube shall have an open top or air entry/release point at the top of the column to allow the calibration tube to be filled with service water and subsequently drawn down. A non-return valve (VA83207/83307) shall be provided immediately downstream of the calibration tube to prevent FSA from entering the tube and potentially overflowing the calibration tube.

6.1.4 Strainers (ST83211/83311)

To prevent pipework shavings, silica scale, or other solid impurities from blocking or damaging the dosing pump internals, magnetic flow meters or the pressure sustaining valves, it is required that PVC Y-body strainers be installed upstream of the dosing pumps. As a minimum the strainer shall be fitted with a mesh having 0.5mm sized perforations. As duty/standby panels are recommended there is no need to provide a bypass around the strainer. However, for single panel systems duty and standby strainers shall be provided to keep the panel running whilst the blocked strainer is taken out for service.

6.1.5 Pulsation Dampener (PD83215/83315)

The pulsation dampener shall be correctly sized to suit the dosing pump stroke volume. There are various equations available to calculate the correct pulsation dampener size. Each pulsation dampener supplier generally has their own equation based on the percentage of pressure dampening required. 95% dampening (2.5% above and 2.5% below the mean operating pressure) is an acceptable target. An easy rule of thumb provided by a pump manufacturer¹⁸ is that to achieve a 90% reduction in pulsation a dampener volume that is 26 times the maximum stroke capacity is required.

Pulsation dampeners shall be installed in a vertical position within 10 pipe diameters of the dosing pump outlet. For the best performance the dampener should be installed directly above the pump discharge in the branch of a tee piece so it absorbs the pressure surges with the FSA delivery line.

Pulsation dampeners shall be constructed of materials suitable for contact with FSA such as PVC, PP or PVDF bodies with Hypalon, Teflon or EPDM bellows. They should be charged with nitrogen or compressed air, to a pressure just high enough to achieve dampening as per the manufacturer's recommended procedure.

Certain pump types do not require the installation of Pulsation Dampeners. Approval to not install a Pulsation Dampener shall be obtained from the Senior Principal Engineer Water Treatment or Senior Principal Engineer Mechanical.

6.1.6 Pressure Gauges (PI83216/83316)

A pressure gauge with a minimum display diameter of 63mm (2.5") shall be provided with sufficient range to allow setting of the dosing panel pressure sustaining valve and to assist in continuous monitoring of correct pump performance. The pressure gauge shall incorporate a diaphragm barrier seal to prevent FSA coming directly into contact with the gauge components. The gauge scale shall be sized so that the operating pressure is a maximum of 75% of full scale.

¹⁸ Advice obtained from Prominent Pumps website – Frequently Asked Questions page.

6.1.7 Magnetic Flow Meter (FE83218/83219)

The flow meter installed on each panel shall be a magnetic flow meter sized for accurate operation over the full range of fluorosilicic acid flows. It shall be selected from one of the suppliers on the Water Corporation’s SCADA Approved Equipment List.

The flow meter shall be installed on the panel via wafer or flanged connections (for easy removal) with 10 sensor diameters upstream and 5 sensor diameters downstream of straight uninterrupted pipework. Many of the flow meters supplied for FSA dosing are mini-magflows with sensor diameters of only 2-4mm, so often the required straight pipe distances are provided for in the custom end connections available from the supplier with the magflow. To ensure correct measurement the flow meter shall be mounted on the panel in an orientation such that the pipe is always full and so air and deposits do not accumulate in the measuring tube. An acceptable arrangement is shown on the standard dosing panel general arrangement GT36-070-083-07. Suppliers will provide guidance on the best arrangement for their models. As can be seen on the dosing panel general arrangement, the flow meter is located between the pulsation dampener and the pressure sustaining valve. This is so the accuracy of the flow meter is not affected by pressure fluctuations that can occur on the downstream side of the pressure sustaining valve.

Due to the small sensor diameter of these mini-magflow meters they can be prone to scaling from silica build-up. In the event of complete obstruction, which cannot be cleared with flushing, the normally closed bypass, that has been included around the magflow and pressure sustaining valve, can be opened to allow pressure relief and flushing of the remaining pipework prior to disassembly for maintenance.

6.1.8 Pressure Control (Sustaining) Valve (VA83219/83319)

A pressure sustaining valve automatically holds a steady preset pressure at its inlet when flowing. The pressure sustaining valve installed on each panel improves the accuracy of dosing by providing and maintaining optimum discharge pressure conditions for the dosing pump. The designer shall specify the required setting for the pressure sustaining valve based on:

- The dosing pump manufacturers recommendations including but not limited to the specified minimum differential pressure across the pump
- The range of pressures expected to occur at the chemical dose point
- The difference in RLs between the chemical dose point and the pressure sustaining valve
- Expected pressure losses in the FSA dose lines
- Flushing water supply pressure

The pressure sustaining valve should be located on the dosing panel downstream of the FSA magflow meter but before the dose/drain selector valve. Given the short distance between the pressure sustaining valve and the solution water line, it was considered that there would be negligible impact on lag time to locate the pressure sustaining valve upstream of the dose/drain valve, rather than placing it as the most downstream item prior to the solution line. This location provides flexibility for the dosing pump to operate under normal back-pressure regardless of whether the dosed fluid is directed to dose or to drain. A normally-closed bypass around the pressure sustaining valve and magflow allows the system to be de-pressurised, prior to maintenance, should the pressure sustaining valve become blocked or fails. It can be de-pressurised entirely when the dose/drain valve is in the drain position.

Commissioning Plan Information
The pressure setting of all pressure control valves (PCVs) shall be recorded on their valve tags.

6.1.9 Air Vent Valve (VA83223/83323)

An air vent valve has been included on each panel to allow the manual venting of air during start up and commissioning. All pipework on the panel shall be graded up to this point. The pipework from the air vent valve shall be connected to the tank vent line so that the released air exits the building.

6.1.10 Dose/Drain Selector Valve (VA83224/83324)

A three-way motorised ball valve shall be included on each dosing panel to direct FSA or flushing water to either the dose point or to the flushing containers/bund sump (drain). When a ‘Dosing’, ‘Flushing’ or ‘Calibrating’ operating mode is selected for the FSA control system, this valve is automatically configured to open to dose.

Care shall be taken when specifying and installing this valve and its actuator to ensure that the correct port type is selected and the actuator correctly installed and configured. Both T and L ports are generally available and depending on the arrangement of the pipework and whether the drain position is in the branch of the tee or not, one particular port type will be suitable.

A flexible hose shall be installed at the valve outlet that is open to drain to direct flushing water to a tundish piped to the bund sump. When required the flexible hose enables the operator to discharge the acid or flushing water to a 10L clear polyethylene container for disposal by the FSA supplier. The container shall be dangerous goods approved type.

6.2 Dilution Water System

As stated in section 1.5.2, the Corporation’s FSA storage and dosing standard design is based on diluting of the FSA on the dosing panel, within the bunded area, before dosing into the recipient water main. This has been done for OSH reasons and to eliminate the need for double containment piping.

6.2.1 Dilution Water Supply

The water used to dilute the FSA can be supplied from any of the following sources:

- Site Service Water
- Chlorine Solution Water
- Sample Return Water

Regardless of which source is used, the designer shall ensure that dilution water flow and pressure are well regulated as variations in flow will result in fluctuating measured fluoride concentrations which can cause nuisance alarms. Potential sources of pressure variation in the dilution water supply shall be considered (e.g. upstream pump starts/stops or safety shower testing) and addressed in the design.

The choice of which dilution water source to use will be a site specific decision, but some of the guiding factors to consider are discussed below.

6.2.1.1 Site Service Water

If site service water is used as the dilution water supply then it will need to have sufficient flow, to provide the necessary dilution (at least 20:1 dilution at maximum FSA dose rate) and sufficient head to overcome the back pressure of the dose point into the treated water main. If the site service water has insufficient flow and pressure than a dedicated dilution pump will be required for the FSA system.

On the other hand, if the site service water has excessive flow and pressure, or significant pressure variation, as may be the case in some site water ring main systems with booster pumps, then a flow control valve (FO83203/83303) will be required to achieve the required constant dilution flow and pressure.

6.2.1.2 Chlorine Solution Water

It is common practice to use the chlorine solution water as the FSA dilution water, especially if the chlorine solution lines already run near the vicinity of the FSA storage room or can be designed to do so. Using the chlorine solution water to dilute the FSA eliminates the need to install a flow switch on the dilution line (FSL83205/83305) on the dosing panel as the flow switches on the chlorine system will perform this duty. However, a flow indicator (FI83205/83305) is still recommended to be included on the dosing panel as a useful visual check of dilution water flow.

Using the chlorine solution as the dilution water also allows the chlorine dosing sparger to be used as the FSA dose point as well.

6.2.1.3 Sample Water Return

For sites with High and Low Range chlorination systems it can be complex to marry up the duty/standby FSA dosing system with the on-line chlorination system. Rather than programming more logic and installing additional motorised valves for these systems either site service water is used or sample return water is used as dilution water.

Sample water return is the water which is recycled to the treated water main after it has been used to provide the bulk of the flow to the analysers to reduce the lag times in the control system. The advantage of using sample water return for dilution is that it is generally always flowing and it is independent of whether the high range or low range chlorination system is in operation. If the sample water return flow is lost then flow to the analysers is lost and this will typically shut down the plant. Using the sample return water to dilute the FSA eliminates the need to install a flow switch on the dilution line (FSL83205/83305) on the dosing panel as the flow switch on the sampling system will perform this duty. However, a flow indicator (FI83205/83305) is still recommended to be included on the dosing panel as a useful visual check of dilution water flow.

6.2.2 Dilution Water Valve (VA83202/83302)

Each dosing panel will include a motorised dilution water valve (VA83202/83302) to direct the dilution water to the online FSA dosing panel.

For duty/standby FSA systems using chlorine solution or sample water return as the dilution water supply, dilution flow shall be possible through at least one of the dosing panels at all times, even if the FSA dosing systems are not operating. This is so the chlorine dosing or sampling flow is not unintentionally obstructed.

For FSA systems using service water to supply the dilution water this additional requirement is not necessary as the service water flow through the FSA panels can be interrupted with no consequences.

6.2.3 Dilution Water Pressure Gauge (PI83204/83304)

A pressure gauge shall be provided with sufficient range to monitor the dilution water pressure. If the dilution water is chlorine solution the pressure gauge shall incorporate a diaphragm barrier seal. The scale shall be sized so that the operating pressure is a maximum of 75% of full scale.

6.2.4 Dilution Point Valves

Manual isolation valves shall be provided on the dosing panel upstream (VA83227/83327) and downstream (VA83229/83329) of the point of dilution and on the FSA line (VA83225/83325).

Non return valves are also provided on the dilution line (VA83228/83328) and FSA line (VA83226/83326) to prevent FSA or flushing water flowing into the dilution water circuit and to prevent dilution water back feeding into the FSA dosing system. It is important that these non-return valves are not located too close to the point of dilution otherwise they can become blocked.

Some sites have experienced scaling at the point of dilution, where neat FSA is injected into the dilution water stream. To overcome this issue and to enable maintainers to completely unblock and de-scale this

section of pipework a union has been included on the dilution water line as shown on the dosing panel general arrangement (GT36-70-83-07) so that the injection tee piece can be removed for cleaning.

6.3 Dosing

The diluted FSA which leaves the panel and exits the FSA building is then dosed into the recipient water main via a dosing spear/sparger arrangement. Where possible the diluted FSA dosing line should be combined with the chlorine solution line (even if not used as the dilution water source) to reduce the total number of dosing spears required. This arrangement may also reduce scaling at the dilution tee and dosing spears due to the acidity of chlorine solution.

6.3.1 Dosing Line

The dosing line from the dosing panel to the dosing point shall be barrier protected in accordance with DS79-03.

If the dosing line is buried, then permanent pipe markers shall be installed to warn operators or others working in the area. These buried chemical signs shall be position at every change of direction or at maximum intervals of 50m.

Depending on the dosing point location and whether it is above ground, or below ground in a pit, the pipework layout and design shall include joints and fittings to enable the removal of the spears.

6.3.2 Dosing Diffusers & Valves

Duty and standby dosing spargers shall be provided. Recipient water mains greater than 1000mm in diameter with high flows and pressures normally require a full bore dosing sparger with locating spigot for support (refer drawings JZ39-02-01 through JZ39-02-04). For recipient water mains less than 1000mm in diameter a dosing spear (open ended pipe projecting half way into the main) should be adequate to provide good mixing. The holes on the dosing sparger should face away from the direction of flow (be on the downstream side of the sparger) and the flow direction should be marked on the flange of the sparger.

Dosing spears should pass through a gate valve so that the recipient water main can be operated even when the spear is not in place. Non return valves shall be provided on the dosing line near to the dosing spear to ensure the recipient water does not back-feed up the dosing line when the spears are not in operation. Isolation ball valves shall also be provided to enable the individual spears to be isolated from the FSA and removed for maintenance whilst the other spear is in operation.

For very long dosing line more than 100m in length, a suitable pressure sustaining valve and pressure gauge (PI) shall be installed near to the dosing spear¹⁹ to provide stable control of the dosing especially during high throughputs. This pressure sustaining valve also acts as an anti-siphon valve when the dosing system is not running, preventing diffusion of FSA into the water main. The setting of this pressure sustaining valve shall be determined during plant commissioning and shall be as low as is necessary to achieve the above aims and no higher. The pressure sustaining valve and pressure gauge shall be constructed of materials suitable for contact with FSA similar to those provided at the dosing panels.

Design of the dosing diffusers and/or mixing devices are site-specific and reference shall be made to DS78 Chemical Dosing Standard for guidance.

6.4 Safety Shower and Eyewash

A safety shower and eyewash located between 2 and 7m from the dosing panels and on the same level (no stairs or other obstacles along route) shall be provided.

¹⁹ Similar installations have been provided at various sites including FSA at Gwelup GWTP and Jandakot GWTP; and hypochlorite at Hamilton Hill CDP

7 SAMPLING & ANALYSING

7.1 Sampling Point

The fluoride sampling is generally combined with the other treated water sampling on site. It can be either the final treated water sampling point (on the inlet or outlet of the Clearwater storage) or the chlorine residual sampling point (usually closer to the chlorine solution dosing point), so long as the FSA has had the opportunity to be mixed thoroughly in the recipient water and the sample flow is continuous.

Depending on the system pressure at the location of this off-take the sample may need to be pumped in order to reach the analyser or reach the analyser in an acceptable time frame.

Normally a retractable sample spear with an open end that projects half way into the main is used for sampling, but for some large diameter high pressure pipework a full diameter sampling infuser with locating spigot is required. The holes on the infuser should face the direction of flow (be on the upstream side of the sparger).

7.2 Fluoride Analyser

A fluoride ion analyser is used to continuously monitor the fluoride ion content of the treated water. The analyser shall be connected to the plant control system to generate alarms (low low, low, high and high high) when the concentration strays outside of acceptable limits. These alarms are also used to shut down the FSA dosing system completely, or to initiate changeover to the standby system.

To reduce the complexity of the control system the analyser is not usually used for feedback control of the fluoride dose rate. However, at sites where the background fluoride concentration of the raw water or recipient water varies widely then feedback trim from the analyser could be considered.

The analyser should be installed on a sampling panel located in a sampling room, laboratory or other covered area suitable for instrumentation. The analyser shall be selected from one of the suppliers on the Water Corporation's SCADA Approved Equipment List and it shall be approved by the client prior to purchase. This is to ensure the selection complements other analysers operated and maintained in the client's region to promote uniformity, familiarity and to possibly reduce spares holdings.

More recently, membrane covered electro-chemical sensors have proven to be a popular analyser choice (such as the Prominent Dulcometer® analysers) due to maintenance simplicity, high reliability, high resistance to product cross-contamination, equipment familiarity and life cycle cost performance. They also do not require expensive buffering solutions, unlike some analysers. This type of fluoride ion analyser is most suited for underlying water quality that is stable and does not fluctuate rapidly²⁰.

²⁰ A study was conducted by Curtin University in 2007 to test performance of the Prominent Dulcometer® analysers on varying water qualities. Results from the investigation indicated that there were some variations in the fluoride measurement depending on the level of Iron, Manganese and Calgon in the water.

8 PIPEWORK

8.1 Pipe Materials

All FSA pipework shall be Schedule 80 PVC-U in accordance with ASTM D-1785. Water Corporation has adopted this standard rather than PN18 PVC-U – Series 1 (AS/NZS 1477) in recognition of the pipework typically supplied by contractors and the desire to standardise on one pipe standard. It is recognized that Schedule 80 PVC-U pipe is a superior product in terms of mechanical strength and UV degradation.

The pressure rating of the PVC-U shall be de-rated for service temperatures above 20°C and for FSA service as per the piping system manufacturers' recommendations. Furthermore, where valves, fittings, flanges or other components are added to the pipework, the line shall be de-rated to the rating of the lowest component in the line.

8.2 Pipework Jointing & Solvent Cements

All PVC-U pipework joints and fittings shall be solvent welded, except the tank to pipework connections and some pipework to equipment connections which shall be flanged. The use of screwed fittings should be avoided wherever possible but will probably be necessary for the installation of the pulsation dampeners and pressure gauges. If threaded connections must be used, threads must be new, sharp and secured with a high-quality Teflon tape.

The solvent welded pipe joints shall be made as per the manufacturer's installation instructions WS-2 Welding and Joining Specification and AS 2032.

The solvent cement used for these joints shall be either Tangit U-PVC or Tangit DTX solvent cement. Solvent cement jointing practices shall note and make appropriate allowances for the larger clearances of Schedule 80 PVC-U pipe and fittings compared to those in the Class 18 PVC-U system.

8.3 Gaskets, Bolts, Nuts & Washers

At all flanged interfaces 3mm full face EPDM gaskets, or an approved equivalent, shall be used with 316 stainless steel bolts, nuts and washers.

8.4 Pipework Supports

PVC pipework shall be supported at specific intervals depending on the average pipe wall temperature, the density of the flow medium, the pipe diameter and wall thickness, and the stress loading on the pipeline. The pipe manufacturer will be able to advise on this spacing and typically provide published data in their design guides.

All supports shall be constructed of materials suitably resistant to FSA such as FRP, PE, 316 stainless steel cable tray, brooker rod and unistrut. Mild steel supports shall not be used unless approval otherwise is granted (they would only be considered if coated with a suitable corrosion resistant coating and where contact with FSA or fumes is not likely).

8.5 Hoses and Tubings

Where used, pump suction and discharge flexible hose material shall be compatible with the chemical. The preferred hose type is braided clear PVC minimum PN16 hose (e.g. 6 mm ID/12 mm OD by [Rehau Rauiflam-E](#)). Hoses shall be protected from direct sunlight.

8.6 Pipework Identification and Labelling

Construction Information

<p>All above ground PVC pipework in the FSA building shall be painted with at least two coats of approved water based acrylic paint in accordance with the Water Corporations Standard Colour Coding for Pipework (EG71-1-1) for ease of identification. Paint on pipes located outside the building shall be UV-resistant. Where the pipes need to be in a more aggressive environment, a chemical resistant paint may be required. The manufacturer/paint supplier will need to be consulted regarding the suitability of the paint on PVC.</p>

<p>Chemical pipework shall be identified and labelled in accordance with DS79-04 Chemical Signage, Labelling and Markers.</p>

<p>Buried pipework or pipework installed in culverts (not exposed to UV) does not require painting, but, shall be labelled for identification purposes.</p>

8.7 Pipework Testing

All pressure pipework shall be hydrostatically pressure tested in accordance with AS 4041 before being commissioned. Unless specified otherwise the pipework should be tested to 1.5 x the maximum design pressure. Care shall be taken to remove or isolate equipment from the lines which cannot be safely tested to the same pressure as the pipework.

9 ANCILLARIES

9.1 Wash Trough

A single wash trough shall be provided for the washing of pump components, valves and other equipment prior to removal from the fluorosilicic acid room. The wash trough shall be constructed of PVC, not polyacetal. The wash trough shall be located at a height convenient for operator use and shall drain into the bund sump.

9.2 Flushing and Spill Neutralisation containers

Two 10L flushing containers and two 25L soda ash containers shall be provided.

Flushing containers shall be constructed of clear polyethylene, have a screwed lid and shall be a dangerous goods approved storage container so that they can be accepted back by the FSA Supplier for disposal of flushing waste.

The soda ash containers shall be constructed of black polyethylene and shall have a large diameter screwed lid to enable the scooping out of soda ash for spill neutralization. Some sites have adopted clearly labelled small (80L) wheelie bins for the storage and transport of soda ash and this is also acceptable.

9.3 Safety Showers & Eyewash Units

9.3.1 Number and Location

Three safety showers and eyewash units shall be provided. One safety shower/eye wash unit shall be provided at ground level outside the chemical building between 2m and 7m horizontal distance from the tanker hose connection point. One safety shower/eye wash unit shall be provided within 2 and 7 meters of the load-in panel on the same horizontal plan. The remaining safety shower shall be provided within 2 to 7m of the Dosing Panels, on the same level, in the FSA storage room. The requirement for additional safety showers shall be identified through risk assessment.

All safety showers shall comply with the requirements of DS79-02 and shall be fitted with flow switches to alarm their use.

9.3.2 Safety Shower Water Supply

Potable water shall be used to supply the safety showers and eyewash units. Where a dedicated potable water supply is not available, the safety shower supply off-take from the potable water system on site shall be located upstream of a reduced pressure zone device (RPZD). Any water usage connections associated with any chemical such as dilution or flushing of FSA, shall be located downstream of the RPZD to protect the safety shower supply from contamination. Hydraulic design shall ensure that there is sufficient water pressure and flow available for the safety shower and eyewash to operate when other normal services are in operation.

Backflow prevention devices and their installation shall be in accordance with the current revision of AS3500.1 Plumbing and Drainage – Water Services and shall be installed by a qualified plumber.

9.4 Hose Reels

Retractable wash down hose reels shall be provided and located such that all areas of the load-in and storage facility can be accessed with the hose. This typically means that at least two hose reels are required, one inside the storage room adjacent to the wash trough and one outside the room on the external platform to hose down the load-in panel and apron.

10 PROCESS CONTROL

The degree of process control and monitoring required for an individual fluorosilicic acid dosing facility will depend on many factors including:

1. Whether the flow rate of the water to be fluoridated is fixed or variable.
2. If the flow is variable, the required range of fluoride dose rates (turndown).
3. Whether background fluoride concentrations exist in the source water and the degree of variability of these background concentrations.

For large facilities where the fluoride dosing system is to operate automatically, the following process control philosophy is recommended.

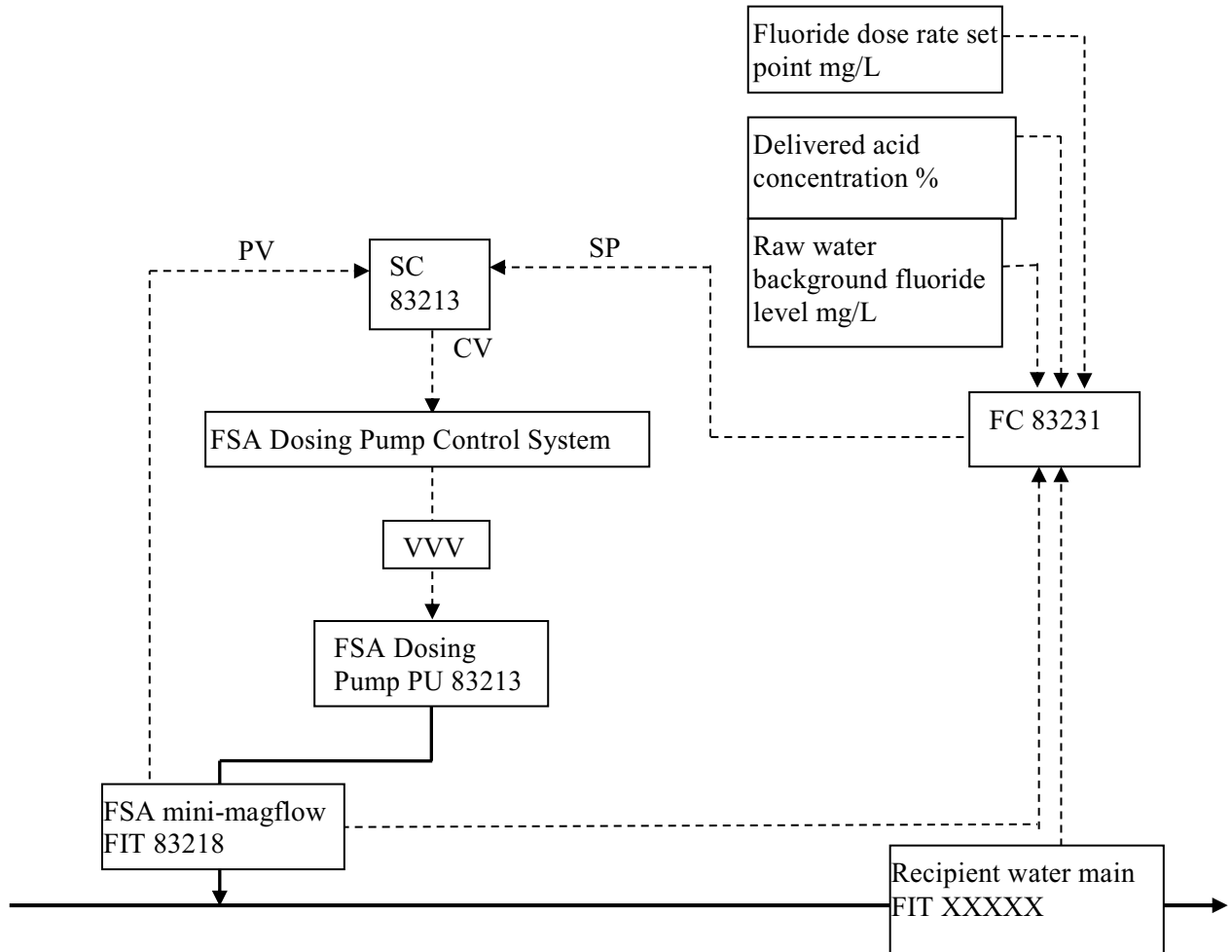
10.1 Control Philosophy

Fluoride dosing shall be flow-paced using feed forward ratio control from the clear water mag-flowmeter to the FSA controller. The required FSA flow rate is then calculated by this controller using operator entered values for FSA delivered concentration, desired mg/l of fluoride ion in the dosed recipient water, and background level of fluoride ion which exists in the source waters. This flow rate is then used as a remote set point input to a feedback flow control loop between the dosing pump and a mini-magflow meter in the FSA dosing line.

This control system operates well provided that:

- i. the clear water magflow meter provides an accurate flow rate
- ii. the ratio controls are set up and calibrated correctly for the pump operational speed to deliver a calculated dosing flow based on the recipient water flow, background fluoride ion and desired fluoride ion level.
- iii. the mini-magflow meter on the FSA dose pump outlet provides an accurate flow rate. (A known problem is long term silica scale buildup in the small bore of the FSA mini magflow meter which causes the instrument flow reading to drift high resulting in a tendency to under-dose FSA. This is managed by routine de-scaling of the instrument).
- iv. the correct acid strength is input by the process supervisor or operator and updated as necessary
- v. the correct desired fluoride ion residual set point is input by the supervisor or operator
- vi. the correct background fluoride ion concentration is input by the supervisor or operator and updated as necessary

A schematic of this control loop is shown in the figure below.



A fluoride ion analyser for the treated water is provided for the purpose of high and low fluoride ion alarm generation and to shut down or changeover the FSA dosing system if fluoride ion limits are exceeded. Cascade trim using a feedback signal from the downstream fluoride analyser is not usually implemented in the process control loop because of the complexity of the control and the need for an analyser with high accuracy and reliability. However, it may be suited for sites where there is frequent wide variation of background fluoride concentrations in the recipient or raw water. Where designers see significant site-specific benefits of implementing fluoride feedback control, this control option should be discussed with the Water Corporation Design Manager.

When the duty dosing system is in ‘Dosing’ mode, the dosing pump will remain idle until a minimum set point flow rate is achieved in the recipient water main. Similarly, the dosing pump will stop running and the system will sit idle in the ‘Dosing’ mode when the flow rate in the recipient water main drops below the minimum set point.

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). The standby system will be allowed a period of time for operation before any faults shuts it down too. In this way, changing back and forth between the duty and standby system is prevented.

To minimize the risk of overdosing of fluoride, the control system shall prevent the concurrent operation of both dosing pumps under any scenario other than when the standby dosing pump is manually run from the MCC (typically done for testing or calibration following maintenance of a dosing pump).

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. Automatic closing of the FSA storage tank isolation valve during the period of power failure is considered unnecessary as other safety measures are in place in the unlikely event of a leak.

The control philosophy is provided in more detail in the standard Functional Control Specification DS71-02.

10.2 Control Location

The FSA storage and dosing system may be controlled from the following locations:

1. Fluoride Local Interface Panel (FLIP) – Full automatic and manual control is possible from this panel located in the viewing room. Any operational mode can be selected from this panel.

For plants where chlorine solution water is used as the dilution flow it is necessary to see the status of flow coming from the chlorine system; hence, these flow indicators would be able to be viewed (but not controlled) from the FLIP.

2. Human Machine Interface (HMI) –The full dosing system is monitored from these computers located in the plant control room (larger treatment plants only) and in the Operations Centre at John Tonkin Water Centre. Controls carried out on the HMIs include ‘Dosing’ and ‘Stopped’ modes and input of set points. Although full automatic and manual control of the FSA system is visible from the HMIs, ‘Flushing’ and ‘Calibration’ modes cannot be selected. These are only available at the FLIP as onsite observation during operation of these modes would be required to minimise potential safety hazards.

10.3 Load-in Control

All delivery tankers have on-board FSA transfer pumps. The multi-pod tankers also have their own power supply on board. Consequently, there is no scope for interlocking the transfer pump power supply with the extra high level alarm on the storage tank as required in AS378021. To compensate for this, each tank is provided with a low (re-order) level alarm and a high high level alarm (visual and audible) on two independent level measurement devices. The low level alarm is to ensure that chemicals are only ordered when the re-order point is reached, greatly reducing the chance for the tank to be overfilled. This is in addition to the high level alarm to alert the tanker driver to stop the pump and the alarms associated with the bund sump level and conductivity.

10.4 Tank Level Alarms

The purpose of the storage tank low low level alarm is to protect the FSA dosing pumps from running dry and to prevent air from being entrained in the suction pipework. Therefore the set point for the low low level alarm should be just above the invert level of the process outlet on the tank.

The low level alarm should be triggered at a level which corresponds to the tank being sufficiently empty to receive a full delivery of FSA. This is also known as the re-order level. This alarm should generate a “Re-Order” message on the HMI.

The high level alarm should be set at a level which corresponds to 2 minutes (~1000L depending on the transfer pump) before a tank would commence overflowing during a filling operation. This alarm will initiate the high level light on the load-in panel and the high level alarm on the HMI.

The high high level alarm should indicate imminent overflow of the tanks and should be set at a level which corresponds to 1 minute before tank overflow. This alarm will initiate the visible and audible high high level

²¹ In situation where the overflow line does not terminate in full view of the person filling the tank (Clause 5.7.7) or where the tank capacity exceeds 50 kL (Clause 5.7.5).

beacon on the load-in panel which should be heard throughout the FSA dosing facility and load-in bay along with high high level alarms on the HMI. The hand switches provided on the load in panel can silence this siren but the light will not stop flashing until the alarm condition has been removed.

Appendix A of the standard FSA Control Functional Specification DS71-02 provides formulas for calculating these alarm levels.

11 LEAK DETECTION AND DECONTAMINATION

11.1 FSA Leak Detection within the Bund

Detection of high conductivity (say above 2500 $\mu\text{S}/\text{cm}$) would generate the high conductivity alarm (AAH 83136) and indicates a spill other than water within the bund. A portable pH probe or litmus paper could then be used to confirm whether the spill is acid. A portable pH probe or litmus paper should also be used during neutralisation of spills²².

Acid detection, indicated by high conductivity (above 2500 $\mu\text{S}/\text{cm}$), shall inhibit emptying of the bund sump via valve VA83137. It shall also close this valve if it happens to be already open. An operator is able to override this interlock by selecting the “bund sump override” from the FLIP.

A high conductivity alarm alone should not initiate automatic shutdown of the acid dosing system. However, should the high conductivity alarm be registered at the same time as a sump high level alarm (LAH 83135), the closure of the actuated tank isolation valves shall be initiated, which will in turn shutdown the dosing systems.

11.2 Decontamination

This section deals with both decontamination of acid spills and decontamination of plant equipment for inspection or maintenance purposes. In both cases, decontamination is not just a matter of acid neutralisation but also requires consideration of fluoride toxicity as this may remain high even after complete acid neutralisation to pH 7.00 (for decontamination purposes, acid neutralisation is generally accepted as being to above pH 5.60).

The design of the FSA dosing facility shall accommodate the following FSA decontamination methods.

11.2.1 Spills within the Acid Bund

For very small FSA spills (e.g. a few drops) acid neutralisation can be accomplished by dilution with water inside the bund (hose down).

For slightly larger FSA spills (e.g. small puddles less than 10L) soda ash is usually employed for neutralisation, again within the bund. Once neutralised, the resultant sludge should be removed from the bund area and disposed of appropriately. The spill area should then be thoroughly flushed with water. Contact of the soda ash sludge with the skin should be avoided as although not acidic, the sludge may contain appreciable levels of fluoride toxicity.

For very large spills (e.g. greater than 10L), the bulk of the spill should first be pumped into a container or tanker and carted off-site to be handled by the acid supplier. Soda ash can then be used to neutralise any residual acid which could not be pumped prior to thoroughly flushing the spill area.

11.2.2 FSA Dosing Pump, Magflow Meter and Piping Decontamination

Due to the small aperture of the mini-magflow meter, efficient decontamination of the FSA dosing pump, dosing pipe, and mini-magflow meter requires connection of a service water supply with sufficient flow and pressure to be connected to the dosing line upstream of the dosing pump. This provision has been included in this standard design as the automated “flushing system”.

This system, although complicating the FSA dosing facility, does efficiently flush all FSA from the dosing pump, mini-magflow meter and piping prior to disassembly thereby reducing the possibility of occupational exposure to concentrated FSA.

²² It is expected that conductivity will increase during neutralisation i.e. adding soda ash will increase the electrolyte content of the water, even though it is neutralising the acidity. Therefore, pH is a more relevant measure than conductivity when neutralising agents are being used.

Additionally, a wash down trough should be located close to the dosing pump. This facilitates further decontamination of the dosing pump within the bund once the pump has been removed from its mounting for maintenance.

12 PLACARDING, LABELLING AND SAFETY SIGNAGE

The following safety signs and placards shall be provided for any FSA storage and/or dosing facility:

- An FSA Bulk Storage Placard (DS WCSS015-1) shall be posted near each entry door to the FSA storage room. These signs shall be displayed so as to be clearly visible from the normal direction of approach.
- Multi-Fluorosilicic Acid Signs (DS WCSS103) shall be posted on the outside wall of the FSA building near the unloading area and next to the personnel door to the viewing room. These signs shall be displayed so as to be clearly visible from the normal direction of approach.
- A Mandatory Multi-PPE Sign shall be posted next to each entry door to the FSA storage room. This sign shall be displayed so as to be clearly visible from the normal direction of approach.
- Storage Tank Identification & Volume Labels (DS WCSS404) indicating the tank number and size shall be posted on each tank. These labels shall be displayed at a level so that it is visible from the normal direct of approach.
- Fluorosilicic Acid Waste Tank Sign (DS WCSS167) should be posted on the cover of the waste tank or on a free-standing post near the buried waste tank. This sign should be positioned so that it is visible on normal approach.
- Emergency Shower & Eyewash Signs (DS WCSS306) shall be posted on the wall next to the safety shower unit or attached to the rear of the shower. These signs shall be displayed so as to be clearly visible from the normal direction of approach.
- Maximum Fill Level Labels (DS WCSS402) shall be posted on the load in panel. These labels shall be clearly visible to the person conducting the transfer of product into the storage tanks.
- Buried Chemical Line Signs (DS WCSS154) shall be used to identify buried FSA lines. These signs should be positioned at every change of direction or at a maximum of 50m intervals.
- Pipe Identification Markers (DS WCSS452) shall be posted on all pipework to indicate pipe contents and flow direction. These markers should be prominently displayed on the pipework to ensure the observer can clearly read the information.

Construction Information
All signs and placards shall comply with the requirements of DS79-04 Chemical Signage, Labelling and Markers .

Where a sign is fitted onto or near a door, the sign shall be easily visible with the door either open or closed. This may require identical signs to be fitted to both sides of the door.

13 Appendix A: FSA Properties and Safe Handling Requirements

Some of the properties and safe handling requirements of FSA are included in the table below. Please refer to Fluorosilicic Acid Chem Alert available from the OSH website for more information.

Name	Fluorosilicic Acid (FSA)
Other Names	Hexafluorosilicate (2-) Dihydrogen, Fluorosilicic Acid, Hexafluorosilicic Acid, Hydrofluorosilicic Acid, Hydrogen Hexafluorosilicate, Hydrosilicofluoric Acid, Sand Acid, Silicofluoric Acid.
Formula	H ₂ SiF ₆
UN No	1778
Hazchem Code	2X
Poison Schedule	7
DG Class	8
Packaging Group	II
H ₂ SiF ₆ concentration	Produced at CSBP Picton Works at 25% and diluted at CSBP Kwinana works to between 20 - 22% (w/w).
HF concentration	Less than 0.5%
S.G.	1.18 (approximately)
pH	<1
Colour	Clear to straw/yellow coloured
Health Hazards	Highly corrosive – severe irritant - toxic. Avoid eye or skin contact, vapour inhalation an ingestion.
Eye	Contact with eyes may result in pain, lacrimation, redness, conjunctivitis burns and possible permanent damage.
Inhalation	Over exposure may result in irritation, coughing and respiratory damage. At high levels ulceration and breathing difficulties can occur.
Skin	Contact with skin may result in rash, dermatitis, blistering and severe burns. Effects (e.g. burning sensation) may be delayed.
Ingestion	Ingestion may result in severe burns to mouth and throat, nausea, vomiting, pain and diarrhoea. Large does may result in sever ulcerations, unconsciousness and death.
Personal Protective Equipment	Chemical Face Shield Full Length Butyl Gloves Impervious Coveralls (such as Tychem [®] F Coverall)

	<p>PVC Boots PVC Apron Full Face Type B (Inorganic and Acid Gas) Respirator</p> <p>Any or all of the above may be required depending on the task being carried out. Please refer to the “Guideline for Level of Personal Protective Equipment to be worn in Fluorosilicic Acid Storage Rooms” on the Infrastructure Design Branch’s Corrosive Chemicals Hazard & Safety Management System Webpage for more guidance.</p>
<p>Other information</p>	<p>Crystals and scale may form during dilution of concentrated FSA solution with water within the dilution range of 10:1 and 20:1 water to acid ratio.²³</p> <p>The pH of poorly buffered waters will be lowered by FSA dosing.</p>

²³ FSA manufactured as a by-product of phosphate fertiliser tends to precipitate silica on dilution. FSA prepared from HF acid and silica tends not to scale on dilution.

14 Appendix B: Commissioning Plan Issues List

Commissioning Plan Information

As part of construction quality assurance or Factory Acceptance (in the case of modules), the slope shall be checked to confirm that requirements have been satisfied. A test shall be conducted for ponding.

Hazard: Damage to assets, injury to personnel.

Commissioning Plan Information

In response to recent devastating bushfires, doors, windows and ventilation openings shall be designed to better withstand bushfire attack in accordance with the most recent version of AS3959 (including any amendments).

Hazard: Damage to assets.

Commissioning Plan Information (Construction)

All above ground outdoor pipework shall be painted in accordance with Water Corporation Standard DS95 (Coating Specification K1). Paint on pipes located outside the building shall be UV-resistant. Where the pipes need to be in a more aggressive environment, a chemical resistant paint may be required. The manufacturer/paint supplier will need to be consulted regarding the suitability of the paint on PVC. Chemical pipework shall be identified in accordance with DS79-04.
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Buried pipework or pipework installed in culverts (not exposed to UV) does not require painting, but shall be labelled for identification purposes.

Hazard: Personnel being unable to identify correct pipework to work on.

Commissioning Plan Information (Construction)

The as designed pressure setting of Pressure Control Valves and Pressure Safety (relief) Valves shall be recorded on their valve tags.
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Hazard: Equipment failure resulting in injury to personnel and damage to equipment.

Commissioning Plan Information (Construction)

All pressure pipework shall be hydrostatically pressure tested in accordance with AS 4041 before being commissioned. Unless specified otherwise the pipework should be tested to the lesser of 1.5x the design pressure or 1.25x the PN rating of the piping component with the lowest pressure rating. Care shall be taken to remove or isolate equipment from the lines which cannot be safely tested to the same pressure as the pipework.

Hazard: Equipment failure resulting in injury to personnel and damage to equipment.

Commissioning Plan Information

A 24-hour hydrostatic leak test shall be conducted on a bund prior to the filling of its associated storage tank(s) with chemical. Confirm the absence of any bund floor or wall penetrations other than the bund drain as such penetrations have been the cause of several chemical leak incidents.

Hazard: Environmental impact due to failure to contain a leak.

Commissioning Plan Information

Prior to delivery to site, all tanks shall be hydrostatically tested using clean water filled to the overflow level at the workshop. The full static head is to be held for a minimum of 12 hours. Once installed, the tanks should be hydrostatically tested to the full static head again to check for any damage which may have occurred during transportation or installation²⁴.

All tanks shall be transported to site with blind flanges fixed to all nozzles to prevent dust and vermin entering vessels.

If a crane is required to install PE & FRP tanks then soft sling rigs shall be used on the shackles so as not to cause damage.

Hazard: Damage to assets or injury to personnel.

Commissioning Plan Information

Prior to the first delivery of chemical, the filling line shall be hydrostatically pressure tested in accordance with AS 4041 to 1.5 times the operating pressure of the tanker pump and held for a minimum of 30 mins. Written proof of this test will be requested by the chemical supplier and shall be made available to them.

Note: The tank shall not be subject to the test pressure as it is only rated for static head up to the overflow level.

Hazard: Equipment failure resulting in injury to personnel and damage to equipment.

Commissioning Plan Information

Confirm accurate calibration of the tank level indication from the pressure transmitter.

Confirm high and high-high level alarms initiate well before the tank overflows.

Hazard: Overfilling of chemical tank due to incorrect level indication.

Commissioning Plan Information

The pressure setting of all pressure safety valves (PSVs) and pressure control valves (PCVs) shall be recorded on their valve tags (as critical safeguards, PSVs shall use red tags).

Hazard: Equipment failure resulting in injury to personnel and damage to equipment.

²⁴ Water used for testing tanks at site can then be discharged through the scour valves to test the bund as well.

Construction Information

All above ground outdoor PVC pipework shall be painted with at least two coats of approved water based acrylic paint in accordance with the Water Corporations Standard Colour Coding for Pipework (EG71-1-1) for ease of identification. Paint on pipes located outside the building shall be UV-resistant. Where the pipes need to be in a more aggressive environment, a chemical resistant paint may be required. The manufacturer/paint supplier will need to be consulted regarding the suitability of the paint on PVC. Chemical pipework shall be identified and labelled in accordance with [DS79-04 Chemical Signage, Labels and Markers](#).

Buried pipework or pipework installed in culverts (not exposed to UV) does not require painting but shall be labelled for identification purposes.

Hazard: Personnel being unable to identify correct pipework to work on.

15 Appendix C: FSA Standard Design - 2 Tanks & 2 Panels Equipment List

The list of equipment for the Fluorosilicic Acid Storage and Dosing System (in Excel workbook format) can be found as standard document [DS 71-01 -Appendix C](#).

END OF DOCUMENT