Engineering Standard

B-SPE-STD-013

Fluoride Storage, Mixing and Dosing Systems

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Contents

1 Purpose ... **6**
2 Application of Engineering Standard ... **7**
3 Definitions ... **8**
4 Abbreviations ... **9**
5 Reference Documents ... **11**
6 Fluoride Chemicals and Selection ... **16**
6.1 Sodium Fluoride ... 16
6.2 Sodium Fluorosilicate ... 17
6.3 Fluorosilicic Acid (FSA) ... 18
6.4 Selection of Fluoride Chemical Systems ... 18
7 General Requirements ... **20**
7.1 Safety in Design ... 20
7.2 Engineering Units ... 20
7.3 Design Life ... 20
7.4 Site Conditions ... 20
7.5 Materials ... 21
7.6 Equipment Selection ... 22
7.7 Colour and Coatings ... 22
7.8 Pipework, Fittings, Valves and Isolation ... 22
7.8.1 Pipework sizing and Line velocity ... 23
7.9 Civil Works ... 23
7.10 Mechanical and Structural Works ... 23
7.11 Electrical Works ... 23
7.12 Instrumentation Works ... 24
7.13 Control System Requirements ... 24
7.13.1 Control Modes ... 25
7.14 Cyber Security ... 25
7.15 Safety Showers and Eyewashes ... 25
7.16 Signage, Tagging, Marking and Labelling ... 26
7.17 Design Philosophy ... 26
7.18 Asset Redundancy ... 27
8 Sodium Fluoride ... **28**
8.1 Sodium Fluoride Storage and Unloading System ... 28
8.1.1 Vacuum Transfer System ... 28
8.2 Fluoride Saturator System ... 31
8.2.1 Up-Flow Saturator ... 31
8.2.2 Down-Flow Saturator ... 36
8.3 Process Control Narrative ... 36
8.3.1 Sodium Fluoride Powder Transfer ... 36
8.3.2 Dilution Water Addition ... 37
9 Sodium Fluorosilicate ... **38**

9.1 Powder Delivery and Transfer System ... 38
9.1.1 Large Bag Unloading and Storage ... 38
9.1.2 Storage of Bulk Bags ... 39
9.1.3 Hoist and Discharge Hopper System ... 39
9.1.4 Conveyance System ... 40
9.1.5 Local Control Panel ... 41
9.2 Sodium Fluorosilicate Storage Hopper ... 42
9.2.1 Number and Size of Hopper ... 43
9.2.2 Hopper Labelling ... 44
9.2.3 Design Pressure and Temperature ... 44
9.2.4 Hopper Materials ... 44
9.2.5 Fill Line Connection ... 45
9.2.6 Weight Measuring Device ... 45
9.2.7 Level Switch ... 47
9.2.8 Hopper Access ... 47
9.2.9 Dust Collector and Vent Filter System ... 48
9.2.10 Pressure/Vacuum Relief Device ... 49
9.2.11 Heaters ... 50
9.2.12 Bin Vibrators ... 50
9.2.13 Knife Gate Isolation Valve ... 51
9.2.14 Rotary Valve ... 51
9.3 Sodium Fluorosilicate Feeding and Mixing System ... 52
9.3.1 Powder Feeding System ... 52
9.3.2 Mixing and Dosing Tank System ... 57
9.4 Process Control Narrative ... 60
9.4.1 Bulk Bag Unloading System ... 60
9.4.2 Mixing System ... 62
9.4.3 Powder Transfer to Transition Hopper ... 63
10 Fluorosilicic Acid ... 65
10.1 Chemical Delivery and Unloading ... 65
10.1.1 Unloading Bay and Spillage Control ... 65
10.1.2 Chemical Spill Holding Tanks ... 67
10.1.3 Transfer/Fill Points ... 67
10.1.4 Fill Lines ... 69
10.1.5 Local Control Panel ... 70
10.2 IBC Delivery and Storage System ... 71
10.3 Bulk Storage Tank System ... 73
10.3.1 Tank Number and Size ... 73
10.3.2 Tank Materials and Standards ... 74
10.3.3 Tank Design Pressure and Temperature ... 75
10.3.4 Tank Nozzles ... 75
10.3.5 Tank Labelling ... 75
10.3.6 Fill Lines ... 76
10.3.7 Level Devices and Control ... 76
10.3.8 Process Lines ... 80
10.3.9 Overflow Line ... 80
10.3.10 Vent Line ... 80
10.3.11 Drains ... 81
10.3.12 Additional Requirements ... 81
10.3.13 Day Tank System ... 82
10.4 Process Control Narrative ... 82
11 Fluoride Dosing System ... 85
11.1 Suction Lines ... 86
11.2 Calibration Cylinders ... 87

11.3 Dosing Pumps ... 87
11.4 Pressure Relief Valves ... 87
11.5 Pulsation Dampeners ... 88
11.6 Pressure Transmitter ... 88
11.7 Vent Lines ... 89
11.8 Flow Meters ... 89
11.9 Pressure Sustaining Valve/Back Pressure Valve ... 90
11.10 Chemical Return Line ... 90
11.11 Carrier Water ... 90
11.12 Dosing Line ... 91
11.12.1 Dosing Quill ... 92
11.12.2 Buried Pipe ... 93
11.12.3 Dosing Pit ... 93
11.13 Skid and Dosing Line Draining and Flushing ... 94
11.14 Dosing Point Location ... 94
11.15 Chemical Mixing ... 95
11.15.1 Static Mixer ... 95
11.16 Fluoride Analyser ... 96
11.17 Dosing Calculations ... 96
11.17.1 Sodium Fluoride ... 96
11.17.2 Sodium Fluorosilicate ... 97
11.17.3 Fluorosilicic Acid ... 97
11.18 Process Control Narrative ... 98
12 Chemical Building and Bunds ... 100
12.1 Chemical Building ... 100
12.1.1 Access ... 101
12.1.2 Ventilation ... 102
12.1.3 Bund Arrangement ... 102
12.2 Fluoride Powder and Chemical Solution Waste Management ... 105
12.2.1 Fluoride Powder Spillage Capture ... 105
12.2.2 Fluoride Solution Waste Tank ... 105
12.3 Compressed Air Room ... 106
13 Standard Designs ... 107
14 Testing and Commissioning ... 108
14.1 Performance Testing ... 109
15 Changes from previous version ... 110
16 Verification ... 110
17 Further Information ... 110
Appendix A Fluoride Sample Calculations ... 111
Appendix B Fluoride System Typical Interlocks ... 115

1 Purpose

Seqwater Engineering Standards are in alignment with the Seqwater Quality Management System. Their purpose is to provide a consistent approach to the development, modification, and management of Seqwater infrastructure that is fit for purpose and safe.

This Engineering Standard provides the minimum requirements and recommendations to be applied for all Seqwater works relating to the design and construction of fluoride powder and liquid chemicals delivery, storage, mixing and dosing systems used in drinking water plants unless approved otherwise. This document must be used in conjunction with the documents it references in order to assist in ensuring a fit for purpose asset.

This document is not intended to be relied upon solely for design, supply, and installation works; advice from specialist engineers and/or Manufacturers may be required on a case-by-case basis.

This document provides specific information in relation to Seqwater's requirements, preferences and best practices for fluoride chemical storage, mixing/batching and dosing systems based on Seqwater's experience, as well as recommendations provided in *Queensland Health Water Fluoridation Code of Practice (2021*) and *Queensland Water Fluoridation Regulation (2020).*

The requirements herein shall apply to two powder and one liquid fluoride chemicals. Refer to Section 6 for specific details of the three permitted fluoride chemicals and their properties.

The requirements herein shall apply to the design and construction of the following sub-systems for the three permitted fluoride chemicals:

- Fluoride powder chemical unloading from small and large bags and storage.
- Fluoride liquid chemical unloading from bulk trucks and storage.
- Fluoride powder solution and liquid chemical dosing systems.
- Process control narratives and sample dosing calculations for the above systems.

This Engineering Standard excludes the following requirements for fluoridation facilities:

- Operational performance criteria, maintenance and cleaning schedule.
- Regulatory record keeping, reporting and other daily operational requirements.
- Emergency response plan for the spill management of fluoride chemicals.
- Personal Protective Equipment (PPE) requirements for handling fluoride chemicals.
- Specification of fluoride analysers and analyser sampling facility.

2 Application of Engineering Standard

This Engineering Standard applies to all Seqwater employees, suppliers, contractors and consultants working for, or on behalf of, Seqwater unless otherwise stated. It applies to all new infrastructure and to all existing infrastructure undergoing refurbishment or modification. It must be used in conjunction with other relevant Seqwater Asset Standards and project specific documents to define the technical requirements for infrastructure design and construction.

Seqwater Engineering Standards detail Seqwater's minimum requirements and recommendations to provide infrastructure that will be fit for purpose, and safe to operate and maintain. However, at all times the designer remains responsible for ensuring infrastructure designed is fit for purpose and safe to construct, operate, maintain, and demolish. In doing so the designer must exercise appropriate due diligence to identify and manage hazards so far as is reasonably practicable.

Designers must also ensure compliance with relevant Australian Legislation, Standards, Codes and Guidelines (including those produced by WSAA). Where no Australian Standard exists for a particular application, work must conform to the most current version of an industry accepted international standard.

Deviation from the requirements in this standard requires written agreement from Seqwater as per the deviation process detailed in Procedure X-PRO-STD-008 Asset Standards Management and Application. This process includes completion of an Asset Standards Deviation Request Form and submission via the Seqwater Project Representative (for external parties) or via Seqwater's Engineering Mailbox (engineering@seqwater.com.au) (for internal parties).

Where noted in this Engineering Standard that Seqwater approval or acceptance shall/must be sought, approval or acceptance must be gained through the Seqwater Asset Standard Deviation Request process, as identified above.

Responsibility for ensuring compliance with Seqwater Engineering Standards lies with those engaged in the management and execution of design, construction, and modification of Seqwater assets. This includes modifications to the functional design of an asset including technical changes made which would extend an asset outside of its design operating envelope and/or approved operation and maintenance practices.

In the case that it is identified that a specific requirement within this Engineering Standard does not meet the requirements of project specific documents, another Seqwater Engineering Standard, or Australian Legislation, Standards, Codes or Guidelines, the conflict must be brought to the attention of the Seqwater Principal Engineering Standards and Assurance (or their delegate) via the Engineering Mailbox (engineering@seqwater.com.au), and written agreement must be gained prior to application of the requirement.

Advice must be sought from Seqwater to clarify any ambiguities regarding this Engineering Standard.

Seqwater undertakes regular updates of Engineering and Asset Standards. Before utilising this Engineering Standard, the complete list of Seqwater Engineering and Asset Standards should be reviewed, to ensure currency and applicability of standards applied to the works.

3 Definitions

The following definitions in Table 3-1 apply to this Engineering Standard.

Table 3-1 – Definitions

Term	Definitions
Ambient Conditions	Refers to the weather-related conditions of the Site, including minimum, maximum and average values and durations of the following: temperature, UV exposure, humidity, rainfall.
Contractor	An entity engaged by Seqwater to undertake work in accordance with an agreed contract and defined scope of work.
Coefficient of Variation (CoV)	The CoV describes the deviation of local concentration from the mean within a cross section of a radial mixing device such as a pipe or channel. The lower the value of CoV, the better the mixing quality. A CoV of between 0.01 to 0.05 is a reasonable target for most mixing applications.
Critical Control Point	A step in the process where control can be applied to prevent or eliminate a significant hazard that could cause harm to customers, the environment, or the business.
Day Tank	A tank to store a sufficient volume of chemical solution to treat water for one day.
Designer	An entity engaged by Seqwater to produce or modify a design for a project (including the design of temporary works); or who provides instructions to another party to complete works in a described manner. May also be the Contractor.
Design Life	The design life of equipment is the period of time during which the item is expected by its designers to provide the required functionality and availability, for the specific operating conditions.
Manufacturer / Supplier / Vendor / Original Equipment Manufacturer (OEM)	The entity that manufacturers or supplies equipment to meet the specifications of the Contractor.
Owner / Principal / Seqwater	The entity that engages the Contractor to undertake the work and takes custody of the outcome. The Owner may delegate responsibilities to other entities to act on its behalf (e.g. a consultant).
Process Conditions	Refers to the conditions that assets may be subject to as a result of operating plant and equipment.
REX	Seqwater's Electronic Document and Records Management System.
SCADA	The system which acquires data from remote devices such as valves, pumps, instruments, transmitters etc. and provides overall control remotely from a host software platform. The host platform also provides functions for graphical displays, alarming, trending and historical storage of data.
Seqwater Engineering Approval / Acceptance	Written sign-off gained via the Deviation Request process, as detailed in X-PRO-STD-008 Asset Standards Management and Application.
Shall / must	Indicates a mandatory requirement.
Should	Indicates a recommendation or guidance.

Term	Definitions
Site	Refers to the location at which the treatment work exists or is to exist.
Site Conditions	Means any of the ambient conditions, process plant, ground conditions and operating conditions that may be reasonably expected to occur during normal operation.

4 Abbreviations

The following abbreviations in Table 4-1 apply to this Engineering Standard.

Table 4-1 – Abbreviations

Abbreviation	Description
ADG	Australian Dangerous Goods (Code / Regulations)
ADWG	Australian Drinking Water Guidelines
AS	Australian Standards
CoV	Coefficient of Variation
FRP	Fibreglass Reinforced Plastic (see also GRP)
FSA	Fluorosilicic Acid
GRP	Glass-fibre Reinforced Plastic
HACCP	Hazard analysis and critical control points
HDPE	High Density Polyethylene
HMI	Human-Machine Interface
IBC	Intermediate Bulk Container
ID	Internal Diameter
LAHH	Level Alarm High-High
LALL	Level Alarm Low-Low
LCP	Local Control Panel
LIW	Loss-in-Weight
LLDPE	Linear Low-Density Polyethylene
LSHH	Level Switch High-High
LSLL	Level Switch Low-Low
MCC	Motor Control Centre
NHMRC	National Health and Medical Research Council
NSF	National Sanitation Foundation
OHL	Operational High Level
OLL	Operational Low Level

Abbreviation	Description
OHW	Operational High Weight
OLW	Operational Low Weight
PLC	Programmable Logic Controller
PPE	Personal Protective Equipment
P&ID	Piping and Instrumentation Diagram
SCADA	Supervisory Control and Data Acquisition
SME	Subject Matter Expert
SPO	Special Power Outlet
TSI	Technical Support and Improvement
VSD	Variable Speed Drive
WAL	Weight Alarm Low
WALL	Weight Alarm Low-Low
WAH	Weight Alarm High
WAHH	Weight Alarm High-High
WSAA	Water Services Association of Australia
WTP	Water Treatment Plant

5 Reference Documents

The documents listed in Table 5-1,

Table 5-2 and Table 5-3 and the requirements therein, are relevant to this Engineering Standard. In their latest editions, these documents form a part of Engineering Standard. Note that this is not an exhaustive list of documents relevant to the works.

Seqwater Engineering Standards are Controlled Documents stored in REX utilising the Controlled Document Number as their REX Document Number. Links to the REX controlled documents are provided in Table 5-1. All other versions in REX are uncontrolled and may not be the current version.

Links to Seqwater Engineering Standards, including Standard Drawings, are also available via the Engineering and Asset Standards Page.

Table 5-1 – Reference Seqwater Documentation

Asset Standard Document Number	Document Title	Controlled Document Number
B-PRO-STD-003	Piping and Instrumentation Diagram Drafting Procedure	PRO-02320
B-SPE-STD-003	Commissioning Requirements	SPE-00346
B-SPE-STD-005	Functional Description Documentation	SPE-00349
B-SPE-STD-007	Process Flow Diagram and Piping and Instrumentation Diagram Requirements	SPE-00351
B-SPE-STD-009	Liquid Chemical Storage and Dosing	SPE-00445
B-SPE-STD-012	Lime Storage, Mixing and Dosing	SPE-00496
D-SPE-STD-001	Water Supply Networks Planning, Design and Construction (Seqwater Supplementary Manual to WSAA, Water Supply Code of Australia WSA03-2011)	SPE-00395
E-SPE-STD-001	Electrical Design and Construction	SPE-00352
I-SPE-STD-015	Instrumentation	SPE-00353
I-SPE-STD-005	High Priority Alarms & Interlocks Management	SPE-00356
I-SPE-STD-006	Monitoring and Control System Alarm and Event Management	SPE-00357
I-SPE-STD-009	Control Systems Architecture	SPE-00358
I-SPE-STD-010	Tag Naming Convention	SPE-00359
I-SPE-STD-011	Control System Testing	SPE-00360
I-SPE-STD-013	Control Systems Design and Construction	SPE-00361
I-TMP-STD-001	Functional Description Part A	TEM-00221
I-TMP-STD-005	Functional Description Part B	TEM-00222
M-SPE-STD-001	General Mechanical Specification	SPE-00367
M-SPE-STD-002	Fixed Platforms, Walkways, Stairways and Ladders	SPE-00366
M-SPE-STD-003	Valves for Water Applications	SPE-00323
M-SPE-STD-004	Protective Coatings	SPE-00348
M-SPE-STD-009	Flow Meters	SPE-00434
M-SPE-STD-010	Chemical Dosing Skids	SPE-00435
M-SPE-STD-012	Chemical Dosing Pumps	SPE-00430
M-SPE-STD-013	Chemical Dosing Piping	SPE-00355
X-LST-STD-001	Seqwater Preferred Equipment	REG-01074

Asset Standard Document Number	Document Title	Controlled Document Number
X-PRO-STD-001	Asset Standards Document Classification and Naming Structure	PRO-01873
X-PRO-STD-002	Engineering Drawing Number Procedure	PRO-01872
X-PRO-STD-004	Development and Review of Asset Standards	PRO-01874
X-PRO-STD-006	Equipment Numbering and Naming Convention	PRO-02190
X-PRO-STD-007	Drawing & Spatial Data Standards	PRO-02187
X-PRO-STD-008	Asset Standards Management & Application	PRO-02205
X-PRO-STD-009	Engineering Design, Construction, Operation and Maintenance	PRO-01617
X-PRO-STD-013	Engineering Technical Hazard Study	PRO-02140
X-TMP-STD-022	Asset Standards Deviation Request	TEM-00224
N/A	Drinking Water Treatment Chemicals – Specifications, Monitoring and Assessment Procedure	PRO-02564
N/A	Control Systems Cyber Security Technical Guidelines	GDE-00326
N/A	Enterprise Risk Management Framework	FRA-00014
N/A	WHS Hazardous Chemicals Procedure	PRO-00008
N/A	WTP and Supply System Process Validation	SPE-00320
N/A	Commercial Services – Chemical Supplier Matrix	REG-00250
N/A	Powder Chemical Storage and Batching Asset Class Plan	PLN-00402
N/A	Seqwater Energy Management System and Plan	PLN-00393
N/A	Seqwater Energy Strategy	PLN-00452
N/A	Powder Chemical Storage and Batching Asset Class Plan – Assessment	D15/117201

Table 5-2 – Reference External Standards, Specifications and Codes

Standard/Specification / Document Name	Document Title
Act	Water Fluoridation Act (2008), Queensland
ADG Code	Australian Code for the Transport of Dangerous Goods by Road & Rail
ANSI/AWWA B701-18	American Water Works Association Standard (AWWA) Standard, Sodium Fluoride
ANSI/AWWA B702-18	American Water Works Association Standard (AWWA) Standard, Sodium Fluorosilicate
ANSI/AWWA B703-19	American Water Works Association Standard (AWWA) Standard, Fluorosilicic Acid
ANSI/AWWA B200-22	American Water Works Association Standard (AWWA) Standard, Sodium Chloride
API 620	Design and Construction of Large, Welded, Low-Pressure Storage Tanks
API 650	Welded Tanks for Oil Storage
AS 1000	International System of Units (S.I.) and its Applications
AS/NZS 1170	Structural Design Actions (set)
AS 1216	Class Labels for Dangerous Goods
AS 1319	Safety Signs for the Occupational Environment
AS/NZS 1477	PVC pipes and fittings for pressure applications
AS 1418	Cranes, Hoist, and Winches Set
AS 1554	Structural Steel Welding
AS 1657	Fixed platforms, walkways, stairways and ladders - Design, construction and installation
AS 1668	The Use of Ventilation and Air-conditioning in Buildings set
AS 1680	Interior and Workplace Lighting
AS 1768	Lightning Protection
AS 2118	Automatic Fire Sprinkler System
AS 2312.1	Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings - Paint coatings
AS 2312.2	Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings – Hot dip galvanizing
AS 2359	Powered Industrial Trucks
AS 2566.1	Buried Flexible Pipelines Part 1: Structural Design
AS 2566.2	Buried Flexible Pipelines Part 2: Installation
AS 2634	Chemical plant equipment made from glass-fibre reinforced plastics (GRP) based on thermosetting resins
AS 2809	Road Tank Vehicles for Dangerous Goods (series)
AS/NZS 3000	Wiring Rules 2007, Electrical Installations
AS/NZS 3500	Plumbing and Drainage
AS 3600	Concrete Structures
AS 3774	Loads on Bulk Solids Containers
AS 3780	The Storage and Handling of Corrosive Substances
AS/NZS 3833	The Storage and Handling of Mixed Classes of Dangerous Goods in packages and IBCs

Standard/Specification / Document Name	Document Title
AS 3959	Construction of Building in Bushfire-prone Areas
AS 3990	Mechanical Equipment – Steelwork
AS 3996	Access Covers and Grates
AS/NZS 4020	Testing of products for use in contact with drinking water
AS 4100	Steel Structures
AS 4766	Polyethylene storage tanks for water and chemicals
AS 4775	Emergency Eyewash and Shower Equipment
ASTM D1998	Standard Specification for Polyethylene Upright Storage Tanks
AWWA Manual	Water Fluoridation Principles & Practices M4
BS EN 12573 series	Welded static non-pressurized thermoplastic tanks system
BS EN 13121-3	GRP tanks and vessels for use above ground – Part 3: Design and Workmanship
DVS 2205 series	Calculation of thermoplastic tanks and apparatus
Fluoride Code of Practice	Queensland Health Water Fluoridation Code of Practice (2021).
Regulation	Water Fluoridation Regulation (2020), Queensland
UN Model Regulation	Recommendations on the Transport of Dangerous Goods
WHS Act 2011	Work Health and Safety Act 2011
WSA 01 - 2004	Polyethylene Pipeline Code V 3.1
WSA 03 - 2011	Water Supply Code of Australia V 3.1
WSA 201-2017	Manual for Selection and Application of Protective Coatings
WSAA Guidance Manual	Water Services Association of Australia *Manual for the application of Health-Based Target's for Drinking Water Safety, September 2015.*
Water Corporation - DS 71-01	Fluorosilicic Acid Storage and Dosing System – Basis of Design

Table 5-3 – Seqwater Standard Drawings

Drawing	Description	REX Record ID
B-DWG-STD-001	P&ID Legend - Sheet 1 of 5, Piping, Valve and Fitting Symbols	691454
B-DWG-STD-002	P&ID Legend - Sheet 2 of 5, Instrument & Control Valve Symbols	691455
B-DWG-STD-003	P&ID Typical Details - Sheet 1 of 2, Instrumentation Valve	843200
B-DWG-STD-004	P&ID Typical Details - Sheet 2 of 2, Motor Control	843198
B-DWG-STD-005	P&ID Legend – Sheet 3 of 5, Material Codes	D18/165556
B-DWG-STD-006	P&ID Legend - Sheet 4 of 5, Major Equipment Symbols	D18/165558
B-DWG-STD-007	P&ID Legend - Sheet 5 of 5, Minor Equipment & Miscellaneous Symbols	D18/165560
B-DWG-STD-031	Sheet 1 of 5 - Sodium Fluoride Down-flow Saturator	D22/333972
B-DWG-STD-032	Sheet 2 of 5 - Sodium Fluoride Up-flow Saturator	D22/333985
B-DWG-STD-033	Sheet 3 of 5 - Sodium Fluorosilicate System	D22/334000
B-DWG-STD-034	Sheet 4 of 5 - Fluoride Chemical Dosing System	D22/334011
B-DWG-STD-035	Sheet 5 of 5 - Fluorosilicic Acid (FSA) System	D22/334020

6 Fluoride Chemicals and Selection

This section provides a brief introduction to the three fluoride chemicals this Engineering Standard applies to. The following three fluoride compounds are permitted to use in Queensland as prescribed under *Queensland Water Fluoridation Regulation (2020) and Queensland Health Water Fluoridation Code of Practice (2021).*

The three permitted fluoride chemicals are:

- Sodium Fluoride
- Sodium Fluorosilicate
- Fluorosilicic Acid

The above three compounds are deemed safe to use in drinking water based on the NHMRC Australian Drinking Water Guidelines (ADWG).

Seqwater only uses fluoride chemicals it procures under contract to ensure that the quality of this product meets the required specifications. The overarching document PRO-02564 Drinking Water Treatment Chemicals - Specifications, Monitoring and Assessment Procedure provides Seqwater's chemical quality requirements for the three permitted fluoride chemicals.

In addition to ADWG, the fluoride chemical quality specification is based on the *Queensland Health Water Fluoridation Code of Practice (2021),* the American Water Works Association Standards, and NSF International Standard / American National Standard for Drinking Water Treatment Chemicals – Health Effects (NSF/ANSI 60).

For some key risks associated with these chemicals, and for generic requirements and considerations including personal protective equipment requirements, refer to Seqwater PRO-00008 *Hazardous Chemicals Procedure*.

Seqwater is required to maintain fluoride concentration of 0.8 mg/L as F^- (± 0.1 mg/L) in drinking water for the local government areas pertinent to Seqwater as stated in *Queensland Water Fluoridation Regulation (2020).* This requirement forms an important basis for chemical selection and design requirements as stated in this Engineering Standard.

The following sections provide some key properties of the three permitted fluoride chemicals, comparative analysis between them, and guidance on chemical selection.

6.1 Sodium Fluoride

Sodium Fluoride (NaF) is a white, odourless compound available as a powder or crystals of various sizes. It is a hazardous and toxic substance which must not be inhaled or allowed to come into contact with the skin.

Sodium fluoride is non-flammable, stable at temperatures up to and beyond its melting point (990°C), and does not react with air or moisture. The crystalline type is preferred for use in treatment plants because it minimises the potential for generation of dust when emptying bags. Sodium fluoride is generally available in purities ranging from 90% to 98 %.

Sodium fluoride must be made into a solution in a mixing tank or a saturator before being dosed into the main. Its formula weight is 41.99 g/mol (fluoride 18.99 g/mol and sodium 23 g/mol) and results in available fluoride content of 45.2% [as F^-].

Its solubility is practically constant at near 40 g/L of water at temperatures generally encountered in water supplies. This equates to fluoride content in the saturated solution about 18.08 g/L. Because of its constant solubility, sodium fluoride is normally used for dosing as a saturated solution. When added to water, it dissolves readily and dissociates into sodium and fluoride ions and achieves a saturated solution within five minutes into a saturator. The usual grade of product produces a saturated solution with pH values near 7.6.

Sodium fluoride is normally used for small systems.

Sodium fluoride is currently delivered to Seqwater sites in 25 kg pails which is unlikely to change in future. It is the most expensive of the fluoride chemicals due to the high processing efforts and large amount of chemicals required for production.

Sodium fluoride is classified as Class 6.1 in the Australian Dangerous Goods (ADG) Code. Therefore, storage, handling and safety requirements of this chemical must comply with *AS 4452 The storage and handling of toxic substances, American Water Works Association (AWWA) Standard ANSI/AWWA B701* and Safety Data Sheets (SDS) available from chemical suppliers or manufacturers.

6.2 Sodium Fluorosilicate

Sodium Fluorosilicate (Na_2SiF_6) is a white or yellowish-white crystalline solid powder and typically available at 95-100% purity with a bulk density of 2680 kg/m^3. It is a hazardous and toxic substance and inhalation of sodium fluorosilicate dust must be avoided.

Its formula weight is 188 g/mol (fluoride 114 g/mol, sodium 46 g/mol and silica 28 g/mol) and results in available fluoride content of 60.6% [as F^-]. The solubility of sodium fluorosilicate depends on water temperature. The solubility at 0^{o}C is 4.3 g/L and at 100^{o}C the solubility is 24.5 g/L. It hydrolyses in water to form a solution with a pH between 3.5 and 4.0. It requires a relatively lengthy time to prepare a saturated solution which is about 10 to 15 minutes depending on water temperature and water quality.

Sodium fluorosilicate is non-flammable, slightly hygroscopic and has no true melting point, but decomposition begins at about 500°C with the formation of silicon tetrafluoride. It is manufactured principally from fluorosilicic acid.

Sodium fluorosilicate is generally dissolved as an unsaturated solution prior to dosing. The unsaturated solution is normally prepared in a mixing/batching tank prior to transfer to a dosing tank. Seqwater normally uses a 0.2% (w/w) solution of sodium fluorosilicate for dosing into the main which equates to the solution fluoride content about 1.21 g/L.

Sodium fluorosilicate is delivered in 1000 kg bulk bags on pallets and used at Seqwater sites in medium to large sized plants where bulk storage hoppers/silos are required.

Sodium fluorosilicate is classified as Class 6.1 in the ADG Code. Therefore, storage, handling and safety requirements of this chemical must comply with *AS 4452 The storage and handling of toxic substances, AWWA Standard ANSI/AWWA B702* and SDS available from chemical suppliers or manufacturers.

6.3 Fluorosilicic Acid (FSA)

Fluorosilicic acid (H_2SiF_6) is a strong acid and has an aggressive character with a propensity to attack many materials and surfaces. It has a pungent odour, an irritating action to the skin and may decompose to toxic fumes, including those of hydrogen fluoride. It is commercially available as an aqueous solution with the acid strength of around 20% to 25% (w/w). A 23% (w/w) acid solution has a pH of 1.3.

It has a formula weight of 144 g/mol (hydrogen 2 g/mol, silica 28 g/mol, fluoride 114 g/mol) and this results in available fluoride content of 79.2% and for 23% (w/w) acid solution the fluoride content is about 18.2% (or 214.7 g/L for S.G 1.18).

Fluorosilicic acid is the most commonly used chemical in the world for dosing fluoride into drinking water. The largest factor in the increased use of fluorosilicic acid for water fluoridisation is due to the strong preference of a liquid feed system over a powder feed system. The liquid system avoids the need to manual handling of dry powder and frequent maintenance requirements of associated powder handling, mixing and dosing system equipment.

Fluorosilicic acid is dosed as a neat solution as delivered or with carrier water to improve the mixing into the main. Fluorosilicic acid is manufactured in Australia and from a supply chain disruptive perspective, locally manufactured products may provide some advantage. Fluorosilicic acid is generally delivered to the water treatment plant sites either by truck tankers or with intermediate bulk containers depending on the site location and demand. Fluorosilicic acid is classified as Class 8 in the ADG Code. Therefore, storage, handling and safety requirements of this chemical must comply with AS *3780 The storage and handling of corrosive substances, AWWA Standard ANSI/AWWA B703* and SDS available from chemical suppliers or manufacturers.

6.4 Selection of Fluoride Chemical Systems

From the three fluoride chemicals as discussed above, the following three basic fluoridation systems are available for fluoride dosing:

- Saturated solution of sodium fluoride.
- Unsaturated solution of sodium fluorosilicate.
- Aqueous solution of fluorosilicic acid.

Table 6-1 provides some common advantages and disadvantages of the three fluoride chemical systems which should be considered in the fluoride chemical selection and system design.

Table 6-1 – Advantages and disadvantages of three fluoride chemical systems

Fluoride Chemical System	Advantages	Disadvantages
Sodium Fluoride	• Dissolves easily and makes a saturated solution within five minutes. • Saturated concentration nearly uniform within applicable temperature range. • Easy to operate and maintain for small treatment plants.	• Most expensive chemical option. • Water softening is required for hard water to avoid scaling from calcium fluoride. • Toxic powder.
Sodium Fluorosilicate	• Least expensive chemical. • Seqwater is familiar with this chemical system. • Relatively less safety concern to handle 0.2%	• Relatively longer time taken to dissolve and saturated concentration is temperature dependant.

Fluoride Chemical System	Advantages	Disadvantages
	unsaturated solution compared to liquid chemical. • Suitable to use with high water hardness and not subject to scaling.	• Mechanical mixing is required to prepare an unsaturated solution. • Capital expenditure is generally high due to the need of storage hopper, feeder, mixing and dosing tank. • Need manual handling for powder transfer from bulk bags to storage hoppers/silos. • More maintenance required for the system. • Toxic powder, dust is hazardous and inhaling must be avoided.
Fluorosilicic Acid (FSA)	• Direct dosing of delivered chemical is possible. • No manual handling required for regular operation. • Most commonly used fluoride chemical in the world. • Less equipment needed for the dosing system compared to a powder system. • Locally available and reliably sourced.	• Chemical cost is higher than sodium fluorosilicate but lower than sodium fluoride. • Aggressive chemical with pungent odor and toxic fumes under certain conditions. • Additional day tank may be required to achieve a physical barrier from overdosing. • Carrier water is needed to achieve mixing as fluoride concentration of the delivered chemical is relatively high compared to a powder solution. • Seqwater is not familiar with this chemical.

Seqwater currently uses sodium fluoride system for small WTPs and sodium fluorosilicate system for large treatment plants. Liquid fluorosilicic acid is currently not used in Seqwater.

Following current Seqwater and Industry best practices and based on water treatment plant size, capital expenditure, and ease of operation and maintenance, the following recommendations are provided for the selection of a fluoride chemical and associated systems for a water treatment plant:

A. For an average plant production capacity equal or less than 10 ML/day, a sodium fluoride saturated solution system is recommended. This will require approximately 110 kg powder per week (4.4 no. of 25 kg pail) at a nominal fluoride dose rate of 0.7 mg/L (powder purity 98%) for a production rate of 10 ML/day. A saturator with capacity above 3000 L is generally not used in the industry. This chemical consumption and the number of saturators required should be considered for the selection of a sodium fluoride system. Note that this system could be more expensive that a liquid system for new installations.

B. For an average plant production capacity above 10 ML/day, the use of either liquid fluorosilicic acid or sodium fluorosilicate is recommended. However, from these two chemicals, liquid fluorosilicic acid is strongly preferred for a new fluoride dosing system or for the complete renewal of an existing sodium fluorosilicate powder system. This is due to anticipated much lower capital costs and ease of operation and maintenance of a liquid chemical dosing system including avoiding the need for frequent manual handling of dry toxic fluoride powder.

7 General Requirements

This section provides a number of general requirements for the design and installation of the three permitted fluoride chemical systems specified in this standard with reference to other applicable standards.

7.1 Safety in Design

In order to incorporate safety in design, Seqwater has a number of Engineering Standards that shall be used in the design and review of new assets and installations and modifications to existing systems:

i. *X-PRO-STD-009 Engineering Design, Construction, Operation and Maintenance*

ii. *X-PRO-STD-013 Engineering Technical Hazard Study*

These standards include discussion of the various risk assessments/reviews, studies, and management systems that must be in place/demonstrated and used in order to satisfy legislative and Seqwater requirements.

All designs and installations shall ensure due consideration is given to reliability, accessibility, maintainability, constructability, operability and mitigation strategies to prevent fluoride overdosing. This shall be demonstrated through auditable design documentation, reviews, communication, meetings, processes/procedures etc.

Design decisions and residual risks in design shall be supported, reviewed and accepted in accordance with FRA-00014 *Enterprise Risk Management Framework.*

For key risks associated with fluoride chemicals, generic requirements and considerations, refer to PRO-00008 *Hazardous Chemicals Procedure,* Safety Data Sheets (SDS) and this Engineering Standard. The details of chemicals provided in this standard are non-exhaustive and the designer shall consider industry and supplier expertise in the design, handling and management of fluoride chemicals and fluoride systems.

7.2 Engineering Units

Where not specified in this document, equipment and instrument units shall be in accordance with the requirements of *AS 1000 International System of Units (S.I) and its Applications* and *I-SPE-STD-013 Control Systems Design and Construction.*

7.3 Design Life

Seqwater document PLN-00402 *Powder Chemical Storage and Batching Asset Class Plan* shall be referred to for the design life of silos, hoppers, mixing/batching tanks and dosing tanks.

Seqwater relevant *Asset Class Plans* and standard specification *M-SPE-STD-001 General Mechanical* shall be referred for the design life of valves, pumps, flow meters, pipework and protective coatings. For the design life of electrical equipment refer to *E-SPE-STD-001 Electrical Design and Construction.*

7.4 Site Conditions

The term Site Conditions is intended to mean any of the ambient conditions, process conditions, ground conditions and operating conditions that may be reasonably expected to occur during normal operation.

Ambient conditions for mechanical, electrical and control equipment shall be specified from the following documents:

i. *E-SPE-STD-001 Electrical Design and Construction*

ii. *I-SPE-STD-013 Control System Design and Construction*

iii. *M-SPE-STD-013 Chemical Dosing Piping*

Design and construction shall allow all assets to operate continuously and uninterrupted between the minimum and maximum Site Conditions specified.

If not defined by Seqwater, Site Conditions for design and construction of process equipment shall be determined by the Designer or Contractor and submitted to Seqwater for approval.

7.5 Materials

Materials selected for silos, hoppers, mixing/batching and storage tanks, screw feeder, saturator, piping and equipment shall be appropriate to the applications and compatible to selected fluoride chemicals and site conditions for which they are intended.

The use of stainless steel shall be limited to dry product only. Dry product takes on atmospheric moisture and will cake and corrode. Therefore, the atmosphere of the dry chemical area shall be dehumidified, or the stainless-steel heat traced to increase the dew point temperature.

If stainless steel is used, passivation and pickling must be carried out correctly in accordance with ASTM A380 to protect fabricated welded areas.

Where not specified, material requirements shall be sought from the following sources as a minimum:

i. Relevant Australian and industry standards and specifications for the material(s) selected.

ii. Vendor and supplier recommendations and experience.

iii. Safety Data Sheet (SDS)

iv. *M-SPE-STD-001 General Mechanical*

v. *M-SPE-STD-002 Fixed Platforms, Walkways, Stairways and Ladders*

vi. *M-SPE-STD-004 Protective Coating*

vii. *M-SPE-STD-010 Chemical Dosing Skids*

viii. *M-SPE-STD-013 Chemical Dosing Piping*

ix. *D-SPE-STD-001 Water Supply Networks Planning, Design and Construction*

x. PLN-00402 *Powder Chemical Storage and Batching Asset Class Plan*

xi. *Powder Chemical Storage and Batching Asset Class Plan – Assessment (REX ID – D15/117201).*

Materials used in equipment, piping, coatings, joining and others which may come in contact with drinking water must have an appropriate certification to *AS/NZS 4020*. Refer to potable water compatibility section of *M-SPE-STD-001 General Mechanical* for further details.

7.6 Equipment Selection

In general, this Engineering Standard does not specify the type and manufacturer of equipment (pumps, valves, mixers, instruments etc.) for a design. Where not specified, requirements shall be sought from the followings as a minimum:

i. *X-LST-STD-001 Seqwater Preferred Equipment*

ii. *M-SPE-STD-012 Chemical Dosing Pumps*

iii. *M-SPE-STD-009 Flow Meters*

iv. *M-SPE-STD-001 General Mechanical*

v. *I-LST-STD-001 Control System Prescribed Equipment*

Improved energy performance of new equipment shall be considered in the equipment selection process as specified in the following documents:

vi. PLN-00393 *Seqwater Energy Management System and Plan*

vii. PLN-00452 *Seqwater Energy Strategy*

7.7 Colour and Coatings

Where needed, buildings, enclosures and shelters, pipes, tanks, silos, hoppers, saturators, fittings, fixtures, equipment and surfaces shall be coloured / coated in accordance with:

i. *M-SPE-STD-001 General Mechanical*
ii. *M-SPE-STD-004 Protective Coatings*
iii. *WSA 201-2017 Manual for Selection and Application of Protective Coatings*
iv. *AS 2312.1 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings - Paint coatings*
v. *AS 2312.2 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings – Hot dip galvanizing*
vi. Other relevant legislation and Australian Standards, especially those referenced in the above documents.

7.8 Pipework, Fittings, Valves and Isolation

i. All pipework and fittings shall comply with the requirements of the following standards, and the relevant industry and Australian Standards referenced within:

   a. *M-SPE-STD-STD-001 General Mechanical*
   b. *M-SPE-STD-003 Valves for Water Applications*
   c. *M-SPE-STD-010 Chemical Dosing Skids*
   d. *M-SPE-STD-013 Chemical Dosing Piping*

ii. Any flexible connecting sleeves will be designed and installed as best as practical to avoid large losses of fluoride chemical powder or solution in the case of failure.

iii. Mechanical isolation of piping and dosing systems shall be in accordance with *M-SPE-STD-001 General Mechanical*.

7.8.1 Pipework sizing and Line velocity

Suitable line velocities should be considered in all pipework to manage stagnation, settlement and degradation of chemical as well as maintain the integrity of assets. Line velocities requirement in Table 7-1 should be taken as a guideline unless deemed inappropriate by the designer for a particular application, specifically for small systems.

Table 7-1 Recommended Line Velocities for Liquid Fluoride Chemical or Powder Solutions

Purpose	Pipe Material	Maximum (No Fast Opening / Closing Valves)	Maximum (Fast Opening / Closing Valves)	Minimum Line velocity
General	Plastic, GRP	2 m/s	1.5 m/s	0.5 m/s
	Metallic	3 m/s	2.5 m/s	0.5 m/s
Pump suction	All	1 – 1.5 m/s		0.5 m/s

The pipework used to transfer and dose liquid fluoride chemical and powder solutions are required to be included provisions of flushing with potable water for periodic cleaning.

7.9 Civil Works

Civil works shall comply with the requirements of WSA 03 *Water Supply Code of Australia,* SPE-00395 *D-SPE-STD-001 Water Supply Network Planning, Design and Construction (Seqwater Supplementary Manual to WSAA Water Supply Code of Australia WSA03-2011 Version 3.2)*, and relevant Seqwater, Australian and industry Standards, Specifications and Codes.

All concrete shall be suitably finished and coated for the application and in accordance with SPE-00348 *M-SPE-STD-004 Protective Coatings*.

7.10 Mechanical and Structural Works

Mechanical and metal structural design, construction and equipment selection shall be completed in accordance with the requirement Seqwater's specifications, legislative, Seqwater, Australian and industry Codes, Specifications and requirements.

Refer to *M-SPE-STD-001 General Mechanical Specification* for further guidance.

7.11 Electrical Works

For fluoride systems, electrical switchboards and Motor Control Centres (MCCs) shall be located in a separate room from the fluoridation room to minimise deterioration due to corrosion and to minimise the need for entry into the fluoridation room by operational and maintenance staff. The electrical control room shall have a separate entry door with no interconnections with the fluoridation room to prevent exchange of air between the two rooms. The fluoridation room and the MCC room must have a common wall with a window to allow operators to have a clear view of the fluoridation system equipment when working.

Dosing pumps must be hard-wired to the control room rather than connected by any wall plugs.

All electrical works shall comply with the requirements of *E-SPE-STD-001 Electrical Design and Construction*, the standards referenced within, *Queensland Health Water Fluoridation Code of Practice (2021), relevant legislation* and relevant Seqwater, Australian and industry Standards, Specifications and Codes.

7.12 Instrumentation Works

Instrumentation shall comply with the requirements of this Engineering Standard, *E-SPE-STD-001 Electrical Design and* Construction, *I-SPE-STD-015 Instrumentation* and legislative, Seqwater, Australian and industry Codes, Specifications and requirements.

i. Transmitters and control circuits shall comply with the voltage requirements of *E-SPE-STD-001 Electrical Design and Construction*.

ii. Safety devices or switches used for equipment protection or critical process safety or protection against environment release or personal safety shall be hardwired and fail-safe with the requirements of *I-SPE-STD-013 Control Systems Design and Construction*.

iii. Flow meters shall comply with the requirements of *M-SPE-STD-009 Flow Meters and X-LST-STD-001 Seqwater Preferred Equipment* for the selection and installation.

iv. Indicators shall comply with the requirements of the *Instrumentation Indicators* section of *E-SPE-STD-001*.

v. Displays shall be digital and suitably weatherproof to the site conditions and shielded to prevent glare.

7.13 Control System Requirements

This section provides Seqwater requirements on control systems for fluoride chemical storage, mixing/batching and dosing facilities.

Control systems shall comply with the requirements of the key standards listed below:

I. I-SPE-STD-005 High Priority Alarms & Interlocks Management

II. I-SPE-STD-009 Control Systems Architecture

III. I-SPE-STD-013 Control Systems Design and Construction

Standards noted above are the key standards relevant to this section, but the standards noted within these key standards shall also apply and must be considered as part of the design.

A Functional Description for the fluoride chemical unloading, storage, mixing/batching and dosing system(s) shall be developed in detail to cover control requirements. Functional Descriptions shall use the following standards and templates as necessary:

- *B-SPE-STD-005: Functional Description Documentation*
- *I-TMP-STD-001: Functional Description Part A*
- *I-TMP-STD-005: Functional Description Part B*
- *I-TMP-STD-013 Cause and Effect Matrix*
- *I-SPE-STD-013: Control Systems Design and Construction*

Process control narratives for the three permitted fluoride chemicals covered in this Engineering Standard have been included in the relevant Section for each respective chemical.

Appendix B summarizes typical trip and hardware/hardwired interlocks to be considered for unloading, storage, mixing/batching and dosing systems for three fluoride chemicals and for the preparation of Cause-and-Effect Matrix. Trips and interlocks as defined in *I-SPE-STD-013 Control Systems Design and Construction* have been specified in Appendix B. These must be modified in accordance with project design requirements, and additional interlocks may be necessary depending on the specific application and design. These should be outlined in key control system documents as mentioned above.

7.13.1 Control Modes

The fluoride control system shall support two out of three distinct control modes for plant, processes, and equipment as included in I-SPE-STD-013 which is outlined below.

I. Local – plant may only be operated in the field independent of the control system. In this mode, only hardwire/hardwired interlocks remain active. This mode shall only be used during fluoride system commissioning and maintenance. Only spring return momentary switches shall be used for fluoride system local manual equipment operation.

II. Remote Manual Mode – NOT TO BE USED for the fluoride control system other than transfer of liquid chemicals from a storage tank to a day tank (where used) following recommendations in *Queensland Health Fluoride Code of Practice (2021).* However, the design may consider keeping this mode only to be used for 5 to 10 seconds in each activation if identified that the function of an equipment or electrical control component cannot be verified without this mode during commissioning, maintenance or replacement.

III. Remote Automatic Mode – plant is controlled by the control system. In this mode, all interlocks (i.e., hardware/hardwired, trip), process and start permissive remain active. Under remote automatic mode:

   a. Fixed Speed and Fixed Flow control modes for screw feeders and fluoride dosing pumps shall NOT be used.

   b. Flow paced with chemical flowmeter feedback shall be the only control option for fluoride dosing pumps, see section 11.18 for more details.

Manual operation of any equipment of the fluoride mixing and dosing system shall not be allowed other than commissioning, maintenance and for the transfer of fluorosilicic acid from a storage tank to a day tank (if incorporated in the design). Manual operation shall not be used mainly to avoid potential risks of overdosing.

7.14 Cyber Security

For all units associated with fluoride chemical storage, transfer, mixing/batching or dosing, whether supplied as a package unit or not, the vendor shall comply with Seqwater cyber security requirements as specified in the GDE-00326 *Control Systems Cyber Security Technical Guidelines.*

The vendor shall provide sufficient information as requested by Seqwater to allow the assessment of cyber security risks.

7.15 Safety Showers and Eyewashes

Safety shower and eye wash facilities shall be supplied with potable water and must comply with the requirements of *AS 4775 Emergency eyewash and shower equipment.* In addition, emergency eyewash, shower equipment, service water pipework and materials installed for use in supplying emergency showers and eyewashes shall:

i. Be installed out of direct sunlight, or

ii. Where not practicable to install out of direct sunlight, be insulated and lagged to ensure the safety of personnel and prevent excessive water temperature.

Safety showers and eyewashes shall be fitted with a flow switch and the switch shall generate a flow alarm to SCADA. The flow alarm is to identify the activation of these devices when used by an individual who may be in an accident and need assistance from others monitoring SCADA.

Safety showers, eye wash facilities and hose reels shall be provided at all levels within the building, in each bund or each product transfer point or where product packages are opened. Hose reel may be of use for chemical wash down during spills, where appropriate.

The safety shower and eye-wash facilities shall be provided within 7 m, but not nearer than 2 m, to any product transfer point and where product packages are opened.

The safety shower shall be positioned in an accessible location that requires no greater than 10 sec to reach. The shower shall be located on the same level as the hazard and bunds must be arranged to ensure a clear path free of trip hazards to use the equipment.

A green light shall be installed near the safety shower and eye-wash facilities at a suitable height to assist in locating them easily at nighttime.

7.16 Signage, Tagging, Marking and Labelling

All equipment, instrumentation, and pipework should be numbered and labelled, and include nameplates in accordance with:

i. *M-SPE-STD-001 General Mechanical*
ii. *E-SPE-STD-001 Electrical Design and Construction*
iii. *I-SPE-STD-010 Control System Tag Naming*
iv. *X-PRO-STD-006 Equipment Numbering and Naming Conventions*
v. PRO-00008 *Hazardous Chemicals Procedure*

7.17 Design Philosophy

In this Engineering Standard, the design and construction requirements for three permitted fluoride chemicals i.e., sodium fluoride, sodium fluorosilicate and fluorosilicic acid, have been provided. The proposed process design puts special attention to identify all possible causes of fluoride overdosing and adopts strategies to prevent overdosing. A high-level summary of key design aspects for the three permitted fluoride chemicals has been provided below.

Sodium Fluoride: A system consisting of either a down-flow or an up-flow saturator has been proposed for saturated sodium fluoride systems to dose fluoride into a main. In general, due to low maintenance requirement and current industry trends, an up-flow saturator is preferred over a down-flow saturator for a new system. Vacuum transfer of sodium fluoride powder from small bags or pails to the saturator is adopted with a dust extraction line fitted with a water trap. Water softening must be provided for saturator feed water with water alkalinity of 75 mg/L [as $CaCO_3$] and above.

Sodium Fluorosilicate: A system consisting of a sodium fluorosilicate powder unloading facility from large bags, single storage hopper, a screw feeder, a mixing tank and a dosing tank are proposed for dosing sodium fluorosilicate solution at a fixed concentration (generally 0.2% (w/w) solution) into a main. In general, the use of a Loss-in-Weight (LIW) feeder is preferred over a volumetric feeder due to its self-calibration feature and capability of complete control over product quality variations. This standard proposes a wetting system to pre-wet the sodium fluorosilicate powder before feeding into a mixing/batching tank.

This Engineering Standard proposes separate mixing and dosing tanks. The mixing tank includes an underflow weir to gain the required detention time before the solution overflows to the dosing tank. The mixing system will start and stop based on the dosing tank liquid level. The water flow rate to the mixing tank is required to be maintained within 5-15% higher than the maximum sodium fluorosilicate solution dosing flow rate.

Fluorosilicic Acid *(FSA):* The design proposes to dose fluorosilicic acid directly from a storage tank to a main by incorporating the philosophy of an “electronic day tank” system with several interlocks from electronic devices to overcome potential fluoride overdosing scenarios. Key interlocks include:

i) higher daily draw-down volume recorded from either of two storage tank level transmitters.

ii) high-high flow signals either from primary or secondary chemical dosing flowmeters or flow discrepancy between them.

iii) high-high fluoride level in treated water from any of two fluoride analysers.

iv) higher daily chemical consumption volume from either of two chemical flowmeter totalizers.

v) flow discrepancy alarm from two main water flow meters.

This Engineering Standard prefers to use the concept of electronic day tank instead of a physical day tank due to the requirement of an additional tank, pump, valve, instrument, control and daily operator engagement for manual chemical transfer. Where an electronic day tank system cannot be implemented, a physical day tank must be used to transfer FSA from a storage tank to a day tank before dosing fluoride into a main. An example for this scenario could be where daily draw-down chemical volume cannot be monitored from storage tanks or a suitable reliable chemical flowmeter cannot be obtained to monitor, control low dosing rates, and obtain daily chemical consumption volume from the chemical flow meter totalizer.

Carrier water must be added for fluorosilicic acid dosing near to the dosing point with a ratio not lower than 20:1 to assist mixing into the main and minimize any silica scaling potential on the dosing line.

7.18 Asset Redundancy

This Engineering Standard does not specify redundancy requirements for all essential equipment and dosing lines. The project shall determine the final number and redundancy requirements for equipment and dosing lines on a case-by-case basis considering the site's size, availability, criticality requirements, fluoride chemical supply chain risk, usage, site location and staffing, reliability, operability, maintainability, regulatory requirements, other Seqwater standard requirements and any other relevant issues.

8 Sodium Fluoride

This chapter covers sodium fluoride powder transfer and saturator systems. The details for sodium fluoride dosing system are covered in Section 11 herein and the requirements for sodium fluoride building and bunding arrangement are included in Section 12 herein.

The storage and handling of sodium fluoride must comply with requirements of the *Work Health and Safety Act 2011*, *AS/NZS 4452 The storage and handling of toxic substance* and *Queensland Water Fluoridation Code of Practice (2021)*. The design must ensure that the handling facility provides a safe working environment and facilitates safe working practices for operators.

This section should be read in conjunction with sodium fluoride P&ID Standard Drawings *B-DWG-STD-031* and *B-DWG-STD-032* as referenced in Section 13.

8.1 Sodium Fluoride Storage and Unloading System

Sodium fluoride shall be stored inside a building in a cool, dry, and well-ventilated area. Humidity control of the storage room should be considered if the average sodium fluoride turnover is low. The design and construction requirements for the fluoride building are discussed separately in Section 12.

The storage requirement for sodium fluoride pails and water softener resin regeneration sodium chloride salt (where used) shall generally follow the same basis of minimum chemical demand as provided for the sizing of bulk storage tanks for FSA in Section 10.3.1. The final chemical storage size should be determined considering chemical properties, general availability of chemical including the supplier's location and reliability of supply during any period of shortage, delivery time delay due to natural or human-caused emergencies, site's availability and criticality requirements.

Seqwater generally receives sodium fluoride in 25 kg pails which are stored temporarily inside a building in the designated storage area. Sodium fluoride is generally transferred to the saturator by a vacuum system and the design requirements for powder transfer are described below.

8.1.1 Vacuum Transfer System

The preferred method of transferring sodium fluoride powder or crystal chemical from small package bags/pails to saturators shall be by a vacuum conveyor system. The design must ensure a dust free working environment, minimise manual handling and eliminate direct contact with the chemical. Vacuum conveyance transfer arrangements shall include:

i. An unloading point: The unloading/fill point of the transfer system should be a hand-held pick-up wand that the operator can freely move and insert into a pail/bag to facilitate the transfer. This will prevent unnecessary manual handling of chemicals and pouring of a pail/bag into saturators which can result in airborne dust.

ii. A vacuum generator: A vacuum motor/fan shall be generally used for this application that moves powder from the pail through the conveying flexible piping to the receiving collection unit on top of the saturator.

iii. A hand-held vacuum suction wand: When inserted into a bag/pail, the powder withdrawn, and the air shall be drawn upwards by a vacuum motor through the filter to remove any powder particles and the withdrawn powder shall enter into the collection unit. A large volume inside the unit will cause the air velocity to drop and thus allow the powder to drop to the bottom of the unit.

iv. A flexible vacuum transfer line to the saturator with a solenoid valve at the entry point of the saturator which closes and opens at a certain interval with start and stop of the vacuum motor.

v. A collection unit with a solenoid dump valve which shall open to dump powder to the saturator when the vacuum motor stops.

vi. A filter, and the filter shall:

a. be generally a cartridge type and housed in a container within the collection unit with an access lid for filter replacement unit located on top of the saturator. The filter lid shall be sealed to prevent the escape of powder chemical dust.

b. be capable to remove at least 99.9% of the smallest powder particle size as defined on the chemical Safety Data Sheet (SDS) or 1 µm, whichever is lower.

c. be sized appropriately for the design criteria as mentioned below in item (ix) and to allow maintenance staff to safely carry out replacement of filter elements to the top of saturator.

d. be designed to be cleaned with a compressed air reverse pulse for a couple of seconds while the dump valve remains open. The filter self-cleaning system must prevent dust escaping to the environment. Refer Section 8.1.1.1 for reverse pulse filter cleaning system requirement.

e. be considered to be provided with a pressure differential switch across it to alert of its condition.

f. have a dust extraction line from the filter via the vacuum motor into a water trap to collect any residual dust. The extraction line shall be directed outside of the fluoridation room with its end to discharge into a water trap. The line shall be ducted via a flexible connection to the water trap and properly supported. See Section 8.1.1.2 for water trap requirements.

vii. A vacuum motor/fan which is side mounted or positioned in a way that allows for filter maintenance/replacement without the need for it to be removed.

viii. A transfer line pipework which is resistant to abrasion and corrosion from powder chemical materials. The transfer pipe shall have a minimum ID of 50 mm and the pipe length should be kept as short as possible.

ix. The vacuum transfer system should be designed to transfer 25kg of fluoride powder generally in less than 5 minutes.

x. A Local Control Panel (LCP) with buttons/indications to transfer sodium fluoride powder chemical from pails or small bags to the saturator, refer to Section 8.1.1.3 for LCP requirements.

8.1.1.1 Reverse Pulse Filter Cleaning

The reverse pulse filter cleaning system shall include the following requirements:

i. The reverse pulse filter cleaning system shall automatically clean the filter with a compressed air pulse after powder being dumped to the saturator while the dump valve remains open.

ii. the system shall consider to trigger an alarm to the site control system for the filter blockage from the high-pressure differential switch across the filter.

iii. The compressed air supply for the pulse air cleaning shall be clean, dry and comply with the pulse air cleaning system manufacturers specification.

iv. Air supply system shall be fitted with a pressure regulator if a specific pressure is required for filter cleaning. A pressure relief valve shall be considered in the air supply line to isolate the air supply in the event of a pressure regulator failure.

8.1.1.2 Water Trap

Dry sodium fluoride chemical shall not be allowed to escape from the fluoridation room to the external atmosphere. To address this, a water trap must be used to capture fluoride dust from the filter dust extraction line. A water trap is designed to trap dust into water by allowing the dust-air mixture to pass through the water leaving the air to be vented clean to the atmosphere.

The water trap system, as a minimum, shall include the following requirements:

i. Water trap is a small tank, manufactured from chemical and UV resistance materials. UV-stabilised polyethylene tank is acceptable.

ii. Water trap shall be sized appropriately considering site fluoride usage rate and the requirement of water trap solution discard frequency to maintain dust trapping capability.

iii. The trap shall be mounted on the ground floor located outside the fluoride building.

iv. The water trap shall be fitted with connections for air-dust pipework, overflow line, drain line, vent, and hinged inspection hatch.

v. The dust extraction line outlet shall always be submerged in water to trap dust; however, the design shall not create any excessive back pressure to the vacuum motor.

vi. The tank may be fitted with a water line via a non-return valve and a float valve to maintain the water level without the need for topping up manually.

vii. A sample tap shall be installed into the tank to test the fluoride concentration.

viii. The water trap drain and overflow lines shall be directed to the site fluoride waste tank (where available) or to the fluoride building bund sump via a manual valve.

8.1.1.3 Local Control Panel

A Local Control Panel (LCP) shall be provided to operate the vacuum transfer systems locally.

The LCP arrangement shall:

i. Be clearly labelled with the panel tag number, chemical name, all dials, buttons and displays as per Seqwater’s labelling requirements.

ii. LCP should Include:

a. A “ON/OFF” pushbutton to initiate the panel.

b. A ready indicator.

c. A “START/STOP” pushbutton to initiate the powder transfer.

d. A running indicator.

e. An audible alarm form filter pressure differential instrument (if available).

f. Alarm and lamp test buttons as appropriate.

iii. Include one latched, twist to release Emergency Stop Pushbutton and an illuminated Emergency Stop Reset Pushbutton located in front of the panel. The emergency stop shall:

a. Be clearly labelled.

b. Be designed with the appropriate category of emergency stop circuit as decided by the designer.

c. Be detailed with the functionality by the project specific design team. But, as a minimum, this shall isolate power to all drives in the vacuum transfer system upon activation.

As a minimum, the design shall include the following signals related with the operation of vacuum transfer system viewable remotely via SCADA:

- Vacuum motor status.
- Emergency stop status.
- Compressed air solenoid valve signal.

8.2 Fluoride Saturator System

Fluoride saturator system is used to dissolve sodium fluoride powder into a saturated solution at its saturation point of 40 g/L, and free of suspended solid. There are two types of sodium fluoride saturators used in the industry, namely

- Up- flow saturator
- Down-flow saturator

The main difference between the up-flow and down-flow saturator is the position of the dilution water inlet line and saturated solution outlet line. All sodium fluoride saturators installed at Seqwater sites, to date, are down-flow saturators. The up-flow saturator is much more prevalent in the industry and has been found to experience less operational and maintenance issues compared to the down-flow saturator.

As mentioned in Section 7.17, an up-flow saturator is preferred over a down-flow saturator for new installations due to lower maintenance requirements. However, this standard does not constrain the installation of a new down-flow saturator where the designer considers it appropriate for a specific site application.

This section includes the design and construction requirements for up-flow and down-flow saturators. A sodium fluoride saturator system, at a minimum, shall include the following main equipment, instruments, components, and fittings:

- Saturator tank
- Tank level instruments
- Dilution water system
- Water softening (where applicable)
- Saturator outlet line (discussed under saturator and in Section 11.1).

8.2.1 Up-Flow Saturator

A saturator is simply a tank where sodium fluoride powder is mixed with water to achieve a saturated solution. Generally, this is achieved without mechanical mixing. In the up-flow saturator, dilution water is distributed from the bottom of the tank under pressure, allowing it to flow up through the sodium fluoride bed and dissolves it to provide a saturated solution.

The saturator shall be above ground and the up-flow saturator shall:

i. Generally, be vertically oriented cylindrical tanks.

ii. Be fitted with connections for powder fill line, dilution water inlet line, outlet line, overflow line, drain line, return line and level switches.

iii. Be preferably constructed with translucent polyethene materials so as it is possible to observe the level of undissolved fluoride compound in the saturator tank. Where applicable, appropriate codes and standards as listed for FSA storage tank in Table 10–1 should be considered for sodium fluoride saturator tanks.

iv. Include one (1) saturator tank per site. Additional saturator tanks should be considered with the criteria of criticality requirements, the site's size, usage, site staffing, site location and access (e.g. in fair and poor weather), reliability, operability and maintainability considerations.

v. Contain a sodium fluoride bed at the tank base which is 30 to 45 cm thickness to achieve the optimum result. The bed shall never be filled so high that undissolved powder can be drawn into the pump suction line. In addition, a deeper bed needs to be avoided as this may lead to uneven flow with forced flow channels due to additional pressure required by the dilution water to enter into the bed.

vi. Be sized to provide a minimum contact time of 5 minutes with the fluoride bed at the maximum fluoride solution dose rate and plant design flowrate.

vii. Include a powder addition connection/valve on top of the tank with totally enclosed container and designed to prevent unwanted dust clouds and risk of spills.

viii. Include a potable water inlet line extended to the base of the saturator with a spider-type or similar flow distributor. The distributor arms should be typically PVC pipes with numerous slits allowing water flows upward through the sodium fluoride bed at a controlled rate to ensure sufficient contact time. The water distributor slits shall be designed as self-cleaning. As an added measure the design shall include provision for periodic cleaning, with the frequency of cleaning to be determined considering water hardness and impurities accumulation from fluoride powder.

ix. Include an outlet line at the top of the saturator and be located on the opposite side of the powder connection point. This shall be designed to ensure that solution is drawn off just below the liquid surface regardless of the constantly changing liquid level using a floating suction arm. The floating arm draw point shall have a foot valve to prevent the pipe becoming empty when the dosing pump stops. The outlet line arrangement should prevent the fluoride bed from being disturbed and provide clean, free of suspended solid saturated fluoride solution for dosing. More details of saturator tank outlet line which also serves as the dosing pump suction line is provided in Section 11.1.

x. Include an overflow line its outlet to discharge directed to the bund sump or the tank bund floor. The overflow line outlet shall be fitted with vermin proof mesh. If the design presents the risk of powder escaping from the overflow line, then the line shall be discharged via a water trap and the submersion length shall not create any excessive backpressure to the saturator. The overflow line must be installed above the level of the outlet line and the line size must be 1.5 times of inlet water fill line with minimum diameter of DN 80 mm.

xi. A vent line with a filter shall be installed at the top of the saturator if a water trap is used in the overflow line. The design may also consider the vent with a filter if the overflow line is insufficient to prevent excessive positive or negative pressures during filling/emptying and exceeding structural limitations of the saturator tank. The vent needs to be sized considering tank inflow, outflow, thermal inbreathing and outbreathing.

xii. Be fitted with a drain line with a manual isolation valve and the discharge shall be directed to the bund sump.

xiii. Include an access hatch, as appropriate, on top of the saturator tank for inspection and maintenance. The design must consider additional connections and appropriate methods to clean the saturator periodically particularity to remove the build-up of insoluble cinders.

xiv. Be fitted with an additional nozzle at the top of tank for a manual stirrer/mixer.

xv. Be designed and constructed to operate at atmospheric pressure and ambient temperature.

xvi. Be earthed (where needed) in accordance with *E-SPE-STD-001 Electrical Design and Construction*, relevant codes and standards

8.2.1.1 Saturator Level Switch

The saturator tank(s) shall be equipped with four level switches for level measurement and protection of pump and overflows. This shall be achieved by the use of:

- Two (2) level switches to start and stop of the dilution water supply into the saturator.
- One low level switch to interlock the dosing pump.
- One high level switch to prevent tank overflow.

The design may consider the use of a level transmitter instead of two (2) level switches to start and stop the dilution water supply and for continuous monitoring of the saturator level.

The following level set points and alarms shall be available from four level switches for the operation of an up-flow saturator:

- **Open dilution water line valve:** At this tank level, the dilution water supply line valve will be opened. Reaching this level will be recorded as an event in SCADA.
- **Close dilution water line valve:** At this tank level, the dilution water supply line valve will be closed. Reaching this level will be recorded as an event in SCADA.
- **Level Switch High-High (LSHH):** At this tank level, an alarm will be triggered, and Operator notified. The process shall be interrupted automatically by stopping sodium fluoride powder transfer and/or dilution water supply into the saturator.
- **Level Switch Low-Low (LSLL)** At this tank level, an alarm will be triggered, and Operator notified. The process shall be interrupted automatically by stopping sodium fluoride solution dosing pump and closing tank outlet line valve.

8.2.1.2 Saturator Labelling

Saturator tanks shall be labelled and placarded in accordance with PRO-00008 *Hazardous Chemicals Procedure*, Work Health and Safety Regulation 2011, Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Australian Dangerous Goods Code and relevant legislative requirements.

i. Each saturator tank shall include a name plate which will remain clearly legible for the design life of the saturator tank and should be visible and legible from both within and outside of the secondary containment area where practicable. Each nameplate shall include:

- Manufacturer's details
- Date of manufacture
- Saturator tank number
- Materials of construction
- Product content
- Dimensions
- Design volume
- Design temperature and pressure
- Overflow level
- Design standard
- Solution Concentration
- Empty weight of saturator tank etc.

ii. Chemical hazard placard shall be printed, adhered to the saturator tank and suitable to remain in place and legible for the design life of the saturator tank following Seqwater *X-PRO-STD-006.Equipment Numbering and Naming Convention*.

8.2.1.3 Dilution Water System

The saturator dilution water supply source must be from the site potable or treated water system or from a source of equal or better water quality than that into which fluoride chemical is being dosed. The water source selected must not adversely affect treatment or pose a risk to treated water.

The dilution water, used to make a saturated sodium fluoride solution, must be supplied at a fixed flow rate unless adjusted by the plant operators. The dilution water flow rate shall generally be set at 120% of the maximum solution pumping dose rate considering maximum fluoride dose rate and plant maximum design production rate.

The dilution water system design specification shall:

i. Include a Y-strainer with a minimum mesh of 0.5mm.

ii. Include a solenoid valve and interlock the water supply system upon reaching high-high level in saturator.

iii. Be fitted with a non-return valve and preferably be positioned downstream of the line or prior to saturator, where applicable.

iv. Have a manual flow control valve, preferably a V-notch ball valve with the option of lock-in position.

v. Have a flowmeter with the option to generate flow deviation alarms.

vi. Have a pressure regulator to ensure the consistent feed pressure. The supply water pressure must be maintained higher than the hydrostatic pressure exerted by the water and sodium fluoride powder bed to overcome the pressure on the bottom of the tank. The design shall also consider pressure loss across the water distributor slits and upwards flows through the bed.

vii. Include a distributor arm with slits as described in 8.2.1 (viii).

viii. Have a manual isolation valve upstream of the saturator connection for maintenance.

ix. Consider installing a conductivity meter to measure the background dilution water electrical conductivity where the source water may have variability in conductivity. This is to assist to measure accurate fluoride solution conductivity as an indicative measurement of fluoride concentration as mentioned in Section 11 (iii).

x. Include a water softener sub-system upstream of the water supply equipment where the total hardness of water exceeds 75 mg/L as $CaCO_3$ as described in Section 8.2.1.4.

In addition to the above requirements, the potable dilution water system shall be protected from the fluoride saturator by using a reduced pressure zone (RPZ) backflow prevention device. Only proprietary RPZ back flow prevention devices shall be used. Double check valves are not considered adequate double layer protection. Arrangement must comply with the *AS / NZS 3500 – Pluming and Drainage and Queensland Plumbing and Wastewater Code.*

8.2.1.4 Dilution Water Softening

Fluoride ions (F^-) can react with soluble cations including Calcium (Ca^{2+}) and Magnesium (Mg^{2+}) present in the dilution water to form insoluble complexes and precipitates. These chemicals tend to scale in a saturator tank, in the dosing line and in the injection point. Excessive scaling and precipitation can cause issues for appropriate powder dissolution in the tank and blockage in the dosing line which will increase maintenance requirement, potential for pipe rupture and equipment failure.

The dilution water system shall have a water softener where the total hardness of the dilution water exceeds 75 mg/L as $CaCO_3$ as recommended in *Queensland Fluoride Code of Practice (2021)*.

Where required, a water softening system shall be used as a package unit from an approved supplier and be installed upstream of the dilution line and downstream of RPZ unit. Generally, the system includes an ion exchange resin bed and a regeneration solution tank normally with brine solution to regenerate saturated resin by exchanging hardness ions (Ca^{2+} and Mg^{2+}) with sodium ions (Na^+). The chemical specification of resin regeneration salt (sodium chloride) shall comply with the requirements specified in PRO-02564 Drinking Water Treatment Chemicals - Specifications, Monitoring and Assessment Procedure. The system should also include a carbon filter installed upstream of the resin bed to remove some dissolved constituents from water to increase the life and efficiency of resin.

The water softening system design shall include the following:

i. Be sized for continuous operation with the capacity of maximum saturator tank fill rate and the regeneration cycle should be generally once in a week.

ii. Be connected with a bypass line to be used during regeneration or maintenance.

iii. Be fitted with a solenoid valve in the resin bed drain line and regeneration solution gravity transfer line from the regeneration solution tank to the resin bed. Solenoid valves shall have feedback signals to SCADA.

iv. Have manual isolation valves upstream and downstream of the water softener system for maintenance.

v. The design shall consider, during the regeneration cycle, whether the softener system bypass will be used, or the dilution water supply to the saturator will be stopped. Saturator size and the requirement to stop fluoride solution dosing into the main shall be included in the design assessment.

8.2.2 Down-Flow Saturator

In the down-flow saturator, dilution water is introduced from the top of the tank, allowing it to flow downward through the sodium fluoride bed and support media, to dissolve sodium fluoride and provide a saturated solution.

The mechanical design of the down-flow saturator shall generally follow the requirement of up-flow saturator as provided in Section 8.2.1 with the following exceptions:

i. The base of the saturator shall be provided with supporting media below the sodium fluoride bed. The supporting media shall:

   a. Provide adequate filtration aid to capture undissolved sodium fluoride particles or impurities within the media.

   b. Preferably be a multilayer media with different sizes (e.g. coarse and fine) and different materials (e.g. gravel and sand) with coarse materials at the bottom and fine materials at the top.

   c. Be inert and shall not adsorb or react with sodium fluoride chemical.

ii. The down-flow saturator shall always contain at least 15 cm of sodium fluoride bed above the top of the filtration supporting media. However, the design shall ensure that the saturator shall never be filled to the top of the tank with sodium fluoride where it may impede dilution water flow downward through the bed.

iii. The dilution water line shall be introduced on top of the saturator above the overflow line. It shall be at the opposite end of the powder addition connection.

iv. The solution outlet line from the saturator is situated at the centre bottom of the saturator but above the drain line. The line location shall be selected to ensure flooded suction for the dosing pumps (where required) and to avoid drawing any support media. This shall be determined considering tank geometry and internal arrangements, bund arrangement and pump position in the dosing skid.

8.3 Process Control Narrative

The following describes a typical process control philosophy for the sodium fluoride powder transfer and saturator system. This should be read in conjunction with Section 8.3.2 to 8.1.1.2 of this document.

8.3.1 Sodium Fluoride Powder Transfer

The following describes a typical process control philosophy for the sodium fluoride powder transfer process from small pails to a saturator. This should be read in conjunction with Section 8.3.2 of this document.

Normal Operation

The small bag/pail unloading process will be undertaken locally by a site operator. The operator will transfer 25 kg sodium fluoride pails from the storage area to the designated filling point manually.

The operator can then perform sodium fluoride powder transfer process using the LCP. Prior to starting the sodium fluoride powder transfer process, the operator will energize the LCP with “ON” switch.

The control system will then check that the following requirements are met:

- Saturator high-high level switch is healthy and not active.
- Vacuum motor/fan is healthy.
- No alarm from filter pressure differential instrument (where available)
- Reverse pulse cleaning solenoid valve and Compressed air system is available.

Once all the above conditions are met, this will enable “Ready” indicator in the LCP.

The operator should then be able to start the powder transfer selecting the ‘START’ push button on the LCP, and the transfer line solenoid valve will open and the vacuum motor/fan will start. The operator will then need to insert the hand-held vacuum wand into the 25 kg pail and powder transfer will start.

The transfer process will continue for the designed time (usually less than a minute) before it stops automatically. The transfer line solenoid valve to the saturator will then be closed, and the dump valve will open simultaneously to allow the collected sodium fluoride powder from the collection unit to drop into the saturator. While the dump valve remains open, the solenoid valve in the compressed air line will open automatically for a short time to give a reverse pulse to the filter to dislodge sodium fluoride powder from the filter into the saturator.

This cycle will continue until the operator stops the powder transfer by pressing the “STOP” button in the LCP. The LCP will show “Running” indicator when the cycle is running. When the cycle is running, the operator can change the vacuum wand from one pail to another pail.

Abnormal Operation

If the saturator reaches High-High Level or compressed air not available, the control will interlock the operation of the vacuum loader to stop the powder transfer process. The unloading stop sequence can also be triggered by an emergency stop button on the LCP.

In addition, an audible alarm will be raised in the LCP if the vacuum loader system filter pressure differential alarm is high (where available).

8.3.2 Dilution Water Addition

Normal Operation

Dilution water will be added to the saturator automatically and the dilution water line solenoid valve will be closed and opened from signals from two saturator level switches (or from start and stop level signal of a level transmitter, if used). The position of these two-level switches will determine the saturator working level.

During water softening bed (where available) regeneration cycle, the dilution water fill line solenoid valve will be closed and opened again after the completion of the regeneration cycle. Depending on the design and saturator size, this may require to stop the fluoride dosing pump automatically.

Water softening regeneration cycle will start once initiated from SCADA and stop automatically. A timer will alert the operator to run the softener regeneration cycle.

Abnormal Operation

If the saturator reaches High-High Level, the control system will close the dilution water solenoid valve to stop water addition.

In addition, high and low flow alarms will be raised in SCADA from the dilution water flowmeter.

9 Sodium Fluorosilicate

This chapter covers sodium fluorosilicate powder transfer, storage hopper, powder feeding and mixing systems.

The requirements for sodium fluorosilicate building and bunding arrangement are included in Section 12 and details of sodium fluorosilicate dosing system are included in Section 11.

The storage and handling of sodium fluorosilicate must comply with the requirements of the *Work Health and Safety Act 2011*, *AS 4452 Storage and Handling of Toxic Substance,* and *Queensland Health Water Fluoridation Code of Practice (2021).* The design must ensure that the handling facility provides a safe working environment and facilitates safe working practices for operators.

This section should be read in conjunction with P&ID Standard Drawing *B-DWG-STD-033, Sodium Fluorosilicate System* as referenced in Section 13.

9.1 Powder Delivery and Transfer System

Seqwater receives sodium fluorosilicate in 1000 kg large bags on pallets, which are temporarily stored indoors in the designated storage area. It is recommended to confirm with the supplier that the bulk bags supplied contain four lifting loops and a central bottom outlet spout.

Facilities for sodium fluorosilicate large bag delivery, storage and powder transfer from large bags into a storage hopper/silo are described by the following sub-systems:

i. Large Bag Unloading and Storage

ii. Hoist and Discharge Hopper System

iii. Conveyance System

iv. Local Control Panel

9.1.1 Large Bag Unloading and Storage

The design shall include the following requirements to transfer sodium fluorosilicate powder bags from the delivery area into the storage area and from the storage area into the filling point:

i. The ability to drive the delivery vehicle as close as practicable to the storage area and filling point.

ii. Bulk bag delivery or receiving area from the truck is required to be covered, bunded and drain to a collection sump.

iii. Use delivery vehicle or a lifting appliance to minimise manual handling, for example, mobile trollies and forklifts. Where forklifts are used, consider using a protective cover that fits onto the tips of forks to reduce accidental piercing of powder bags.

iv. Forklift trucks shall comply with the relevant requirements of *AS 2359 Powered Industrial Trucks.*

v. If package storage area is not within the same level as the delivery truck, an inclined conveyor, dock leveller, hoist, or an elevator shall be considered to match the height of the fluoride loading floor with the tray of the delivery truck.

The operation of the plant and sodium fluorosilicate mixing/batching, and dosing system shall not be adversely affected during chemical delivery and unloading.

9.1.2 Storage of Bulk Bags

Sodium fluorosilicate bulk bags shall be stored inside a building in a cool, dry, vermin proof, and well-ventilated area. Humidity control shall be used in the storage room given historical incidences of powder caking. The design and construction requirements for the fluoride building are discussed separately in Section 12.

The storage area sizing for bulk bags shall generally follow the same basis of minimum chemical demand as provided for the sizing of bulk storage tanks for FSA in Section 10.3.1. However, the final storage area should be determined considering sodium fluorosilicate chemical properties, general availability of chemical including the supplier's location and reliability of supply during any period of shortage, delivery time delay due to natural or human-caused emergencies, site's availability and criticality requirements.

The followings shall be considered for the storage of sodium fluorosilicate powder bags:

i. Bags shall be stored on pallets on the floor depending on the site space availability.

ii. A double racking system for the storage of bulk bags can be considered to minimise the amount of floor space required and assists in reducing the potential humidity build up by allowing sufficient space for air to circulate around the bags. Where a double racking system is used, cross members are recommended on the racks to provide additional support for the pallets with 1000 kg bulk bags.

iii. The layout of the bulk bags' storage shall:

    a. Allow the rotation of chemical bags (to manage aging).

    b. Provide clear passage of personnel to locate/remove bags using delivery vehicles (where applicable).

    c. Permit full observation and provide suitable access and manoeuvrability for cleaning spills.

    d. Include necessary measures to ensure that stored dry powder compound does not become damp or wet.

iv. Other water treatment chemicals excluding fluoride chemicals shall not be stored in the fluoridation room, see more details in Section 12.

9.1.3 Hoist and Discharge Hopper System

Sodium fluorosilicate powder from bulk bags must be transferred by a suitable discharge system into a storage hopper for feeding into the chemical mixing system. The bag empty and transfer system shall be designed to ensure reliable material flow without any dust generation and to minimise manual labour requirements.

The hoist and discharge hopper system should generally include the following:

i. A gantry crane and electric hoist, controlled by an operator via a remote controller/pendant connected via a cable to manoeuvre the package bag into and out of the bag massager platform on the top of the discharge hopper. The hoist must be suitable for the design lifting capacity and comply with *AS 1418, Cranes, hoist and winches set.*

ii. A safety gate to access hoist operation and be fitted with a safety guard switch and local reset push button to de-energise/re-energise the hoist motor operation. Safety gate must be closed and the reset button activated prior to the operation of the hoist. The hoist lifting chain shall have a bulk bag lifting attachment connected to the hook which connects to the four lifting points on each corner of the bulk bag.

iii. A supported bag massager platform frame to securely position the fluoride bag over the top of a discharge hopper. The assembly is preferably fitted with a circular penetration in the centre and a bag neck isolator or a power cincher mechanism or similar to isolate the bag outlet spout. The platform shall include four guard plates to protect operators from any potential falling of bags.

iv. A safety door in the bag massager platform to access the bag outlet spout isolation, untie and/or make a penetration. The safety door must be fitted with a safety switch and local reset push button to de-energise/re-energise the conveyance system, dust extraction fan, and dust extraction valve operation (if actuated). Safety door must be closed and the reset button activated prior to the start of the unloading sequence.

v. Pneumatically operated mechanical paddles as bag massagers or vibrating pans or other types of bag flow activators in the bag massager platform to overcome bridging and ratholing and thus assist powder flow from the bulk bag to the discharge/unloader hopper.

vi. A mechanism to seal the bulk bag discharge spout and prevent dust escape during emptying. An extendable flexible tube fitted with assembly mentioned above in point (iii) may be used for the application.

vii. A suitable mechanism to collapse the bag during bag removal using the hoist and minimise dust emission to the working environment.

viii. A suitable sized discharge hopper to receive powder from the bulk bag and allow to flow to the conveyance system.

ix. Vibrators or other type of mechanism to assist in powder flow from the discharge hopper to the conveyance system. Vibrators shall not be allowed to operate when the discharge hopper level is low and shall be designed with a suitable vibration intensity without impacting operation of other adjacent equipment.

x. A dust extraction pipe connection from the discharge hopper to the storage hopper or to the central dust collection system. The dust extraction line should have a solenoid valve to open/close automatically during unloading operation.

xi. A low-level switch in the discharge hopper shall trigger an alarm on the LCP, and stop discharge hopper vibrator operation.

xii. A pneumatically or manually operated knife gate valve at the bottom of the discharge hopper to provide positive isolation during maintenance. Designer should consider the provision to close the valve from LCP after completion of powder transfer to avoid the risk of moisture entering into the storage hopper.

9.1.4 Conveyance System

The designer shall select the preferred conveyance system to carry sodium fluorosilicate powder from the discharge hopper to the storage hopper considering the material properties, reliability and safety. Considering the usual close proximity between the storage hopper and discharge hopper system, a mechanical screw conveyance system is recommended for sodium fluorosilicate transfer.

Pneumatic conveyance is normally considered for longer distance transfer and vacuum conveyance generally used for small systems which are not discussed here and not used for sodium fluorosilicate large bags transfer in Seqwater. Seqwater Engineering Standard *B-SPE-*

STD-012 Lime Storage, Mixing and Dosing can be referred to for some details of these two conveyance systems.

The design of mechanical or screw conveyance system shall consider the following requirement:

i. A single or multiple helical flight of a shaftless conveyor or mounted on a central shaft aligned vertically/horizontally or combination, depending on the requirement.

ii. Include an enclosed fabricated casing comprising standard lengths bolted together as required. Riveted sections should not be used to allow for maintenance access.

iii. Discharge into the centre top part of the storage hopper to allow for an equal distribution of powder chemical.

iv. Provide interlocking of the screw conveyor motor to the high-high weight and/or high-high level of the storage hopper.

v. Where applicable, interlocks shall be included to prevent the operation of horizonal screw conveyor when vertical screw conveyor has failed to operate. This is to avoid any powder compaction within the screw conveyors and any damage to the conveyance system.

vi. Provide access hatches to allow maintenance personnel to inspect conveyance system and remove blockages.

vii. A mechanism that prevents the operation of screw conveyor when the conveyor housing is left open to avoid an unsafe condition.

viii. Screw conveyer material shall be corrosion resistant to sodium fluorosilicate powder.

9.1.5 Local Control Panel

A Local Control Panel (LCP) for bulk bag unloading shall be provided to operate the bag discharge and conveyance systems locally.

The LCP arrangement should, as a minimum:

iv. Be clearly labelled with the panel tag number, chemical name, all dials, buttons and displays as per Seqwater's labelling requirements.

v. Include:

    a. An On/Off unloading switch to initiate the panel. The status shall be viewable remotely via SCADA.

    b. A ready indicator (e.g. Green Light) – indicating all pre-requisites to fill the hopper are met.

    c. A not ready indicator (e.g. Amber Light) – indicating it is not safe to fill.

    d. An Unload Start/ Stop Pushbutton to initiate the bag discharge and conveyance system. The status shall be viewable remotely via SCADA.

    e. A running indicator.

    f. A purge button – to manually run the screw conveyor to purge any residual powder from the screw conveyor into the storage hopper.

    g. An amber beacon type lamp to alert the operators to alarm conditions.

    h. An alarm test button.

    i. A lamp test button.

vi. Include an audible alarm to alert the operators if the storage hopper has reached high weight/level; or the discharge hopper becomes empty or high pressure-differential across the filter.

vii. Include one latched, twist to release Emergency Stop Pushbutton and an illuminated Emergency Stop Reset Pushbutton located in front of the panel. The emergency stop shall:

  a. Be clearly labelled.

  b. Trigger a local alarm (visual and audible) and telemetry alarm visible from the control room.

  c. Be designed with the appropriate category of emergency stop circuit as decided by the designer.

  d. Be detailed with the functionality by the project specific design team. But, as a minimum, this shall isolate power to all drives in the unloading and conveyance system upon activation.

The design may also consider an alternative suitable location instead of LCP for the Emergency Stop Pushbutton.

As a minimum, the design shall include the following signals related with the operation of bulk bag discharge and conveyance system viewable remotely via SCADA:

- Status of the LCP.
- Unloading sequence and running status.
- Motor running status, motor temperature, and fault status. This may include vibrator, screw conveyor, and dust extraction fan operation.
- Any valve status or valve position status which includes but not limited to bag massager solenoid/actuated valves, knife gate valve, bag neck isolator pneumatic supply line valve, dust extraction line valve (where applicable).
- Discharge hopper low-level switch indicator.
- Emergency Stop status.

9.2 Sodium Fluorosilicate Storage Hopper

Storage hopper(s) shall be used for the storage of sodium fluorosilicate powder prior to mixing and dosing system.

Storage hopper shall be an above-ground, fixed, well-supported, permanently positioned vessel that is filled and discharged in-situ and located inside a building.

The storage hopper shall be designed to provide a flow pattern that ensures flow of all materials whenever any solid is withdrawn to avoid ratholing, short circuiting or retention, aging of pockets of powder, powder sidewall hang-ups and cohesive arching under all conditions.

Corners shall be minimized in the hopper design as Seqwater has observed corrosion in storage hopper corners in multiple sites. In view of this, a cylindrical storage hopper is strongly recommended with a conical bottom.

The storage hopper shall have a supporting structure and foundations. The hopper structure is to be designed to ensure adequate strength and stability to withstand any relevant load including the load exerted by the bulk solid on the hopper walls, the impact stress caused by large portion of powder falling from the top of the hopper, and asymmetrical loading from the contents.

The design of the hopper cap shall be with a slight radial downward slope or crowned from the centre to prevent pooling of water on top and allow drainage.

The design and construction of the storage hopper shall follow the appropriate standards as listed below in Table 9-1. Designer can apply additional standards as required.

Table 9-1 Recommended standards for the design and construction of storage hoppers.

Standard Number	Standard Title
AS/NZS 1170	Structural Design Actions (set)
AS 3774	Loads on Bulk Solids Containers
AS 1657 and M-SPE-STD-002	Fixed Platforms, Walkways, Stairways and Ladders
AS 3990	Mechanical Equipment – Steelwork
AS 4100	Steel Structures
AS 1554	Structural Steel Welding

All hopper equipment and instruments shall be fitted such that they may be removed without draining the hopper contents.

The storage hopper, at a minimum, shall include the following main equipment, instruments and fittings:

i. Hopper fill line
ii. Weight and level monitoring device
iii. Hopper access (both internal and external)
iv. Dust filter and extraction fan
v. Pressure/vacuum relief device
vi. Bin vibrator
vii. Aeration system
viii. Heater
ix. Knife gate isolation valve
x. Rotary valve

9.2.1 Number and Size of Hopper

Generally, a single storage hopper is recommended for sodium fluorosilicate powder at each site. The final number should be determined considering the site's availability and criticality requirements, stored chemical properties, site staffing, site location and access (e.g. in fair and poor weather), powder usage rate, reliability, operability and maintainability considerations.

The followings should be considered for hopper sizing:

i. Size to be equivalent volume of at least 2 large bags.
ii. To hold around 7 days of storage at the maximum dose rate with average plant flowrate.

To determine the final storage hopper's size; chemical properties, availability of operators for hopper filling, reliability of supply, and other site constraints shall be considered.

9.2.2 Hopper Labelling

All hoppers shall have placarding and be labelled in accordance with PRO-00008 *Hazardous Chemicals Procedure*, *Work Health and Safety Regulation 2011*, *Globally Harmonised System of Classification and Labelling of Chemicals (GHS)*, *Australian Dangerous Goods Code* and relevant legislative requirements.

Where multiple hoppers are installed, each hopper shall be labelled with the hopper number (i.e. Hopper 1, Hopper 2 etc) such that it is clearly visible and readable from the hopper fill point. This labelling convention should also be carried over into SCADA.

Each hopper shall include a name plate printed on stainless steel following *Seqwater X-PRO-STD-006.Equipment Numbering and Naming Convention* and suitable to remain in place and be clearly legible for the design life of the hopper. It shall be positioned to allow visibility from the ground level, if adhered to the hopper surface.

Each nameplate shall include the following information:

- Manufacturer
- Manufacturer's details (name, address, contact number)
- Design Code
- Date of manufacture
- Serial Number
- Hopper Number (if applicable)
- Materials of construction
- Product / content (including chemical name, formula)
- Design Mass Capacity
- Height, Diameter and Volume
- Design Temperature and Pressure
- Powder Chemical Bulk Density
- Maximum Specific Gravity (of powder to be contained)
- Weight of empty hopper.

9.2.3 Design Pressure and Temperature

Hoppers shall be designed for Site Conditions, Atmospheric Conditions and Process Conditions as defined in Section 7 of this document.

The pressure or vacuum resulting from filling, emptying, thermal inbreathing and outbreathing, or atmospheric change shall not exceed the maximum design stress of the hopper. The hopper should be designed to withstand the pressure generated in the system and shall include a safety factor of 2x of the calculated possible built-up pressure.

Storage hoppers shall generally be designed and constructed to operate at near atmospheric pressure and slightly negative pressure for hopper filling and discharge operations.

9.2.4 Hopper Materials

Materials for hopper construction shall ensure hoppers and their fittings and attachments are suitable for use under the Site Conditions. Where materials require additional protection as a result of Site Conditions, adequate protection, appropriate shelter, painting or coating, or other fit for purpose means of ensuring the required design life is achieved shall be provided.

Materials for hopper construction shall ensure hoppers and their fittings and attachments that are likely to come into contact with sodium fluorosilicate are substantially immune from attack by the sodium fluorosilicate under all service conditions. They must be of a quality and do not leach any substances in quantities capable of producing adverse health effects for drinking water applications.

Stainless steel grade 316 is the preferred material for sodium fluorosilicate storage hoppers.

9.2.5 Fill Line Connection

The filling line connection battery limit is from the flange connection of the screw conveyor at the hopper nozzle to the hopper internal. This should:

i. Include a separate flanged nozzle/connection on the topside (roof) of each hopper with the same diameter as the screw conveyor connecting line.

ii. Enter the roof of the hopper in a vertical orientation and connected through the centre of the storage hopper roof to maximise storage volume.

iii. Provide a minimum 100 mm straight funnel discharge pipe connection from the hopper flanged nozzle connection on the internal topside roof to direct the discharge orientation.

9.2.6 Weight Measuring Device

Hopper weight shall be the primary monitoring and control parameter for the operation of the storage hopper. The designer may also consider hopper level monitoring as a backup to weight monitoring to identify ratholing if it cannot be eliminated with hopper heaters and bin vibrator systems.

The storage hopper shall be mounted on load cells to measure the hopper weight with the following requirements:

i. A storage hopper weighing system should consist of three or four load cells, each with a weighing module. Each load cell should be connected to a junction box and a transmitter with the ability to send the weight signal to the site PLC/SCADA.

ii. The hopper stairs and platforms shall not be structurally connected to the hopper otherwise the performance of the hopper load cells can be affected. A flexible connection between screw conveyor and storage hopper shall be provided to avoid interference with the load cells.

iii. Load cells shall be installed in such a way that they can be removed without emptying the hopper for jacking or lifting purposes.

iv. The vibration of vibrators shall not affect the performance of load cells.

v. The load cells shall have combined accuracy within ±0.5% across all design conditions (i.e. temperature and hopper content weight).

vi. Electrostatic charges must be discharged to the ground without crossing the load cells. Earthing shall be provided according to the requirements in *I-SPE-STD-015 Instrumentation*.

vii. Load cells shall be equipped with calibration hooks for hanging weights.

viii. The load cell types, and their components shall be suitable for Site Conditions.

ix. Hopper weight shall be readily viewable as an electronic digital readout at:

a. Local to the hopper and viewable at ground level

b. Local to the hopper filling Control Panel, and viewable by Operator / Delivery Staff during filling operation.

c. Remotely at SCADA.

9.2.6.1 Alarms and Trip Setpoints

The following provides guidance as to Seqwater's requirements for alarms and trips from the weight measuring device for the operation of storage hoppers.

The following high weight setpoints shall be available for storage hopper operation:

- Maximum Operating Weight / Operation High Weight (OHW): This operator settable setpoint provides no alarm. The process will continue to run with no action. Reaching this level will record as an Event[1] only in SCADA.

- Weight Alarm High (WAH) Setpoint: At this point an Operator alarm shall be triggered requiring operator action to correct any issues if the trigger does not self-correct. The process shall continue to operate.

- Weight Alarm High-High (WAHH) Setpoint: At this point, the alarms and interlocks are based on the delivery mechanism of the following:

    - At this point, a further alarm will be triggered, and the storage hopper filling must be stopped via interlocking the screw conveyor system. But it must be set to allow the conveyor to be emptied into the hopper (by the use of a run-on timer).

The following low weight setpoints shall be available for storage hopper operation:

- Minimum Operating Weight / Operational Low Weight (OLW): This operator settable setpoint provides no alarm. The process will continue to run with no action. Reaching this level will record as an Event[1] only in SCADA. This may be used to fill the hopper or automatically switch over to another hopper, where available.

- Weight Alarm Low (WAL) Setpoint: At this point an Operator alarm shall be triggered requiring Operator action to correct any issues if the trigger does not self-correct. The process shall continue to operate.

- Weight Alarm Low-Low (WALL) Setpoint: At this point a further alarm will be triggered, and the Operator notified. At this point, Operator action has been unavailable or unable to correct the low-weight event. The powder feed system to the transition hopper shall be interrupted by stopping/inhibiting the rotary valve, bin vibrator operation and closing the knife gate valve.

In addition, an alarm should also be considered to identify higher rate of powder discharge from the hopper using load cells indicating possible powder fluidization through the feeder or increased consumption than theoretical values, particularly where Loss in Weight (LIW) feeders are not used. The design should also consider closing the knife gate valve for safety and to prevent overdosing during this scenario

[1] Events are a fifth priority alarm in the Seqwater alarm system as defined in *I-SPE-STD-006 Monitoring and Control System Alarm and Event Management.*

When LIW feeders are not used, an alarm should also be considered to identify the feeder blockage from the lower rate of hopper powder weight loss for a defined period using the load cells.

9.2.7 Level Switch

In addition to hopper weight measurement device, the storage hopper shall be fitted with level switches to provide additional control redundancy with the following requirements:

i. Two separate and independent level switch devices to provide point detection level at High-High and Low-Low Level on the storage hopper.

ii. Electronic level switches must be suitable for site conditions and compatible with sodium fluorosilicate powder.

iii. The level switches must be positioned where they will provide a best representative level of the hopper content.

9.2.7.1 Trip Setpoints

The following provides guidance as to Seqwater's requirements for trip setpoints and alarming from level switches for the storage hopper:

Storage Hopper

- High-High Level (LSHH): The High-High Level setpoint and alarm triggered on the High-High Level switch device shall provide the same action as WAHH discussed previously in Section 9.2.6.1.

- Low-Low Level (LSLL): The Low-Low Level setpoint and alarm triggered on the Low-Low Level switch device shall provide the same action as WALL discussed previously in Section 9.2.6.1.

9.2.8 Hopper Access

9.2.8.1 Access Hatch

Storage hopper shall be fitted with an access hatch to allow for internal inspection with requirements to include:

i. A nominal size of 600mm diameter inspection opening mounted on the top of the storage hopper. The hopper should be designed in a way that internal access is not required, or the need is minimised or restricted.

ii. Access cover shall be made from the same material as the hopper and weigh no more than 15 kg. Where this cannot be practicably achieved, a lifting and support mechanism shall be supplied and mounted to the hopper to facilitate access.

iii. Access cover shall be locked in closed position or required a tool to open. It shall be easily lifted by one person and shall be capable of being secured or locked in an open position.

iv. Access cover shall be fully sealed and airtight to prevent chemical powder escaping to the environment.

v. A hinged access cover shall be considered and shall open sideways as it can be positioned as closed to access walkway or hopper side to limit the reach required. The hinged opening shall not impede safe access to the other assets.

9.2.8.2 Stairway Access

Stairway access to the top of the storage hopper shall be provided. The stairs and platform structure shall not be connected to the storage hopper to allow free movement of the hopper and also not to impede the load cells weight measurement.

The stairway and platforms shall comply with the requirements of *M-SPE-STD-002 Fixed Platforms, Walkways, Stairways and Ladders.*

9.2.9 Dust Collector and Vent Filter System

Storage hopper and bag unloading system shall be fitted with a vertically mounted self-cleaning dust collector and vent filter system on the top of the hopper. The system must be designed to vent clean, dust-free, filtered air to the atmosphere outside of the building and return powder removed from the filter to the inside of the hopper. The main components of the system shall include:

- Dust Filter
- Dust Extraction System
- Reverse Pulse Filter Cleaning System

9.2.9.1 Dust Filter

The dust filter requirement shall include the following:

i. Be either bag or cartridge type of filter with filtration capacity sufficient without over pressurising the storage hopper.

ii. Be capable to remove at least 99.9% of the smallest powder particle size as defined on the chemical Safety Data Sheet (SDS) or 1 µm, whichever is lower.

iii. The filter shall be housed in a container with an access lid for filter replacement. The filter lid shall be sealed to prevent the escape of powder chemical dust.

iv. The filter shall be considered to install directly on the top of storage hopper. Other suitable locations can be considered for ease of maintenance access.

v. The filter container and access lid shall be securely positioned to prevent it being dislodged under operating conditions and to enable maintenance access from the access stair’s top platform.

vi. The filter shall be sized appropriately to allow maintenance staff to safely carry replacement filter elements to the top of hopper or other suitable location for replacement.

vii. Be fitted with a pressure differential transmitter across the filter. High-high differential pressure alarm across the filter for a pre-set time shall interlock the unloading sequence.

viii. The filter needs to run through a cleaning cycle at the start and end of a delivery.

ix. Adequate platform shall be provided for safe access and work on the filter for maintenance/replacement.

9.2.9.2 Extraction Fan and Line

The dust extraction system includes a dust extraction fan, two dust extraction lines and a water trap. One dust extraction line is to connect the filter to the bag unloader/discharge hopper system and the other line is for the extraction fan outlet directed to the outside of the building.

The system requirements include:

i. Each dust filter shall be fitted with a dedicated extraction fan and the capacity of the fan shall be determined that can maintain a slight negative pressure in the storage hopper and bag unloader assembly during hopper filling.

ii. Extraction fan should start prior to the start of unloading sequence and will continue to operate for a set period of time when the product transfer or screw conveyors are stopped without creating any negative pressure outside the design limit.

iii. Extraction fan shall be side mounted or positioned in a way that allows for filter maintenance/replacement without the need for it to be removed.

iv. Extraction fan outlet line shall be vented to a water trap located outside of the storage hopper building. The water trap should have a float valve connected to the water fill line to fill the trap automatically. Submersible section of the fan extraction line into the water trap shall not impose any significant backpressure. Refer Section 8.1.1.2 for other requirements of a water trap.

v. Dust extraction line from discharge hopper/bag unloading assembly should be connected either directly to the filter or to the storage hopper. If connected to the hopper, the nozzle shall be connected with a flange joint to allow dismantling for maintenance, and be the same size as the extraction line with a minimum diameter of 100 mm.

vi. The dust extraction lines shall be sized and designed with minimum line pressure drop.

9.2.9.3 Reverse Pulse Filter Cleaning

i. The reverse pulse filter cleaning system shall automatically clean the dust filter with a compressed air pulse preferably at a predetermined interval. The pulse cleaning system shall also be activated at a pre-set pressure differential across the dust filter. The system should trigger an alarm to the site control system for filter blockage from a high-pressure differential across the filter. The operation of screw conveyor system should be interlocked from a high-high differential pressure alarm across the filter.

ii. The dust collector shall also perform cleaning cycles upon starting the powder unloading sequence and when the dust extraction fan is deactivated.

iii. The compressed air supply for the pulse air cleaning shall be clean, dry and comply with the pulse air cleaning system manufacturers specification.

iv. Air supply system should be fitted with a pressure regulator if a specific pressure is required for filter cleaning. A high-pressure switch or pressure relief valve shall also be considered in the air supply line to isolate the air supply in the event of a pressure regulator failure.

9.2.10 Pressure/Vacuum Relief Device

A pressure/vacuum relief valve shall be mounted on the top of the storage hopper to protect the hopper against excessive pressure and vacuum.

The device shall protect the hopper against over pressurisation from dust filter blockage during sodium fluorosilicate powder filling. It shall also protect the hopper from an implosion resulting from excessive air extraction due to erroneous fan extraction operation or a sudden powder chemical discharge.

The pressure/vacuum relief device shall be sized appropriately considering:

- maximum allowable hopper and dust filter pressures.

- maximum air inflow that hopper needed at the highest powder draw down rate.
- venting capacity of the device at specific over-pressures.

The pressure and vacuum relief valve set points shall comply with the hopper manufacturers recommendations.

The relief device shall be selected such that an exit relief line can be connected and extended outside of the hopper building to reduce dust cloud when the relief valve operates. Where directed outside, vent lines shall be directed downward with the opening toward the ground to prevent ingress of water and 500 mm above the ground level to avoid the risk of any dust exposure to a person. The line discharge point shall be fitted with a 2 mm aperture vermin mesh with mechanical fastening.

9.2.11 Heaters

Storage hoppers must be fitted with a suitable number of electrical heaters to prevent condensation and control moisture inside the hopper and therefore assist in flow by avoiding caking and agglomeration of powder.

The following shall be considered in heaters selection and operations:

i. The designer shall divide the hopper into different zones for temperature control with a number of heaters.

ii. Strip heaters, heat trace cables or similar are recommended for this application.

iii. Each heater to preferably be controlled by dedicated hardware temperature controllers locally with temperature feedback to PLC/SCADA.

iv. Heaters shall be covered with protective sleeve or sheath with appropriate protection to personal exposure.

v. Seqwater Engineering Standard *E-SPE-STD-001 Electrical Design and Construction* shall be followed in heaters selection and control.

9.2.12 Bin Vibrators

The storage hopper shall be fitted with vibrators to aid in powder flow discharge. The designer shall select suitable vibration mechanisms to aid smooth powder flow considering:

- Powder density and flow properties,
- Discharge rate and
- Hopper diameter.

Vibrators for a standard fixed hopper cone, electric vibrators are preferred over pneumatic vibrators as any compressed air supply disruption may stop operation of the vibrators.

For vibrators, the design shall consider the following:

a. Number of vibrators required.
b. Location of vibrator installation.
c. Right force for hopper cone and materials load.
d. Vibrator operations shall be kept to a minimum and operation must be prevented in an empty hopper.

e. Vibrators with adjustable force features shall be considered to optimize the vibration intensity needed for the application.

f. Hopper vibration shall not be conveyed to adjacent equipment and support structures to prevent either damaging them or creating excessive noise.

9.2.13 Knife Gate Isolation Valve

The storage hopper shall be fitted with a sliding knife gate valve to provide positive isolation for downstream maintenance. The knife gate valve shall:

i. Be located underneath of the hopper cone and upstream of the rotary valve.

ii. Be preferably pneumatically driven.

iii. Include open and close position switches readable from SCADA.

iv. Have a suitable platform or appropriate steps for easy access.

v. Be designed to remain closed for a specified period to prevent powder from over aerating and flooding through the feeder nozzles when the hopper is filled from empty.

vi. Have an enclosure bonnet and a leak-proof stem seal to prevent escape of powder dust. During commissioning, where needed, the sealing procedure needs to be established to ensure a dust tight seal in the valve open position. The design needs to ensure the valve is designed with suitable knife thickness that can easily overcome any pressure when the hopper is full.

vii. Have a provision to lock the valve in position using a standard isolation padlock.

9.2.14 Rotary Valve

Electrically operated rotary valve shall be installed to transfer powder into the Loss-In-Weight (LIW) transition hopper (where included). The rotary valve shall:

i. Be mounted at the hopper discharge chute underneath of the knife gate isolation valve.

ii. Operate when the transition hopper calls for powder transfer, which is triggered from transition hopper low-level switch and stopped from high-level switch of the transition hopper as mentioned in Section 9.3.1.

iii. Have a fixed speed drive capable of delivering powder at a rate of 10 times the maximum feed rate of the screw feeder.

iv. Be constructed of material compatible with sodium fluorosilicate and be able to handle the abrasion from powder.

v. Include a durable and dust tight seal on the rotating shaft and external fittings to prevent powder emission to the atmosphere.

vi. Be designed to provide for easy and safe cleaning of both the external as well as the internal surface including provision for simple extraction of rotor/end cover assembly.

vii. Be preferably fitted with an open vane rotor to reduce problems with product ingress, bore wear, and product hang-up.

9.3 Sodium Fluorosilicate Feeding and Mixing System

This section describes the requirement for the design and construction of sodium fluorosilicate mixing/batching system and shall be read in conjunction with P&ID Standard Drawing *B-DWG-STD-033 Sodium Fluorosilicate System* as referenced in Section 13.

The mixing system is to prepare sodium fluorosilicate solution with the required concentration for dosing into the main. Sodium fluorosilicate powder is transferred from the transition hopper via the wetting system prior to transfer into the mixing tank.

The mixing system must be capable of achieving sodium fluorosilicate solution concentration of 0.1 to 0.25 % (w/w) unless otherwise specified by the site's specific process requirement. Seqwater normally uses 0.2 % (w/w) of sodium fluorosilicate solution.

The sodium fluorosilicate mixing system includes the following main components:

- Powder Feeding System
- Powder Wetting System
- Mixing and Dosing Tank System.

9.3.1 Powder Feeding System

The design presented here recommends using gravimetric Loss-In-Weight (LIW) screw feeders over volumetric screw feeders. This is to achieve another layer of protection against fluoride overdosing and under dosing. This also offers the benefits of self-calibration feature and capability of complete control over product quality variations as mentioned in Section 7.17. Where LIW feeders are not selected, alarms from increased and decreased powder weight loss from a theoretical value for a defined period from the storage hopper using the load cells shall be included in the design to identify overdosing and under dosing, respectively.

The LIW powder feeding system includes a transition hopper, transition hopper load cells, high-level and low-level switches, an agitator and a screw feeder.

9.3.1.1 Transition Hopper

For Loss in Weight (LIW) screw feeders, powder from the storage hopper is transferred into a transition hopper through a rotary valve to measure loss in powder weight before feeding into a mixing/batching tank.

The transition hopper is generally a small hopper and needed to achieve the high degree of precision in weight measurement. The transition hopper should generally be obtained as a combined unit from the supplier of LIW screw feeder.

The transition hopper design shall include the following:

i. Be fitted with load cells to measure loss in weight of transition hopper during feeding and provide signals to control the speed of the screw feeder. The generic requirements of load cells shall be followed as mentioned in Section 9.2.6. Load cell WAHH shall interlock the rotary valve and WALL shall interlock the mixing system which includes the screw feeder and mixing water system.

ii. Include an agitator as described in Section 9.3.1.2.

iii. Preferably, include a heating element with similar temperature control as described in Section 9.2.11.

iv. Be sized that the required weight measurement sensitivity from the load cells can be achieved to control the feeder.

v. Low-level and high-level switches shall be installed to trigger operation of the rotary valve for filling operation.

vi. Same materials of storage hopper shall be used for transition hoppers.

9.3.1.2 Agitator

An agitator or de-lumper is required in the transition hopper to achieve a uniform powder bulk density, consistent flowrate and to completely fill the screw feeder inlet and ensure an accurate feeder operation.

An agitator shall be installed at the top of the screw feeder with the following requirement:

i. Be a variable speed drive and the speed of the agitator shall match to the speed of the screw feeder to prevent inconsistent concentration and shall be programmed to run during screw feeder operation.

ii. Should be a horizontal type of agitator with the preference of propeller type blades.

iii. Agitator current should be monitored to identity any failure.

iv. Shall be driven from an independent motorised drive to the screw feeder. The motor shall comply with the requirements of *E-SPE-STD-001 Electrical Design and Construction.*

9.3.1.3 Screw Feeder System

There shall be separate screw feeder for each mixing/batching tank. The LIW screw feeder shall include the following requirement:

i. Be sized to prepare the mixing solution of the required strength with the required turn down ratio and margin for the maximum solution dosing pump rate.

ii. Be fitted with a VSD to adjust the feeder speed automatically. For feeders, speed is controlled with loss-in-weight measurement feedback from the transition hopper load cells within a defined tolerance, refer item (iii) below. The feeder powder discharge rate set point shall be obtained from flow pacing with the summation of motive and make-up water flows for a fixed solution concentration. The feeder shall be able to operate in volumetric mode for the period when powder is transferred to the transition hopper.

iii. Have an accuracy of ±1% by weight or better over the full operating range.

iv. Feeder pitch and flight shall be designed to prevent plugging and flooding and the feeder length should be kept as short as possible. A feeder with variable pitch and single flight should generally be considered.

v. Be fully contained (including inlet and outlet connections) within a housing to prevent powder dust escaping and prevent air being drawn inside.

vi. Be preferably designed with heat tracing with thermostat to avoid powder clogging.

vii. The motor drive power to be suitably sized to accommodate the bulk powder weight in the feeder inlet over the full hopper operating range.

viii. Be operated with a dedicated separate motor drive not sharing with the hopper agitator.

ix. If a slide knife gate valve is selected at the feeder discharge to prevent moisture travelling into the feeder when not running, it shall be fitted with open and close position switches with interlocking that the feeder can only run when the slide gate valve is open. This is to avoid any potential damage to the screw feeder if the valve is closed during operation. The valve should be installed horizontally, sized suitably for less contact of valve body with powder, bonneted and fitted with a resilient seat to suit cycle frequency and design life,

x. Be constructed from material compatible with sodium fluorosilicate for all components in contact with the chemical. Seqwater has experienced chemical attacks to the screw feeder made with 304SS at some sites. Duplex SS2205 material has provided good performance against chemical attacks.

xi. Where possible, a clear PMMA (poly methyl methacrylate) transparent plastic (e.g. Perspex) section around the feeder is recommended to monitor the feeder when it is in operation.

xii. Include an inspection port to allow for safe access and cleaning of screw feeder.

xiii. Include access with sufficient space to safely measure powder discharge if needed for calibration when used as volumetric mode or for alternative verification of transition hopper load cell. A sliding collection tray under the feeder shall be considered. A separate calibration mode in SCADA is required to verify the discharge volume and the corresponding motor speed.

xiv. Seqwater often encounters screw feeder blockage for the sodium fluorosilicate system. The design should incorporate the option to change the blocked feeder easily with a new one without the need of unbolting a large section or replacement of mechanical seals. This is to facilitate cleaning the blocked feeder appropriately at a suitable time and location.

xv. Motor drive design should consider the head load weight of the bulk material in the inlet section over the full hopper operating range (where applicable). Where necessary, a cooling fan should be included for main motor drive cooling. The motor shall comply with the requirements of *E-SPE-STD-001 Electrical Design and Construction.*

9.3.1.4 Powder Wetting System

Powder wetting system is used to pre-wet sodium fluorosilicate powder before transferring to the mixing tank. The pre-wetting of powder is needed to prevent powder agglomeration during mixing and achieve a homogenous mixing, minimise dust emission, and reduce mixing time. The wetting system arrangement may reduce the height requirement of storage hopper arrangement as the mixing tank does not require to be located directly underneath of the mixing tank.

In designing the wetting system, the designer shall ensure that the chemical powder is properly wetted to achieve the desired performance as the process requires.

When more than one mixing tank is used, each tank must be supported with an individual wetting system and all its required components.

Powder wetting can be achieved by using the wetting cone or other suitable system as identified by the design.

9.3.1.5 Wetting Cone System

The wetting cone system relies on wetting cone and eductor to mix and transfer the chemical to the mixing tank.

Sodium fluorosilicate powder from screw feeder is mixed with water in a swirling motion inside the wetting cone to create a powder-water mixture. A separate stream of motive water passing through the eductor underneath of the wetting cone creates a sub-atmospheric pressure from a venturi effect which draws the mixture and flows into the mixing tank.

The main components in the wetting cone system include:

- Wetting Cone
- Eductor
- Motive Water System

9.3.1.5.1 Wetting Cone

The wetting cone shall:

i. Be installed straight below the feeder discharge spout.

ii. Be selected such that adequate wetting is provided across the full turndown range of operating conditions and powder delivery rates.

iii. Include a straight funnel outlet port at the bottom of the cone that connects to the eductor through secure, sealed fittings.

iv. Have a sealed top cover that prevents dust emission and is removable allowing internal inspection.

v. Be fitted with a water line connection to the wetting ring, which circles the perimeter of the cone and flows down the wall and into the base where it blends with the powder chemicals.

vi. Be fitted with an overflow line connected at the top of the wetting cone with a high-level switch for alarm. The designer should provide an interlock from the high-level switch to shut off the inlet water supply and powder feeding system.

vii. Be supplied from the same water source as the eductor motive water as described in Section 9.3.1.5.3 using a tee connection with a separate flow control. The wetting cone water supply line shall include:

   a. A manual flow control valve, preferably a V-notch ball valve with the option of lock-in position.

   b. A flowmeter with the option to generate flow deviation alarm.

   c. A manual isolation valve located upstream of the wetting cone connection for maintenance.

9.3.1.5.2 Eductor System

The eductor is used to further mix the resulting solution and transfer powder and water mixture from the wetting cone into the mixing tank. This is achieved as the velocity of the motive water is accelerated through a constriction, resulting in a pressure differential between the bottom of the wetting cone and the motive water line. The eductor shall:

i. Be designed to provide suitable conditions to prevent overflowing of the wetting cone, and adequate mixing of powdered chemical to avoid clumping in the batching across the span of designed powder delivery rates.

ii. Include replaceable wear parts, if required.

iii. Be designed to consider using union or camlock connection in the suction and discharge side for easy removal.

iv. Be connected to the wetting cone discharge and include the following:

   a. Be designed as short as possible to reduce the motive water pressure requirement.

b. Include an injection nozzle, if required, to enhance suction and mixing of the mixture into the motive water stream.

v. Be fitted with a connection for a line from the discharge side to the mixing tank. The line shall:

a. Be designed as short as possible with minimum or no bends or elbows.

b. Be sized to accommodate the required mixture feed flowrate and achieve the required minimum velocity to prevent powder settling.

c. Be fitted with a manual isolation valve for maintenance requirement.

d. Be connected to the top of the mixing tank with a flanged connection.

9.3.1.5.3 Motive Water System

The motive water system shall be designed to split into two streams between the wetting cone and the eductor system. The system shall be designed to provide a constant flowrate.

The water supply must be sourced from potable water, or from a source with water quality equal to or better than that into which the fluoride chemical is being dosed. The design shall ensure that simultaneous operation of the mixing tank make-up water, wetting/motive water system shall not impact the required consistent or controlled flow of water (i.e., flow rate and supply pressure). A common flowmeter shall be used to know the total flow for motive and make up water systems and the flow data shall be used for flow pacing the screw feeder.

The motive water line shall:

i. Include a Y-strainer with a minimum mesh of 0.5mm.

ii. Include an actuated valve with position feedback and interlock water supply system upon reaching high-high level in the mixing tank or high level in the wetting cone.

iii. Include a booster pump when the water source does not have sufficient capacity to maintain the required pressure and flow. The booster pump design shall provide sufficient flow and pressure for the operation with a variable speed drive where needed. Pump operation shall be interlocked with the same requirement of the actuated valve mentioned above.

iv. Be fitted with a non-return valve and preferably be positioned downstream of the booster pump, where applicable.

v. Be fitted with a pressure transmitter with high- and low-pressure alarms and to be installed at the pump discharge side, where applicable.

vi. Have a manual flow control valve in each line, preferably a V-notch ball valve with the option of lock-in position.

vii. Have a low flow switch with a rotameter to generate an alarm.

viii. A pressure sustaining valve to ensure the consistent feed pressure.

ix. Have a manual isolation valve upstream of the mixing tank connection for maintenance.

x. Consider installing a conductivity meter to measure the background motive water electrical conductivity where the source water may have variability in conductivity. This is to assist to measure accurate fluoride solution conductivity as an indicative measurement of fluoride concentration as mentioned in Section 11 (iii).

In addition to the above requirements, the potable water system shall be protected from the wetting cone/eductor by the use of a reduced pressure zone (RPZ) backflow prevention device – only proprietary back flow prevention devices shall be used. Double check valves are not considered adequate double layer protection. Arrangement must comply with the *AS / NZS 3500 – Plumbing and Drainage and Queensland Plumbing and Wastewater Code.*

9.3.2 Mixing and Dosing Tank System

The mixing and dosing tank system shall be fully automated and be capable of preparing the sodium fluorosilicate solution at the required strength for dosing.

The system includes mixing tank and dosing tank, mixers in mixing and dosing tanks and level instruments in dosing tank. When called upon by the control system, the unsaturated sodium fluorosilicate solution with the required concentration overflows from the mixing tank to the dosing tank for dosing into the main.

9.3.2.1 Mixing Tank

Mixing/batching tank (s) shall be above ground, fixed, permanently positioned tanks that are filled and discharged in situ. The mixing tank shall:

i. Generally, be vertically oriented cylindrical tanks.

ii. Preferably, have a liquid level to tank diameter ratio of 0.8 to 1 to allow proper axial mixing.

iii. Be fitted with connections for wetted powder solution line, make-up water line, mixer, overflow (discharge) line to dosing tank, drain line, and a tank top nozzle to connect with dosing tank.

iv. Include an underflow weir appropriately located to achieve the required detention time under all process conditions before the solution overflows to the dosing tank. See Section 9.3.2.3 for detention time requirement.

v. Have a fixed roof and if used as a working platform, it shall be designed to support the weight of a person. The walkway arrangement must be designed in a manner that will prevent any falling objects from entering the mixing tank.

vi. Have a hinged access hatch on top, where applicable, with recommended opening dimensions of 600 mm. The cover should open sideways and lay flat on the roof of the tank, have restrained option for open position, and be able to be lifted by one person.

vii. Include a suitably sized side mounted flanged and bolted access to allow easy access for maintenance for large mixing tanks.

viii. Include internal baffles for large cylindrical tanks to avoid a swirling motion for mixing.

ix. Be designed and constructed to operate at atmospheric pressure.

x. Be earthed (where needed) in accordance with *E-SPE-STD-001 Electrical Design and Construction*, relevant codes and standards.

9.3.2.2 Tank Materials and Standards

Mixing tanks shall be designed following the appropriate codes and standards. Standards listed for FSA storage tank in Table 10-1 shall generally be followed for mixing tanks with considerations of the following points.

i. HDPE welded tanks are preferred due to their higher design life, and better impact, creep, and scratch resistance.

ii. HPDE tanks may also offer the benefit of customized sloped bottoms for complete cleaning and drainage without removal of the top access.

iii. Many metals including stainless steel tanks may be subject to localised attack/corrosion and must be avoided.

9.3.2.3 Tank Number and Sizing

There should be one (1) mixing tank to maintain the continuity of mixing solution and dosing per dosing facility. The final number should be determined considering the plant's size, number of mains, plant's availability and criticality requirements, reliability and maintainability. Where shutdown or failure of reliability, operability and maintainability cannot be tolerated, two mixing tanks should be considered. When sizing the mixing tank, the design should consider the following:

i. The mixing tank should be sized based on the highest chemical solution consumption rate plus a margin of 10% and the detention time required.

ii. The detention time for mixing tank sizing shall be at least 10 minutes under all process conditions for continuous operation if the water temperature is above 15^{0}C. If either the water temperature is less than 15^{o}C or the mixing water has high hardness, the detention time shall be at least 15 minutes.

iii. The frequency of start and stop of the screw feeder and wetted powder solution feed into the mixing tank shall not be high or low.

9.3.2.4 Tank Labelling

Mixing tanks shall be labelled and placarded in accordance with PRO-00008 *Hazardous Chemicals Procedure* and other requirements as provided in Section 10.3.5, as applicable for the mixing tank.

9.3.2.5 Tank Mixer

Each mixing tank shall be fitted with an electrically driven high rated mixer that adequately mixes sodium fluorosilicate powder to prepare the solution. The tank mixer shall:

i. Enter from the top and be suitably supported and suspended from a tank roof if the tank has been structurally designed to accommodate this. Otherwise, supporting frames shall be designed and installed.

ii. Be designed to prevent powder settling and provide adequate mixing energy to homogenously mix within the range of tank operational level for the maximum sodium fluorosilicate concentration of 0.25% (w/w).

iii. Be designed to run all times when the mixing tank is in operation.

iv. Be removable from the tank without the need to remove the roof in its entirety and include a lifting mechanism if single person lifting is not appropriate.

v. Consider installation with an offset from the tank center to avoid wave formation. For an offset mixer, any additional stress on the mixer shaft due to potential unbalanced forces shall be considered in the mixer selection.

vi. Be designed such that the mixer blades provide uniform velocity throughout the tank and operate without cavitation. Blades shall be one-piece construction and connected to the shaft via a keyway or a welded hub and retained via mechanical means that prevents detachment or loosening due to rotation and vibration.

vii. Have the option to start and stop remotely and locally. The designer shall decide the need of delivering varied shear force by the adjustable variable speed drive instead of a fixed speed motor.

viii. Include current monitoring, raise alarms from high and low currents and ability to interlock with the feeding and dosing system when the mixer fails to operate for various reasons including the shaft breaks or impeller falls off.

ix. Be designed to eliminate any chance of leakage of oil from the gearbox. In addition, to ensure potable water compatibility in the event of accidental leakage, any lubricant used in the gearbox must be H1 certified as specified in *M-SPE-STD-001 – General Mechanical.*

x. Mixer blades and shaft materials must be compatible and corrosion resistant to sodium fluorosilicate solution for long term application.

Where more than one mixing tank is provided for a system or multiple systems, they shall be capable of operating simultaneously.

9.3.2.6 Make-up Water Line

Make-up water line shall be required to assist in mixing in the mixing tank. The design will determine the make-up water flow rate as a percentage of water from the required total water for a fixed concentration solution. Generally, it is recommended the make-up water flow rate is about 10-15% of the total water flow rate.

The design requirements of the make-up water supply system should generally follow the requirements as provided in Section 9.3.1.5.3 for the motive water system.

9.3.2.7 Dosing Tank

Dosing tank(s) are used to store unsaturated sodium fluorosilicate solution for dosing into the process main. Dosing tank acts as a buffer tank while solution is prepared separately in the mixing tank at a desired concentration. The dosing tank shall be preferably positioned at the same level as the mixing tank to allow overflow from the mixing tank under all operating conditions.

The dosing tank(s) shall be above ground, fixed, permanently positioned tanks. Tanks shall be designed and constructed to the appropriate standards as detailed in Section 9.3.2.2.

The mechanical requirements for the dosing tank(s) as provided in Section 9.3.2.1 for the mixing tank shall apply, with some additional requirements and considerations as listed below:

i. Be fitted with connections for solution inlet line (the same as overflow line from the mixing tank), outlet line, overflow line, drain line, nozzles for mechanical level instrument and level transmitter.

ii. Although the powder should be fully dissolved in the mixing tank, a mixer shall also be provided in the dosing tank to manage any undissolved powder carryover to the dosing tank under abnormal conditions. Mixer requirements as provided in Section 9.3.2.5 shall be followed.

iii. Be fitted with solution recirculation line connections from the dosing pump relief valve and commissioning lines.

iv. Include a pressure equalization line with the mixing tank from the tank roof.

v. The vent line shall be fitted with a suitable filter to prevent any dust escaping.

vi. Be fitted with an overflow line and discharged to the bund floor or bund sump. The overflow line shall be at least at least 2 times the diameter of the powder wetting solution line with a minimum size of 100 mm.

vii. Additional requirements for the dosing tank as detailed in Section 9.3.2.7.1 shall be followed.

9.3.2.7.1 Level Devices

Each dosing tank that is filled via a mixing tank overflow line shall include level control and protection. This shall be achieved by the use of:

i. An electronic level transmitter to measure the tank level/quantity. The electronic level transmitter shall incorporate the following:

   a. Low-low level (LALL) Setpoint: At this level, Operator action has been unavailable or unable to correct the low-level event. The process shall be interrupted by stopping the dosing pumps. A further alarm will be triggered, and the Operator notified.

   b. Alarm – Low Level (LAL) - At this level an Operator alarm shall be triggered requiring operator action to correct any issues if the trigger does not self-correct. The process shall continue to operate.

   c. Start of mixing and powder feeding system (or Operational Low Level) – level that starts the screw feeder, mixing tank water line and the resultant solution will start to overflow from the mixing tank to the dosing tank.

   d. Stop of mixing and powder feeding system (or Operational High Level) – level that stops the screw feeder, mixing tank water line and stops the solution overflow from the mixing tank to the dosing tank.

   e. Alarm – High Level (LAH) - At this level an Operator alarm shall be triggered requiring operator action to correct any issues if the trigger does not self-correct. The process shall continue to operate.

   f. High-High level (LALL) Setpoint: At this level Operator action has been unavailable or unable to correct the high-level event. The process shall be interrupted by stopping the screw feeder and mixing tank water line. A further alarm will be triggered, and the Operator notified.

ii. Two separate and independent level switches to identify and action level events at High-High (LSHH) and Low-Low (LSHH) levels as required by the design. These switches shall, as a minimum, trigger at LSHH and LSLL

   a. At LSHH measured on the High-High level device, tripping of the mixing system shall occur causing it to cease operating.

   b. At LSLL measured on the Low-Low level device, tripping the chemical dosing pumps shall occur causing them to cease operating.

iii. Where another level sensor (instead of level switches) is used for the purpose as stated in (i) and (ii), a dissimilar technology to the primary sensor shall be used.

iv. A mechanical level indicating device, preferably magnetic coupled type, with appropriate display to provide local level indication should be considered. Where magnetic couple type level display is chosen, magnetic high-level and low-level switches must be selected.

Tank level for primary and backup devices, where applicable, should be readily viewable as an electronic digital readout local to the tank.

9.4 Process Control Narrative

The following sections describe a typical process control philosophy for the sodium fluorosilicate large bag unloading, powder feeding and mixing system. This should be read in conjunction with Section 9.1 to 9.3 of this document.

9.4.1 Bulk Bag Unloading System

A typical process control narrative for the sodium fluorosilicate powder bulk bag unloading system is described below. This should be read in conjunction with Section 9.1 of this document.

Normal Operation

The large bag unloading process is initiated locally by a site operator.

The site operator, using suitable lifting equipment (i.e., forklift), will transfer sodium fluorosilicate powder chemical bags from the storage area to the point for hoist lifting chain connection. The powder chemical bag is then manoeuvred to the bag massager platform on the top of discharge hopper using a remote controller/pendent for the gantry crane and hoist operation. The hoist and gantry crane can only be operated once the safety gate limit switch is in the closed position and the safety circuit is reset.

Once the bag is in position, the site operator will need to open the massager platform safety door to access the bottom of the bag, untie the discharge spout and/or make a penetration at the center of the bag. The unloader door safety switch, when open, will start the dust extractor fan, open the dust extraction line valve and interlock the conveyor system. The unloading operation can only be started once the bag neck isolator (where used) is opened, the safety door is closed and reset.

The operator can then perform bag unloading using the LCP. Prior to starting the powder chemical unloading process, the operator will energize the LCP with panel “ON” button. The control system will then check that the following requirements are met:

- Storage hopper load cells are healthy, and no alarm exists.
- Storage hopper high-high level switch is healthy and not active.
- Fan extraction and dust collector system is healthy.
- Unloader safety door must be closed and reset.
- Motors associated with discharge hopper and conveyor must not have fault signal.
- Compressed and instrument air system are available.

Once all the above conditions are met, this will enable the “Ready” indicator on the LCP. The operator should then be able to start the unloading by selecting the ‘START’ push button on the LCP.

This sequence starts the dust extractor, discharge hopper vibrator, opens the unloader massager solenoid valves, opens the dust extraction line solenoid valve (if already not opened) and activates the conveyance system sequentially as designed. The system will then initiate the screw conveyor for the transfer of powder to the storage hopper.

Once the filling operation is assumed to be completed, the operator will stop the unloading operation selecting the ‘STOP’ push button on the LCP. If included in the design, the screw conveyor may run for a short period for purging after stoppage of unloading. If included, an operator can also purge the conveyor selecting the “Purge” button on the LCP. Then the operator must de-energize the LCP with “OFF” pushbutton.

The operation personnel must re-enter the safety gate and door, detach the bag outlet spout from the clamping arrangement, the dust extraction system should be running at that time. The gantry crane is then used to maneuver the bag off the unloader and onto the floor where it can be removed.

The dust collector filter is automatically cleaned by the actuated reverse pulse air blast at the pre-determined interval and end of fill cycle or when the differential pressure across the filter is high. The dust collection system should run for a pre-set time after finishing the hopper filling process.

The same unloading procedure as described at the start of this section should be followed for the unloading of another bag.

Abnormal Operation

The bulk bag unloading process will be interrupted if any of the following occurs:

i. Storage hopper reaches High-High Weight.
ii. Storage hopper detects High-High level.
iii. High-High pressure differential alarm across the filter.

At the occurrence of any of the above conditions, the control system will interlock the operation of screw conveyor to stop the unloading process.

If the storage hopper reaches High-Weight / Level, high pressure differential across the filter, a visual and audio alarm will be sounded in the LCP and signal to SCADA.

The unloading stop sequence can also be triggered by an Emergency Stop button on the LCP.

9.4.2 Mixing System

Normal Operation

Sodium fluorosilicate mixing system is designed to prepare an unsaturated solution at a fixed solution concentration (generally 0.2% (w/w) concentration) by adjusting the screw feeder speed from motive and make-up water combined flowmeter inputs. Two sources of water will feed the mixing tank: one for make-up water (where used); and the other as motive water via the powder feed wetting cone and eductor.

The total water flow rate to the mixing tank will be designed about 10% higher than the maximum required sodium fluorosilicate solution dosing rate and therefore the mixing system will start and stop based on the dosing tank solution level.

The mixing system will start automatically when the dosing tank level reaches the “Start” level, and the chemical solution will overflow from the mixing tank to the dosing tank after achieving the design detention time in the mixing tank. To start the mixing system, the following additional conditions need to be met:

- Plant is online and relevant process water flowmeters are healthy.
- Storage hopper or transition hopper weight (as applicable) is higher than the low limit setpoint.
- No fault signals from the screw feeder, agitator, dosing tank level instruments, mixers, heaters, motive and make up water supply line actuated valves and flowmeters.

Upon initiation of the sequence, the motive and make-up water actuated valve will open and starting of the booster pump (where applicable) allowing water flow through the wetting cone and eductor system. After a very short delay, the powder chemical feed system will initiate and trigger the operation of storage hopper or transition hopper agitator and starting the screw feeder at the required speed. The system design will keep the mixing tank at variable levels, and be always at or above the tank overflow (discharge) line to the dosing tank. However, the dosing tank level will go below the mixing tank overflow line level or dosing tank inlet line level.

For the LIW screw feeder system, the controller output will be used to adjust the speed of the screw feeder to achieve the calculated sodium fluorosilicate powder mass flow rate setpoint from the set solution concentration and motive plus make-up water flow rate. The transition hopper load cells will provide a weight loss feedback value (in g/s) (process variable) to the controller to adjust the screw feeder speed (controlled variable).

For volumetric feeders, the above control loop will not be available. Instead, a calibration mode shall be provided to determine the calibration factor as used to calculate the feeder speed on a linear feeder speed / mass flow relationship.

The mixing system will continue to operate and stop once the dosing tank level reaches to the "Stop" level. The motive water system will continue to operate for an additional short pre-set time to flush the wetting cone and eductor after the stopping the screw feeder.

Both the mixing tank and dosing tank mixers will operate at all times and are not part of the start and stop sequence.

Abnormal Operation

The sodium fluorosilicate mixing system will stop by the interlocking the operation of screw feeder, motive and make-up water system and raise alarms in SCADA to alert the operator when any of the following conditions are met:

i. Storage hopper or transition hopper (as applicable) reaches to Low-Low Weight / Level.

ii. Wetting cone reaches high level.

iii. Mixing or dosing tank mixer stops or register fault signal or shows high or low current.

iv. Dosing tank reaches High-High Level.

v. The flow meters for the mixing water do not register healthy flows for a pre-set time when the actuated valves are open.

vi. LIW screw feeder raises deviation alarm from the set point.

vii. Solution conductivity is outside of range.

In addition, where included, particularly where Loss in Weight (LIW) feeders are not used, alarms will be raised if higher or lower rate of powder discharge from the storage hopper (using load cells) for a defined period has been identified than theoretical values. To prevent overdosing and for safety, this will interlock the hopper knife gate valve.

9.4.3 Powder Transfer to Transition Hopper

The following describes a typical process control narrative for sodium fluorosilicate powder transfer from the storage hopper to the transition hopper for a LIW system. This should be read in conjunction with Section 9.3.1 of this document.

Normal Operation

The powder transfer from the storage hopper to the transition hopper will start automatically when the transition hopper will reach low level triggered by the low-level switch and the control system will check the following requirements before operating the rotary valve:

- Storage vibration systems are available.
- Storage hopper and translation hopper load cells are healthy, and no alarm exist.
- Storage hopper Low-Low and transition hopper high level switches are healthy and not active.

The transition hopper filling sequence includes starting of storage hopper vibration system and then starting the rotary valve operation.

The rotary valve will operate to refill the hopper until any of the following conditions are met:

- High level switch in any hopper compartment becomes active.

During powder transfer, the LIW screw feeder will work in a volumetric mode (without any feedback from transition hopper load cells) and operate using the fixed speed recorded before the powder transfer starts.

Abnormal Operation

In the event where the transition hopper weight reaches high-high weight, it will stop the rotary valve operation, and stop the storage hopper vibrator.

10 Fluorosilicic Acid

This chapter includes design and construction requirements for liquid Fluorosilicic Acid (FSA) unloading and storage facilities. The requirements for FSA building (where applicable) and bunding arrangement has been included in Section 12 and details of FSA dosing system has been included in Section 11.

The storage and handling of FSA must comply with the requirements under *Work Health and Safety Act 2011*, *AS 3780 The storage and handling of corrosive substances. and Qld Water Fluoridation Code of Practice (2021).* The design must ensure that the storage and handling facility facilitates safe working practices for operators.

This section should be read in conjunction with P&ID Standard Drawing *B-DWG-STD-035, Fluorosilicic Acid System* as referenced in Section 13.

10.1 Chemical Delivery and Unloading

Liquid FSA may generally be delivered in Intermediate Bulk Containers (IBCs) or by bulk delivery road tankers. Chemical delivery by road tankers shall be the preferred mode of delivery.

Chemical delivery by IBCs may be considered for some sites considering monthly chemical demand volume and suppliers' preference. Where this is the case, Seqwater's preference is that empty IBCs are swapped out with a new IBC rather than transferring to an existing one.

The designer shall consider any downtime associated with IBC swapping or transfer activities and whether a duty/standby arrangement may be required to maintain operation.

Irrespective of the delivery mechanism, operation of the plant and chemical systems shall not be adversely affected during chemical delivery and unloading.

FSA bulk road tanker delivery unloading system shall include the following:

- Unloading bay
- Chemical spillage capture and drainage
- Chemical filling point, transfer line and fill control.

10.1.1 Unloading Bay and Spillage Control

A chemical unloading bay shall be designed and constructed to provide safe arrival, parking, off-loading, vehicle turning and departure for FSA deliveries and road tankers.

The design shall consider specific chemical suppliers' requirements which may be obtained directly from chemical suppliers.

Where possible, the reversing of chemical delivery road tankers should be avoided. If reversing cannot be avoided, the arrangement of any unloading area shall allow the tanker driver to reverse into the unloading area and leave the site in a forward direction. The design shall avoid the possibility of a tanker having to pass through a contained spill, if it does occur.

Entry to the unloading bays shall be clearly marked and signed, identifying entry/exit, and ensuring delivery vehicles are oriented such that truck hoses are the same side as the plant fill point.

Spillage control in unloading areas shall be provided for chemical deliveries and transfers which shall:

i. Divert all spillage to a sump measuring at least 600 x 600 x 600 mm with a drain. This drain shall divert to either appropriate chemical spill holding tanks or a stormwater system via appropriate valving. See Section 10.1.2 for further information.

ii. Be graded to the sump sufficiently to prevent pooling or loss of containment. Graded surfaces shall be suitably finished with non-slip surfaces to provide protection to concrete structures and surfaces from chemical and mechanical damage.

iii. Include a protective galvanised steel sump grating sufficient to withstand the weight of any fully laden chemical delivery truck.

iv. Be located adjacent any Fill Points (See Section 10.1.3) in length in accordance with *AS 3780*.

Safety showers and eyewashes shall be provided which comply with *AS 4775* and shall be located within 7 m from any Fill Points but not closer to 2 m in accordance with *AS 3780*. See Section 7.15 for further requirements about it.

Drainage from an Unloading Area Sump shall be via gravity to a Chemical Spill Holding Tank (CSHT) (or similar structure) (see Section 10.1.2). Valving providing diversion of spills from the sump to the appropriate CSHT shall be provided. Diversion via a valve shall also be provided to allow drainage of stormwater from the Unloading Area Sump. This arrangement is shown conceptually in Figure 10-1.

All diversion valves shall be positioned outside of the unloading area, in a valve pit allowing safe manual, above ground operation/actuation by an operator. Valves shall include local and SCADA position indication. The valve connected to CSHT shall be opened to divert any spillage to the appropriate CSHT during unloading procedures and closed at all other times. The valve connected to the storm water system shall be always opened except during the time of unloading. Automation of diversion valves should be considered if the chemical delivery frequency is relatively high.

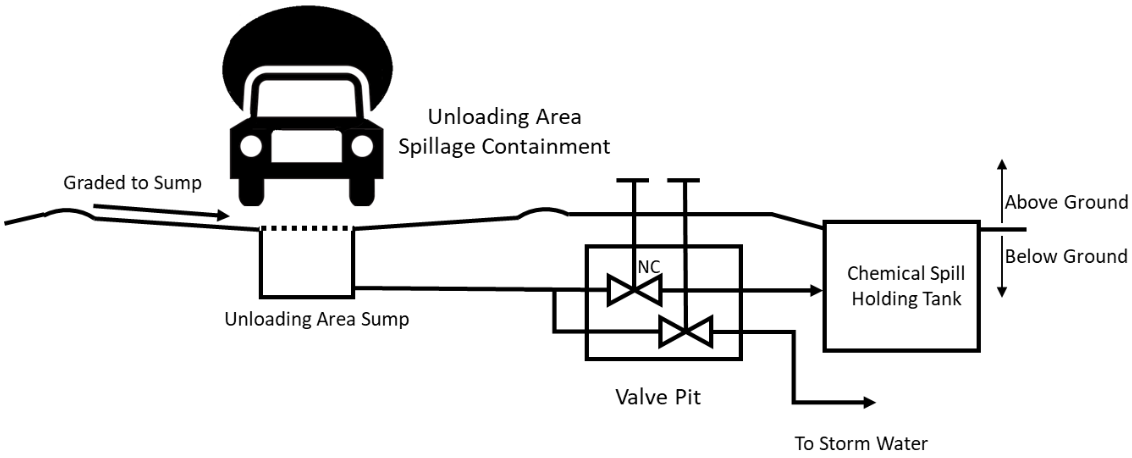

Figure 10-1 – Section view showing unloading bay, sump, and drainage arrangement

The Unloading Area and sump shall be capable of accommodating a spill volume such that it complies with the volume requirements in *AS 3780 The storage and handling of corrosive substances.* Additional allowances in accordance with *AS 3780* shall be made as necessary to provide for rain, clean-up or dilution water, or output from fire protection services. Allowances may include additional spillage volume, or protection from ingress of such sources (such as a shelter structure to protect from stormwater).

Consideration should be given to including unloading area shelters to prevent ingress of stormwater and provide protection to delivery personnel during unloading activities. Eliminating stormwater ingress will influence the capacity of spillage control infrastructure and associated assets in accordance with AS 3780.

A standard arrangement is shown in more detail in the P&ID Standard Drawing *B-DWG-STD-035*.

10.1.2 Chemical Spill Holding Tanks

The Chemical Spill Holding Tank is used to capture and hold spills from an unloading bund spill event, refer to Figure 10-1. This holding tank will allow the unloading area to drain to a safer location and prevent unloading truck and personnel standing in a spill.

The CSHT shall be sized to accommodate volumes as follows:

i. The capacity of the spillage control arrangement as per the requirements of AS 3780 including any rain requirements; plus;

ii. Additional volume to accommodate longer term containment of smaller but cumulative washdown and chemical neutralisation volumes arising from day-to-day operation and clean-up following typical chemical deliveries. This additional volume is intended to prevent the need to empty the CSHT after every small washdown event as part of routine maintenance and housekeeping.

Note: the volume of a significant spill (other than typical small splashes / spills which are cleaned up) would be emptied from a CSHT promptly.

Each Chemical Spill Holding Tank shall provide the following:

iii. The tank shall be double contained if not located within a bund.

iv. Gravity drainage from the spillage control sump.

v. Venting / breathing, and vent pipe should be directed to a safe location.

vi. Level sensor with local and SCADA reported level. A high-high level shall be interlocked with chemical delivery and generated an alarm as a minimum.

vii. A means of emptying the CSHT by use of a vacuum truck:

   a. Above-ground drainage connection point with internal pipe extending to the tank base for drainage via a vacuum truck. This shall include a Mechanical coupling connection with lockable dust cover; or

   b. An alternate approved arrangement or methodology.

viii. A sample port/point to allow sampling of tank content. For buried tanks, a safe and ergonomically accessible sample port in the roof of the tank should be provided.

Where an unloading area's sump is used to service the unloading of multiple chemicals, a separate CSHT shall be provided for each chemical to minimise the risk of incompatible chemicals coming into contact. Based on the findings of a risk assessment, a CSHT may be shared for compatible chemicals.

Emptying of Chemical Spill Holding Tanks should be a manual operation by vacuum truck for offsite disposal. The inclusion of drain valves shall be omitted to reduce the risk of environmental releases, subject to appropriate engineering reviews.

10.1.3 Transfer/Fill Points

The Fill or Transfer Point is the point at which a delivery hose from the tanker connects to the Bulk Storage Tank fill pipework.

Fill points shall be located adjacent the Unloading Area such that a tanker hose does not exceed 6m in accordance with AS 3780 (although this length should be confirmed with chemical suppliers). They shall be positioned such that the tanker delivery personnel do not need to enter any spillage control containment.

Each bulk storage tank shall be filled individually, having its own fill line and fill connection point.

FSA fill points shall be separated by a minimum of 5 m from other chemicals if located in the same area.

Fill points shall:

i. Be clearly labelled, including a nameplate/identification plate above each fill point defining its name, grade and strength, and the tank into which it feeds.
ii. Include a mechanical coupling for connection to a tanker delivery hose which shall be:
    a. The fill point connection type shall be confirmed based on consultation with specific chemical suppliers and Seqwater. Where this cannot be confirmed, may be assumed to be 50mm Male Camlock Mechanical coupling type.
    b. Fitted with a dust cap capable of being locked (via padlock) if necessary.
    c. Fixed to fill lines with a flanged connection to allow easy replacement if damaged.
iii. Positioned above ground level at a height per chemical suppliers' requirements. If not stipulated by the chemical supplier, or if unknown chemical supplier, between 800 – 1200mm above ground level at the point of connection to a tanker hose.
iv. Installed between 45° and 90° to the vertical (in a horizontal to downward orientation).
v. Where possible, be installed inside the lip of the chemical storage bund to capture any spills.
vi. Be designed such that only one tank (where multiple tanks of the same chemical exist) may be filled at any given time.
vii. Include a drip tray under connection points to capture any residual chemical from connection, disconnection and filling of tanks. Drip trays shall:
    a. Drain via gravity preferably to the respective CHST (where practicable) or storage bund or to the storage bund sump. Where connected to the CHST, an isolation valve needs to be included in the drip tray drain line.
    b. Have their drains positioned to prevent chemical spilling onto valves, pumps, skids, instrumentation, pipe, pipe supports and cable trays.
    c. Be made of materials immune from corrosion or attack by the chemicals with which they may come into contact.
    d. Be sufficiently sized to capture spillage typical of connection/disconnection and drainage of fill lines.
    e. Not inhibit access requirements as stated in this document and in accordance with AS 3780.

Where needed, the designer should discuss alternative fill point connection types with the chemical supplier and Seqwater.

Where multiple fill points for multiple tanks of the same chemical are installed in close proximity, they shall have a minimum separation distance of 400 mm (from outer edge of couplings, not centrelines).

To prevent accidental filling of tanks with incorrect or incompatible chemicals (if located in the same area), for each chemical type, designers should assess existing connections and consider incorporating one or more of the following:

i. Use of an automatic chemical identification system (such as Orica's CoDé System®).
ii. Different size mechanical couplings for different chemicals.

iii. Unique mechanical coupling type such as:

a. Male vs female coupling connections; or

b. Proprietary coupling technologies providing different connection shape for different chemicals.

iv. Fitting mechanical couplings with locks, with a different key for each chemical type.

v. Fitting manual isolation valves (which include a position switch) with mechanical isolation (i.e. locks).

vi. Colour coding mechanical couplings and connection points.

10.1.4 Fill Lines

Fill lines shall include a non-return valve, a drain line /valve and a manual isolation valve with position switch. These are described in further detail below.

Fill lines shall:

i. Be at least 80mm in diameter but sized to suit the expected tanker delivery rate based on delivery pressure and velocity.

ii. Be at least PN16 rated.

iii. Made of suitable material, compatible with the chemical and sufficiently robust for the filling procedure.

iv. Include a manual isolation valve with position switch:

a. Ergonomically accessible to the tanker delivery personnel from outside the chemical storage bund.

b. To isolate the LCP Special Power Outlet (SPO) when not in the open position to prevent inadvertent tanker pump operation and filling against a closed valve.

v. Include a non-return valve:

a. Immediately downstream of the hose connection point to limit chemical spill upon disengagement.

b. Upstream of the tee between the mainline and drain to ensure liquid downstream of the check valve can be drained.

c. Shall have a low-pressure spring to ease purging the fill line from the truck compressor after each delivery.

vi. Include a drain line and valve between the non-return valve and manual isolation valve. This is to ensure the fill line is completely drained prior to disconnecting the tanker hose. Drain line valves shall be:

a. At least 25mm NB.

b. Positioned to allow operators to drain the line without risk of contact with chemical spray.

c. Preferably ended to the drip tray, where practicable.

vii. Rise vertically from the transfer connection point as quickly as possible and then slope toward the tank inlet.

viii. Be double contained where the line needs to run outside the storage bund.

ix. Be installed to eliminate any pockets that could collect and hold chemical which cannot be drained from the fill point drain line.

Refer to Section 10.3.6 for additional information regarding the requirements for Fill Line connections to tanks and the tank internal requirements.

Clear signage identifying the connection point chemical must be provided for each fill point.

Power for the unloading pump shall be sourced from power outlets that are integrated with the unloading LCP arrangement. See the following Section for additional information on LCPs.

A hose down facility shall be located adjacent each fill point. This facility may be shared between multiple chemical fill points if layout allows. A hose reel shall be provided for this purpose.

10.1.5 Local Control Panel

A Local Control Panel (LCP) shall be provided for FSA fill location – multiple connection points for the same chemical (in the same bund) may share an LCP. Where multiple bulk storage tanks and fill points for FSA exist, a single LCP shall be provided.

Safe Fill Level for each tank (described in more detail in Section 10.3.1) shall be clearly identifiable at / from the LCP (in Litres) for use by personnel during chemical deliveries, for each tank.

The LCP arrangement shall, as a minimum:

i. Be clearly labelled with the panel tag number, chemical name, all dials, buttons and displays clearly labelled as per Seqwater's labelling requirements.

ii. Include:

   a. An On/Off Unloading switch to initiate the panel. The status shall be viewable remotely via SCADA.

   b. A ready indicator – indicating all pre-requisites for fill are met.

   c. A running indicator.

   d. An alarm test button.

   e. A lamp test button.

iii. Include an integrated Special Power Outlet (SPO) per tank/fill line at each LCP to supply power to the unloading truck pump. SPOs shall:

   a. Typically, be 3-phase 4-pin plug socket, round pin for 415 Volts, 50 Hz, 20 Amp rating, IP56 rated with interlock switch. The requirements shall be confirmed with the chemical delivery supplier and Seqwater based on power availability at the site. Where single phase power is required, the requirements shall be discussed with the chemical supplier and Seqwater.

   b. Be located away from the delivery hose connection point to prevent the risk of splashing by chemical and ensure personnel safety.

   c. Be located within 7.5m of the delivery tank fill point (maximum allowable cable length to be used).

   d. Include interlocks to cut off power to the SPO in the event of a tank high (or high-high as required by design) level alarm (this will likely be from two level sensors in the bulk storage tank).

   e. Comply with the requirements of *E-SPE-STD-001 Electrical Design and Construction*.

iv. Include a local warning device providing visual and audio alert if the chemical delivery exceeds high level in the bulk storage tank, or bund high level is detected:

   a. At least one amber beacon type warning light shall be attached to the top of the LCP. Additional beacons may be included in the chemical storage area based on the requirements of any risk assessments.

v. Include at least one Emergency Stop button located in an accessible position near to the SPO (to cut power to the unloading truck's delivery pump). The emergency stop shall:

   a. Be clearly labelled.

   b. Trigger a local alarm (visual and audible) and telemetry alarm visible from the control room.

   c. Be detailed with the functionality by the project specific design team. But, as a minimum, this shall isolate LCP SPOs and those of any other fill points in the bund.

   d. Additional Emergency Stop buttons (or similar) should be considered in the area in accordance with relevant engineering risk assessments/reviews, HAZOPs and similar design processes, and chemical supplier requirements.

vi. Be designed such that only one tank can be filled at a time.

vii. Be fitted with a test pushbutton to allow operators to check alarm operation.

viii. Include a digital readout of tank level providing a minimum of tank level (litres) and available working volume (litres). Additional parameters may be provided and selectable as fill level (percentage). Displays shall:

   a. Be fitted with a sunshade to provide protection and prevent glare.

   b. Be sufficiently weatherproof to meet operational requirements and required design life.

   c. Be visible and readable from at least 5m.

   d. Where displays for multiple tanks are included on a single panel, be clearly labelled and identify which tank they apply to.

LCP operation should include operator authorisation/enabling and tank selection via SCADA in addition to selection of an "Unloading" setting on the LCP. This SCADA enabling should be timed such that if an unloading activity is not initiated within that time period, the LCP operation is interlocked and requires re-initiation through SCADA.

It should be assumed that all chemical deliveries will be undertaken with supervision and attendance of a site operator as an additional layer of protection.

Designers shall ensure all necessary information is available to operators and delivery personnel during chemical deliveries.

10.2 IBC Delivery and Storage System

Preference for FSA delivery method shall be decided in consultation with chemical suppliers considering monthly chemical demand and site location. Intermediate Bulk Containers (IBCs) can be considered instead of tanker delivery for small to medium size plants. However, where possible, chemical delivery with IBCs should be avoided due to involvement of manual handling for IBC storage, set-up, and connection to transfer line.

If IBCs are selected for the delivery of liquid FSA, the storage and dosing system shall include the following requirements:

i. FSA shall not be dosed directly from an IBC and must be transferred to a bulk storage tank or a day tank for dosing. The provision of bulk storage tank for IBCs has been included to accommodate appropriate level instruments and interlocks for the control of fluoride dosing and to minimise the frequency of IBC handling. The bulk storage tank system shall be designed as described in Section 10.3.

ii. Where selected, the bulk storage tank for IBCs should have a minimum storage size with equivalent volume of two (2) IBCs (generally each 1000 L). At a given time, only one IBC shall be connected to the bulk storage tank.

iii. The total volume of FSA in the IBCs and tanks should provide a capacity to hold 28 days of chemical for dosing at an average dose rate and maximum production rate. The final storage size should be determined considering the available IBC in the market, supply arrangement, supply chain risk for the site and fluoride overdosing risk.

iv. The IBC must comply with construction, testing, inspection, transportation, marking and other requirements within the ADG code.

v. The IBC shall be made from materials compatible with FSA with suitable support stand and a cap on the top to loosen easily for venting.

vi. The IBC must include a bottom discharge valve, be secured against accidental opening and the open or closed position must be readily apparent. A secondary means of sealing the discharge aperture by a blank flange or equivalent device must be provided.

vii. The IBC shall consider including a tote scale to measure the weight of the FSA content and be the only mode of monitoring and control parameter for the operation. It shall have the following requirements:

   a. Be mounted along with weighing modules, junction box and a transmitter to send the weight signal to PLC.

   b. Be capable of reading the tank weight empty and full within ±0.1% accuracy.

   c. Include a low weight setpoint and an alarm to notify operators and automatically trigger shutdown of the FSA transfer pump.

   d. The IBC weight shall be on display as an electronic digital readout local to the IBC and viewable locally at ground level and remotely at SCADA.

   e. FSA transfer operation from an IBC to a bulk storage tank should be designed to perform from an LCP.

   f. Electrostatic charges must be discharged to the ground without crossing the scales. Earthing shall be provided according to the requirements in *I-SPE-STD-015 Instrumentation.*

viii. The transfer line to transfer the FSA solution from an IBC to a bulk storage tank shall:

   a. Be fitted with a dry-break coupling for connecting IBC to the transfer line.

   b. Be fitted with a manual isolation valve and a solenoid valve to open/close automatically when initiated the transfer.

   c. Be fitted with a drain line to enable complete and safe draining of transfer hose prior to decoupling.

   d. Be in a bunded area with the requirements that any spillage shall be directed to the storage tank bund sump.

   e. Be fitted with a vent/degassing line installed at the highest point to vent to atmosphere in a safe location. It shall include an isolation valve with a mechanism to lock open and be easily accessible.

   f. Be fitted with a non-return valve upstream of the bulk storage tank to prevent back flow.

ix. Gravity transfer is generally not recommended as it may require an elevated support stand for the IBC. A transfer pump shall be installed when gravity transfer is not practical with the following requirements:

   a. One (1) fixed speed drive transfer pump with the consideration of a spare pump in the workshop.

   b. Be preferably an air driven diaphragm pump where compressed air supply is available. However, other suitable pumps can also be used. When an air diaphragm pump is used the air inlet line shall:

      1. Be fitted with a solenoid valve to open/close the compressed air supply and a pump interlock from high air pressure.

2. Be fitted with a pressure regulating valve to maintain the required air operating pressure for the pump and a manual isolation for positive isolation.

c. Provide flanged connection at both inlet and discharge ends.

d. Consider including a pressure indicating device at pump discharge.

e. Comply with Engineering Standard *M-SPE-STD-012 Chemical Dosing Pumps.*

x. An alternative compact package design with an IBC installed on top of a day tank can be considered for small sites if all interlocks and functionalities illustrated in this document can be achieved without any additional risks and manual handling. If this has been adopted, the FSA transfer from the IBC to the day tank must be done from SCADA in remote manual mode by the operator.

10.3 Bulk Storage Tank System

This section describes the requirements for the design and construction of FSA bulk storage systems.

Bulk chemical storage tanks to store FSA shall be above-ground, fixed, permanently positioned tanks that are filled and discharged in situ.

Secondary containment shall be provided for all storage tanks. Refer to Section 12.1.3 for additional information on secondary containment or bund arrangement.

10.3.1 Tank Number and Size

Bulk liquid fluorosilicic acid chemical storage:

i. Should generally include two (2) storage tanks, identically sized. The final tank numbers should be determined considering the site's availability and criticality requirements, the site's size, the stored chemical's properties and usage, aging, site staffing, site location and access (e.g. in fair and poor weather), supply chain risk, reliability, operability and maintainability considerations.

ii. Should provide a minimum demand volume which shall account for the influence of the raw water fluoride content by sizing based on the greater of:

a. 14 days at maximum dose, average plant flow; or

b. 28 days at average dose, maximum plant flow.

Where there are significant variations in background fluoride content due to changes in water quality, maximum dose rate shall be determined from 1-2 weeks of historical average dose data from water quality event periods rather than using an instantaneous maximum dose rate. Average and maximum plant data should be obtained from historical daily production data or projected planning data.

iii. Storage tanks shall:

a. Be capable of operating independently and as a combined storage volume.

b. Be provided with an ullage space in tank design to accommodate thermal expansion. Ullage shall be determined in accordance with the standards and specifications for the material, location and contents of the tanks.

c. Be vertically oriented unless instruction otherwise is given by Seqwater, or design requirements dictate a horizontal orientation.

d. Be earthed in accordance with *E-SPE-STD-001 Electrical Design and Construction*, relevant codes and standards.

The following requirements shall be considered in the design, sizing and construction of tanks:

Tank Capacity (Overfill level) is the volume at which either the tank will suffer mechanical damage or contents will be lost from the tank (at overflow line invert level). This is considered 100% of the tank's design volume and excludes any additional ullage or headspace volume.

Safe Fill Level (SFL) (or Normal Fill Level) is the maximum level to which a tank will intentionally be filled on a routine basis using the normal process control system. This shall not exceed 95% of the Tank Capacity (overfill invert level). However, it will be determined based on the setpoint requirements described in Section 10.3.7.

A tank's design volume shall consider the demand volume from the requirements listed in point 10.3.1. (ii) above, plus the requirements to achieve the level setpoints as defined in Section 10.3.5.

10.3.2 Tank Materials and Standards

All bulk FSA storage tanks shall be designed to the appropriate codes and standards as listed in Table 10-1 with considerations of the following points:

Table 10-1 – Approved standards for the design and construction of FSA storage tanks

Operating Pressure	Material	Fabrication Method	Acceptable Standard(s)
Atmospheric	HDPE	Welded	DVS 2205 series / BS EN 12573 series
	LLDPE	Rotationally moulded	AS 4766 / ASTM D1998
	GRP	Combination of reinforcement, contact moulding or centrifugal casting and others	AS 2634 / BS EN 13121-3

i. Most metals are potentially subject to chemical attack and shall be avoided for FSA storage.

ii. High Density Polyethylene (HDPE) tanks are generally preferred due to higher design life, better impact, creep, and scratch resistance. However, they are priced higher than rotationally moulded polyethylene tanks.

iii. HPDE tanks may offer the benefit of customized sloped bottoms for complete cleaning and drainage without removal of the top access.

iv. Special attention is required in design and workmanship for the inlet and outlet connections of rotationally moulded tanks which are generally manufactured from HDPE PE 100 materials and welded directly to dissimilar materials of rotationally moulded tanks. Seqwater has not experienced too many issues with these welded connections, however, some failure incidents have been reported in the industry.

v. The design life of HDPE and rotationally moulded tanks are significantly affected by temperatures above 40^{o}C. For higher temperature application, GRP tanks should be selected.

vi. Glass-fibre Reinforced Plastic (GRP) tanks shall be constructed with a double-synthetic fabric reinforced with a methyl ethyl ketone peroxide (MEKP) or approved equivalent for mediated postproduction curing to minimize the susceptibility of corrosion of the glass strand reinforcement.

vii. Where GRP tanks are selected, provisions must be made for periodic inspection to check for integrity of the gel coat due to glass reinforcement being subject to chemical attack.

viii. GRP tanks are the same design life of HDPE tanks and are similarly priced.

All tanks shall be mounted on a purpose designed and built concrete plinth or tank stand so that the tank base is at least above the bund level of 110% of the capacity of the largest tank located within the same bund.

All tank equipment and instruments shall be fitted such that they can be removed without draining the tank contents e.g. side-mounted pressure sensors may be fitted with an isolation valve.

10.3.3 Tank Design Pressure and Temperature

FSA storage tanks shall be designed for Site Conditions, Atmospheric Conditions and Process Conditions as defined in Section 7.4 of this document.

Bulk storage tanks shall be designed and constructed to operate at atmospheric pressure. Maximum and minimum ambient temperature, maximum and minimum chemical supply temperature included in PRO-02564 Drinking Water Treatment Chemicals - Specifications, Monitoring and Assessment Procedure should be considered in the tank design.

The pressure or vacuum resulting from filling, emptying, thermal inbreathing and outbreathing, or atmospheric change shall not result in exceeding the maximum design stresses of the tank.

10.3.4 Tank Nozzles

All tank nozzles shall be flanged and adequately reinforced with minimum size of DN50.

Storage tanks should have nozzles for fill line, outlet line, overflow line, vent line, drain line, mechanical or magnetic coupled level gauges and level transmitters.

Tanks may also require additional nozzles to accommodate:

- Return lines for commissioning purposes,
- Vapour return lines from the dosing skid,
- Pump discharge pressure relief valve return lines.

The designer shall account for such additional nozzles and ensure they are incorporated in tank fabrication. Section 11.10 has included some requirements of chemical return lines.

P&ID Standard Drawing *B-SPE-STD-035 Fluorosilicic Acid System* as referenced in Section 13 should be referred for generic nozzle locations.

10.3.5 Tank Labelling

All tanks shall be labelled and placarded in accordance with PRO-00008 *Hazardous Chemicals Procedure*, Work Health and Safety Regulation 2011, Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Australian Dangerous Goods Code and relevant legislative requirements.

Where multiple tanks of are installed, each tank shall be labelled with the tank number (i.e. Tank 1, Tank 2 etc) such that it is clearly visible and readable from the tanker fill point.

Each tank shall include a name plate which will remain clearly legible for the design life of the tank and should be visible and legible from both within and outside of the secondary containment area where practicable. Each nameplate shall include the following information:

- Manufacturer
- Manufacturer's details (name, address, contact number)

- Design Code
- Date of Manufacture
- Serial Number
- Tank Number / Tag Number
- Materials of Construction
- Product / Content (including chemical name, formula, and strength in % w/w or %w/v).
- Design Volume / Capacity
- Nominal Height
- Diameter
- Design Liquid Level
- Overflow Level
- Design Temperature
- Design Pressure
- Maximum Specific Gravity (of liquid to be contained)
- Maximum mass in kilograms of stored chemical (when filled to overflow level)
- Weight of Empty Tank
- Test pressure (if applicable)
- Test temperature (if applicable).

The nameplate shall be printed, adhered to the tank following *Seqwater X-PRO-STD-006.Equipment Numbering and Naming Convention* and intended to remain in place and legible for the design life of the tank.

10.3.6 Fill Lines

This section builds on the requirements of Fill Line discussed in Section 10.1.3, with the battery limits defined from the flange connection at the tank nozzle to the tank internal. Tank fill lines, including the interface between fill lines and the tank shall:

i. Include a separate flanged nozzle/connection on the topside (roof) of each tank with a minimum diameter of 50mm but matching the fill line diameter as discussed in Section 10.1.3.
ii. Enter the roof of the tank in a vertical orientation, above the overflow height and opposite of the outlet pipe to minimize air entrainment to the dosing pump during filling.
iii. Provide a submerged inlet for bulk tank filling from tankers i.e. the fill line shall extend to the internal base of the tank to minimise fumes and off-gas. Submerged inlets shall:
    a. Be made of materials suitable for submergence in the chemical tank.
    b. Extend to the base of the tank on the opposite side of the tank to any outlets to prevent air and vapour entrainment into outlets and dosing pumps.
    c. Include a mechanism to prevent siphoning the contents of the tank through the fill line, such as a siphon breaker or drilled hole at the top of the internal line above the maximum fill level.

10.3.7 Level Devices and Control

Each bulk chemical storage tank that is filled via tanker or from any automated transfer system, excluding where filled by hand, shall include level control and protection as defined here.

Tank level measurement and protection shall be achieved by the use of:

i. A mechanical level indicating device, preferably magnetic coupled type, with appropriate display to provide local level indication. The Safe Fill Level (SFL) of a tank shall be clearly marked on the level-indicating device and visible to the tank fill operator.

ii. A primary electronic level sensor to measure the tank level/quantity. The electronic level transmitter shall incorporate:

  a. Alarms – Level Alarm High (LAH) and Level Alarm High-High (LAHH). At LAHH, isolation of any Fill Point SPO shall occur during filling.

  b. Alarms – Level Alarm Low (LAL) and Level Alarm Low-Low (LALL). At LALL, closure of the tank outlet valve and trip of the chemical dosing pump shall occur.

  c. If the chemical draw-down rate within a 24 hour period exceeds the theoretical volume requirement considering average dose rate and maximum plant production, closure of the tank outlet valve shall occur and trip to the chemical dosing pump.

iii. Instead of high-high and low-low level switches, a redundant secondary electronic level sensor shall include to measure the tank level/quantity. This shall incorporate the same alarms and trips of the primary level sensor. This is mainly to achieve further protection against fluoride overdosing using daily high draw down volume.

iv. The secondary level sensor must be a dissimilar technology to the primary level sensor.

v. Electronic level sensors must be suitable for Site Conditions and compatible with the FSA in service.

Tank level shall be readily viewable as an electronic digital readout for primary devices and, where applicable, backup devices. Tank level shall be viewable:

  i. Local to the tank and viewable at ground level**.**

  ii. Local to the tank LCP, and viewable near the LCP during filling operation as described in Section 10.1.5.

  iii. Remotely.

A local and telemetry alarm shall be provided to indicate if tank level falls while the outlet pumps (if applicable) are not operating, or tank level rises while LPC SPO is not active.

10.3.7.1 Setpoints

FSA storage tanks shall all be equipped with alarm setpoints, triggered by appropriate level transmitters with appropriate prompts for operator-driven and automated actions as required by the design.

The following provides guidance to Seqwater's requirements for setpoints and alarming of tanks. Specific design requirements shall dictate final setpoints.

The following high-level setpoints shall be available for tank operation:

- **Maximum Operating Level / Operational High Level (OHL):** This operator settable setpoint provides no alarm. The process will continue to run with no action. Reaching this level will be recorded as an Event[2] only in SCADA. Generally, OHL is set just below SFL which shall not be more than 95% of tank capacity (assuming 100% from tank outlet to overflow line invert level).
- **High-level (LAH) Alarm:** At this level an Operator alarm shall be triggered requiring operator action to correct any issues if the trigger does not self-correct. The process shall continue to operate.

[2] Events are a fifth priority alarm in the Seqwater alarm system as defined in *I-SPE-STD-006 Monitoring and Control System Alarm and Event Management.*

- **High-High level (LAHH) Alarm:** At this level a further alarm will be triggered, and the Operator notified. At this level Operator action has been unavailable or unable to correct the high-level event. The process should be interrupted, or further actions triggered.

The following low-level setpoints shall be available:

- **Minimum Operating Level / Operational Low Level (OLL):** This operator settable setpoint provides no alarm. The process will continue to run with no action. Reaching this level will be recorded as an Event[2] only in SCADA. This may be used to allow autonomous duty tank changeover without triggering an alarm.
- **Low-level (LAL) Alarm:** At this level an Operator alarm shall be triggered requiring operator action to correct any issues if the trigger does not self-correct. The process shall continue to operate.
- **Low-low level (LALL) Alarm:** At this level a further alarm will be triggered, and the Operator notified. At this level Operator action has been unavailable or unable to correct the high-level event. The process should be interrupted, or further actions triggered.

In addition, the following daily draw down setpoints shall be available:

- **High Daily Draw-down Rate (HDDR) Alarm**: This is to trigger an alarm and alert the Operator if the chemical consumption in any 24 hour period is higher than the theoretical value of chemical consumption calculated from input average dose rate and maximum plant production. At this level, Operator action has been unavailable, and the process shall be interrupted, or further actions triggered.

When sizing a tank and determining level setpoints for alarms, designers should consider the response time. Response time is the duration following a certain event (such as LAH) being reached before the next event (such as LAHH) is reached, the same is applicable for LAL and LALL events. The greatest tank fill rate or draw down rate shall be considered for response time that is likely to be experienced during operation (including tank filling events). This time allows an operator or control system to correct itself before an escalation in control system management is triggered.

The level setpoint as a percentage of total tank volume/level will therefore be calculated from this response time. Operational High Level and Operational Low Level shall be settable by operators and result in only an event being logged with no alarm generated.

Figure 10-2 shows the visual representation of standard level setpoints, and Table 10-2 shows a guidance for response time for different level set points.

The designer should make remaining available tank volume to be filled on the HMI and displayed in litres. This will enable operators to quickly determine the volume that may be transferred into a tank.

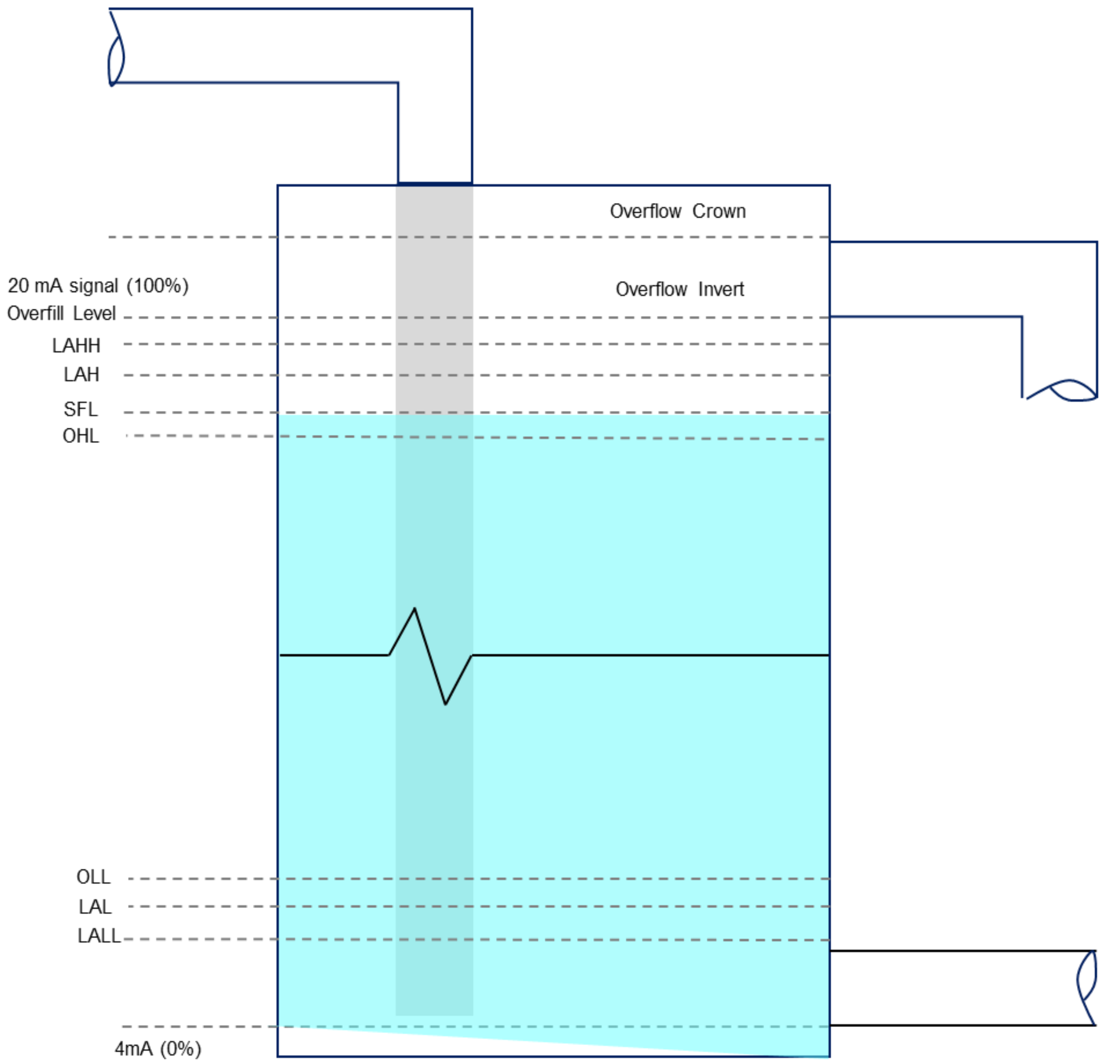

Figure 10-2 Visual representation of standard level setpoints.

Table 10-2 Guideline response times for level setpoint determination and tank sizing.

Description	Shorthand	Response Time (minutes)	Reference Level
High-High Level	LAHH	≥ 3	From SFL
High Level	LAH	2	From SFL
[3]Operational High Level	OHL	N/A	≤ SFL
[3]Operational Low Level	OLL	N/A	> LAL
Low Level	LAL	5	From OLL
Low-Low Level	LALL	≥ 6	From OLL

[3] OHL and OLL will be settable by operators and result in only an event being logged with no alarm.

10.3.7.1.1 Analogue Instrument Calibration and Setup

Analogue level instruments shall be calibrated such that:

i. 4 mA corresponds to 0% tank level (tank outlet invert). The 0% level shall exclude any excess volume or ullage in a tank.
ii. 20 mA corresponds to 100% and is aligned with the invert level of any overflow pipe. The 100% level shall exclude any excess volume or ullage in a tank.

A visual representation of the above calibration requirements is depicted above in Figure 10-2.

10.3.8 Process Lines

Where multiple bulk storage tanks feed a dosing system, a common skid manifold (fed from each tank) shall be provided. Each tank shall be manually and remotely isolatable from the manifold.

See Section 11 for the requirements of dosing systems.

10.3.9 Overflow Line

Each tank shall have an overflow line installed which shall:

i. Have a diameter of at least 1.5 times the diameter of the fill line.
ii. Have a minimum size of 80mm regardless of point (i) above.
iii. Have no valves or restrictions and discharge above 200 mm above the bund ground level.
iv. Discharged through a water trap/seal pot to capture any fume if the storage tank is installed inside a building. Where used, the depth of water trap should be determined during the design to limit the tank venting out through the overflow line particularly during tank filing and to limit additional backpressure when overflow is required
v. Be installed in full view of the point of tank filling allowing any personnel involved in the filling procedure to witness any discharge. This may not be possible where multiple large tanks exist.
vi. Be fitted with a 2 mm aperture vermin mesh with mechanical fastening at the discharge point for outside tanks (when no water trap used). The mesh shall be weather proofed and mesh materials shall be compatible with acid fumes. The design needs to size the overflow line appropriately considering the flow area reduction from the recommended aperture size.
vii. Comply with the relevant standards for the tank type, content and material.

10.3.10 Vent Line

Each bulk storage tank shall have its own vent in accordance with the relevant standard for the tank's construction.

Vents shall be sized appropriately taking into consideration the following:

i. Size of the inlet and outlet pipes.
ii. Maximum fill rate and/or drain down rate. This shall include line purging rate with air after chemical unloading.
iii. Thermal inbreathing/outbreathing due to temperature changes.

iv. Allowance for adequate airflow during filling, dosing, and while the tank is being drained so as not to upset operation and not exceed the allowable stresses of the tank.

v. Shall be a minimum size of DN50 regardless of point (i) to (iv) above.

vi. In absence of data for point (ii), the vent line shall be at least 2 times the diameter (four times the area) of the inlet or outlet line (whichever is greater).

vii. Where tanks are installed inside, vents must be directed outside of the building. Where directed outside, vent lines shall be directed downward with the opening toward the ground to prevent ingress of water and 500 mm above the ground level to avoid the risk of any chemical dripping on a person.

viii. The vent discharge point shall be weather proofed and fitted with a 2 mm aperture vermin mesh with mechanical fastening, and mesh materials shall be compatible with acid fumes.

ix. Vents directed outside of buildings should be preferably taken through the wall of a building rather than a roof or ceiling to minimise water ingress through seals.

x. Where tank filling points are to be positioned above the height of tanks and tank vents, or if ventilation in the area is considered poor (e.g. in buildings), designers shall ensure the filling area remains safe to all personnel during filling operations.

10.3.11 Drains

Tanks shall be capable of fully draining to empty. Each tank shall have a separate drain line facilitating tank drainage from the lowest point within the tank. Drain lines shall:

i. Where practicable, be diverted to the bund sump.

ii. Allow isolation via a drain valve, located as close to the tank body as possible.

iii. Be kept separate from overflow lines.

iv. Be adequately protected, sized and of suitable construction to prevent inadvertent damage resulting in tank drainage.

10.3.12 Additional Requirements

All tanks shall:

i. Be installed such that they will not float in the event of a loss of containment.

ii. Where installed outside, or in a shelter with open sides, be anchored to the plinth using hold down bolts. Hold down bolts should not be tightened until the tank has been filled. Seqwater has experienced stress-induced failure of tanks because of flexing during filling/emptying as a result of the use of hold down bolts. The design and installation procedure for hold down bolts must consider and account for this active flexing.

iii. Constructed to prevent vortexes forming within the tank and at any outlets.

iv. Include the ability to sample each tank’s contents, independently, for testing purposes. Where fixing a nozzle directly to the tank is not viable or mechanically suitable, an alternate means of collection a sample, preferably from the tank outlet line, shall be provided.

v. Maintenance hole/hatches should be typically provided in the tank roof with a minimum size of 600 mm diameter for maintenance and inspection. Maintenance holes shall be provided with a cover that is vapor and liquid tight at the test pressure and shall comply with the relevant requirements of the standards for specific tank classes.

vi. Where identified that a side access hatch is needed for tank maintenance for taller tanks (> 3m), special attention is needed to ensure liquid tight of the seal, maintenance requirement and chemical compatibility of seal with FSA.

Particular care should be taken to protect tank outlets nozzles, pipe and valves and especially non-metallic components to prevent accidental damage and tank draining.

10.3.13 Day Tank System

This standard proposes to adopt an "electronic day tank" for the FSA system with the reliance on electronic devices instead of a physical day tank as outlined in Section 7.17. Where the design cannot achieve a system of "electronic day tank", a physical day tank shall be used.

A physical day tank needs an additional tank, a pump, valves and instruments, and operators' involvement for daily transfer of fluoride chemical.

Where a physical tank is selected, the following shall be considered in the design:

i. The size of the day tank shall not exceed that required to achieve the prescribed fluoride concentration for the maximum treated water production over a 24-hour period plus some allowance for instrument alarms and tank overflow line connection.

ii. Day tank must have a vent and an overflow line.

iii. If the day tank is located inside a building, the overflow line must discharge to a water trap and the vent line shall be taken outside of building with a similar arrangement to storage tanks.

iv. The transfer of FSA from the storage tank to the day tank must be done by a pump.

v. The transfer pump shall be initiated manually from SCADA by an Operator and stopped automatically from the signal of a weighing scale.

vi. The transfer line pump discharge shall have an actuated valve, and be initiated from SCADA with the pump and closed automatically with the pump.

vii. The design shall incorporate provisions not to repeat the transfer of FSA within any 24 hour period.

viii. Where a day tank is connected to more than one storage tanks, storage tank outlet lines or pump suction lines shall have actuated valves for the tank selection.

ix. Day tank shall be fitted with a weighing scale and be used by operators to transfer FSA.

x. In addition to a weighing scale, the day tank shall have a high-level switch to trip the transfer pump and a low-level switch to trip the dosing pump.

xi. Day tank shall be located in the storage tank bund.

xii. An alternative design of a day tank arrangement with an IBC for small sites can be considered if all interlocks and functionalities illustrated in this document can be achieved without any additional risks as mentioned in Section 10.2 (x).

10.4 Process Control Narrative

The following describes a typical process control philosophy for the chemical unloading and delivery system from truck tankers. This should also be read in conjunction with Section 10.1 of this document. The order of operator actions is indicative only and shall be reviewed on a site-by-site basis.

Prior to starting an unloading operation from a tanker, an operator may need to enable an LCP and select a tank in SCADA if this function has been incorporated.

Once a delivery tanker is in position, the operator will open the appropriate manual valve from the unloading area sump (in a valve pit) to the CSHT and close the storm water valve. The control system will need to register the CSHT valve in an 'open' position and storm water valve in a "close" position to allow energisation of the SPO. The delivery personnel shall select 'ON' button on the FSA Unloading LCP to enable the panel.

The delivery personnel connect the truck pump cable to the relevant power outlet at the Unloading LCP and the tanker hose to one of the bulk storage tank fill line connections. The delivery personnel shall then open the manual isolation valve on the relevant tank's fill line. The SPO for the respective tank will then become energised by the control system provided all permissives are met:

- Correct unloading area CSHT inlet valve open (limit switch).
- Unloading area storm water drain valve close (limit switch).
- Correct fill line manual isolation valve in open position (limit switch).
- No high-high bulk storage tank level.
- No high-high level in CSHT.
- No high-high bulk storage bund sump level.
- Storage bund valve not open (limit switch, where available).

The delivery personnel should then be able to start unloading pushing 'START' button, continue with the filling procedure and monitor the tank level in LCP and tank local level indicating device.

Once the chemical filling operation is completed, the delivery personnel must push 'STOP' at the Unloading LCP. The delivery personnel shall purge the fill line with air using the truck purge line system, then close the fill line manual isolation valve and turn off the panel. Once the tanker has safely rolled off the unloading area, the CSHT valve shall be closed and storm water valve shall be opened.

Only one Bulk Storage Tank in a single bund and fill point shall be fillable at a time.

Abnormal Operation

The relevant tank SPO shall become de-energised and appropriate alarms triggered if any of the following conditions are met:

- Unloading area CSHT inlet valve limit switch does not register 'open'.
- Unloading area storm water drain valve limit switch does not register 'close'.
- Bulk storage bund sump reaches a high-high level (where installed).
- Bulk storage tank detects a high-high level.
- CSHT detects a high-high level.
- More than one manual fill line isolation valve opened.
- Storage bund valve opened.

If a High-High Level is reached on any storage tank or CSHT level transmitter, a visual and audible alarm shall be raised at the Unloading LCP, and the SPO shall be de-energised and interlocked.

The bulk chemical storage area bund High-High Level Device, where used, shall de-energise and interlock all Unloading LCP SPOs into that bund.

Where installed with valves, if a bulk storage bund sump drain valve is in the open position, all the Unloading Area LCP SPOs shall be de-energised and interlocked.

If the CSHT diversion valve is kept open and storm water valve left closed more than a specified time period, an alarm shall be raised in SCADA.

A local and SCADA alarm shall be provided to indicate if tank level rises while LPC SPO is not active.

Alarm and control systems shall be fail-safe and fail to High-High alarm upon loss of echo or instrumentation failure.

11 Fluoride Dosing System

This section describes the requirement for the design and construction of fluoride dosing systems for sodium fluoride, sodium fluorosilicate and fluorosilicic acid chemicals. This chapter shall be read in conjunction with P&ID Standard Drawing *B-DWG-STD-034 Fluoride Dosing System* as referenced in Section 13.

The fluoride dosing arrangement shall use positive displacement pumps in most circumstances, with 100% duty/standby capability. Dosing systems, including pumps, shall be provided with duty rotation in accordance with *I-SPE-STD-013 Control Systems Design and Construction.*

The main components of the dosing system include the following:

- Dosing pump and other relevant dosing equipment in a skid.
- Dosing line, dosing point and chemical mixing.
- Carrier water system (where needed).

The requirement of dosing skid containment and bunding has been included in Section 12.

Dosing systems employing dosing with positive displacement pumps shall include the following (refer to the subsequent sections for more detail on each item):

i. Manual and actuated isolation valves, filters or strainers (as appropriate) on the outlet of the FSA storage tank or sodium fluorosilicate dosing tank or sodium fluoride saturator.
ii. Where multiple tanks are used, the designer may choose either a combined inlet manifold to the dosing pump skid or dedicated pumps for each tank.
iii. An insertion type conductivity probe for sodium fluoride and sodium fluorosilicate solution preferably installed in the common header of the suction line as an indicative surrogate measurement of fluoride concentration. The probe needs to be retractable with restraining cable, include compression fittings and full-bore ball valve.
iv. A dosing skid. Dosing skid generally includes the following, in order of upstream to downstream relative to the fluoride dosing system P&ID:
    a. Dosing skid manual isolation valve.
    b. Suction-side calibration cylinder for suitable systems, refer to Section 11.2.
    c. Suction-side manual isolation valve for each pump.
    d. Suction-side pulsation dampener only if required or recommended by the pump manufacturer.
    e. Flushing and drainage points for skids and ancillary pipework.
    f. Duty/standby positive displacement pumps to deliver fluoride chemical.
    g. A pressure relief valve for each pump, preferably returning to dosing tank (in addition to any pump internal pressure relief valves, where applicable).
    h. Discharge-side manual isolation valve for each pump.
    i. Discharge-side pulsation dampener if required or recommended by the pump manufacturer.
    j. A pressure transmitter installed upstream of pressure sustaining valve.
    k. Flowmeter. An additional flowmeter shall be preferred near to the dosing point. see Section 11.8.
    l. Discharge side pressure sustaining/backpressure valve for certain pump types, and an additional pressure sustaining valve near to the dosing point, refer to Section 11.9.

m. Pump commissioning and calibration return line connected to the return line manifold fitted with locked close valve and flushing point.

n. For FSA, a manual degassing arrangement should be provided for acid fumes, including a suction side (as a minimum) vent returning to the top of the chemical tank.

o. Discharge side flushing points for skids and ancillary pipework.

p. Dosing skid shall be installed in a suitably bunded area, preferably within the applicable fluoride building mixing and dosing tank bunded area or FSA storage tank bunded area, as applicable. Any possible spillage from the skid must be contained within the skid bund.

v. Inclusion for carrier water as required for FSA – refer to Section 11.11 for further details.

vi. Chemical mixing device arrangement for chemical mixing (where needed) – refer to Section 11.15 for further details.

vii. An automated isolation valve for dosing line isolation and to prevent siphoning.

viii. Generally. a single dosing line should be considered where a facility can accept an extended period of shutdown of the dosing system for dosing line and equipment maintenance.

Refer to *M-SPE-STD-010 Chemical Dosing Skids* for detailed mechanical requirements of the chemical dosing skid design and construction. Seqwater standards *M-SPE-STD-012 Chemical Dosing Pumps* and *M-SPE-STD-013 Chemical Dosing Piping* shall also be used in the design and installation of chemical dosing systems.

The remainder of this section shall be used to identify other further requirements of dosing system components.

11.1 Suction Lines

The suction line supplies powder fluoride chemical solution or liquid chemical from a tank or saturator to the duty dosing pump(s). The design requirements are:

i. Suction line to the dosing pump shall be kept as short as possible.

ii. Where needed, the design shall ensure flooded suction to the pump centre line under all process conditions, particularly recommended for FSA.

iii. Refer Section 0 for suction line sizing and velocity recommendations. The diameter of the suction shall be at least equal or larger than the pump suction port diameters.

iv. Suction lines should minimise or eliminate the use of right-angle bends and include bellows to minimize stresses on the polyethylene tank joints.

v. Include both a manual and actuated isolation valve just next to the tank.

vi. Include duty/standby Y-strainers with a maximum 0.5 mm mesh for sodium fluorosilicate, sodium fluoride down-flow saturator and FSA systems; and filters for sodium fluoride up-flow saturators. The design shall determine an optimum filter size for sodium fluoride up-flow saturators considering cleaning frequency and pressure drop across the filter.

vii. A conductivity meter for sodium fluoride and sodium fluorosilicate solution preferably on the common header of the suction line as mentioned in Section 11.

viii. The piping design and material selection must prevent any cracking or failure to tank/ saturator joins due to changes in tank/saturator liquid level and/or ambient temperature.

11.2 Calibration Cylinders

Designer should consider the installation of calibration cylinders when it is practical considering the value of required dosing flow rate. For large WTPs, particularly for the sodium fluorosilicate system where the dosing flow rates are high, the installation of calibration cylinders may not be practical.

Where installed, a suitably protected, capped, graduated, transparent and calibrated cylinder should be provided on the suction side of the pumps for pump calibration. This is particularly important for a system where the pump curve needs to be calibrated at periodic intervals in the absence of a flowmeter and flowmeter control feedback, or where a flowmeter deviates from accuracy. Appropriate isolation valves shall be provided to allow the calibration of each pump to be checked. The calibration cylinder shall be fitted with a vent line, an overflow outlet line with an isolation valve and returned into the top of the dosing tank.

Refer to *M-SPE-STD-010 Chemical Dosing Skids* for further detail on calibration cylinder requirements.

11.3 Dosing Pumps

A minimum of one (1) duty and one (1) standby pump shall be provided in all circumstances. Standby capability shall ensure 100% of the duty arrangement can be achieved. To minimise the risk of fluoride overdosing, the control system shall prevent the simultaneous operation of both pumps under all scenarios.

Suitable positive displacement dosing pump types shall be selected from the X-LST-STD-001 Seqwater Preferred Equipment List based on chemical properties, flow rate range, current Seqwater practice and experience and following the guidance and requirements included in *M-SPE-STD-012 Chemical Dosing Pumps*.

The pump capacity and pressure rating must be suitable for the whole dosing range, with a strict avoidance of prolonged operation within undesirable operating zones to maximize the pump design life. The pumps must be selected with the capacity as close as practicable to the maximum flow rate required considering the maximum fluoride dosing concentration at the plant maximum flow rate, this is to minimise any potential fluoride overdosing scenarios.

Pump materials shall be compatible with the fluoride chemicals handled and other requirements included in Section 7.5.

Dosing pumping systems shall be designed to provide duty rotation which shall comply with the requirements detailed in *I-SPE-STD-013 Control Systems Design and Construction*.

SCADA shall be capable of displaying each pump's speed (Hz), stroke, and derived flow.

Dosing pumps shall comply with the requirements of *M-SPE-STD-012 Chemical Dosing Pumps.*

11.4 Pressure Relief Valves

External pressure relief valves shall be included on the discharge line of all positive displacement pumps, positioned near to the pump outlet to achieve protection against high pressure.

This requirement also applies to positive displacement pumps with integral pressure relief valves. This is intended to prevent short circuiting of fluoride chemical from the discharge port of positive displacement pumps, immediately to a suction port by internal relief valves in case of a blocked discharge. In addition, internal relief valves may not provide adequate protection to dosing lines due to the existence of check valves in certain types of pumps like diaphragm pumps (where applicable).

An external pressure relief valve also gives operational flexibility to set and test the relief valve pressure according to the system need whereas internal relief valves is often required to use the pressure set and test by the pump manufacturer.

Pressure relief valves shall:

i. Include provision for the attachment of a hand-held pressure gauge to test the valves operation.
ii. Be set to relieve pressure:
    a. At approximately 100 kPa below the pump internal pressure relief valve.
    b. Regardless of the point above, be set at least 10% below the pressure rating (after any design de-rating for Site Conditions) of the lowest pressure rated fitting or item in the system.
    c. Designers should ensure there is sufficient margin between the pressure relief setpoint of pressure relief valves and the set pressure of pressure sustaining valves (where used) to ensure pressure relief valves are not subjected to 'chatter'.
iii. Include the set pressure recorded on a valve tag attached to the valve. This tag shall be separate from the naming tag.
iv. Discharge to the dosing tank. Where a return line to the storage tank may be an excessive length, introduces a process or safety risk, or inhibits safe access, return to the pump suction side will be acceptable if it does not create unacceptable back pressure from tank head.
v. Where the discharge line is returned to the dosing tank, it is recommended to connect the discharge line to the outlet of the calibration cylinder (where available) to identify a leak or relief of the pressure relief valve (i.e., liquid accumulation in the calibration cylinder will confirm a leak or relief from the pressure relief valve).
vi. Consider including a flow switch in the discharge line to identity the event of a relief.
vii. Be sized for the full flow relief.
viii. Be lockable (e.g., locking nut) such that the setpoint pressure cannot accidentally be changed e.g., by vibration in pipelines.
ix. Be installed immediately downstream of the pump discharge and shall not include any isolation valve between the pump and the relief valve.

11.5 Pulsation Dampeners

If required, as per the pump manufacturers' recommendations, a suitably sized pulsation dampener shall be provided inline or on a branch line from the suction or discharge sides of dosing pumps to reduce pressure fluctuations. A pulsation dampener is generally recommended for diaphragm and peristaltic pumps.

Refer to *M-SPE-STD-010 Chemical Dosing Skids* and pump manufacturers' recommendations for further detail on pulsation dampener requirements.

11.6 Pressure Transmitter

Pressure transmitters shall:

i. Be installed preferably on combined discharge line, as appropriate, to monitor pressure in the dosing line.
ii. Be installed upstream of pressure sustaining or back pressure valves, where available.
iii. Include an isolation valve to allow easy replacement and maintenance.
iv. Include a chemical barrier diaphragm to protect the transmitter.

v. Be provided with high-high pressure alarm for dosing pump interlock.

11.7 Vent Lines

The design shall consider vent lines on the suction and discharge lines of the dosing pumps as part of acid fume venting arrangement for FSA systems. Relying solely on an integrated pump degassing valves (where applicable) shall not be accepted.

Vent lines shall:

i. Be at least 25mm nominal pipe diameter (to reduce the risk of siphoning).
ii. Be installed at the high point of suction lines and discharge lines.
iii. Return to the top of the vapour space of the tank – returning at least 500mm above the top of the tank to prevent siphoning.
iv. Include an isolation valve with mechanism to lock open in the suction line and lock close in the discharge line. Valve shall be positioned near to the skid and easily accessible and preferably be a vented manual ball valve.
v. Where practicable include a transparent section at the inlet point to the tank to identify if liquid is transferring through the line.

11.8 Flow Meters

Two chemical flow meters shall be installed for a fluoride dosing system, one flow meter shall be located in the skid and the second flow meter preferably near the dosing point if the installation does not incur significant costs due to extra electrical and control cable lengths. This will provide indication of failed dosing lines and/or fault of flowmeters. The secondary flowmeter is recommended from Seqwater experience to achieve another layer of protection on accurate dosing or to avoid any potential fluoride overdosing scenarios.

Flow meters should be installed upstream of pressure sustaining valves, where available.

The flowmeter in the dosing skid shall be used as a primary flow meter and be part of the fluoride dosing pump feedback control loop. The secondary flowmeter shall be used to raise discrepancy alarms between two flow meter readings and this shall be interlocked with the dosing pumps and shutdown the fluoride dosing system to minimise the risk of overdosing. In addition, individual flowmeters shall raise high-high flow alarms to interlock the dosing pumps.

To avoid fluoride overdosing for the FSA system, daily flowmeter totalizer readings shall be used to raise alarms and interlock the dosing system if it does exceed the theoretical daily volume of chemical demand considering the fluoride dose rate at the maximum plant production. This will act as part of the electronic day tank system for the FSA system as mentioned in Section 7.17. A dynamic plant production rate can be considered for this alarm only if it does not create risks of creating spurious alarms.

The design must provide special attention to ensure dosing accuracy with suitable flowmeter sizes particularly for low solution dosing flowrates for small sites as this could be the case for the sodium fluoride and FSA dosing systems. Monitoring of potential silica scale build-up on small bore flowmeters particularly for the FSA dosing system shall be ensured during maintenance and managed by routine de-scaling.

Flow meters shall comply the requirements of *M-SPE-STD-009 Flow Meters* and *M-SPE-STD-010 Chemical Dosing Skids*.

The requirements and locations of flow measuring devices to measure main water flows for flow paced control of fluoride dosing are not covered in this Engineering Standard. Refer to *QLD Water Fluoridation Code of Practice (2021)* and *M-SPE-STD-009 Flow Meters* for this requirement. Where two flow meters are used to measure the main water flow rates, discrepancies in water flow rates between them shall trip the dosing system.

11.9 Pressure Sustaining Valve/Back Pressure Valve

Systems using diaphragm pumps, a pressure sustaining valve (also known as back pressure valve or loading valve) are recommended in the dosing skid to provide a minimum backpressure for effective pump operation and control, and to assist in providing accurate flow meter readings. For other types of positive displacement pumps, the pump manufacturer's recommendation shall be followed for the requirement of a pressure sustaining valve in the dosing skid.

Pressure sustaining valves shall:

i. Be installed in accordance with and comply with *M-SPE-STD-010 Chemical Dosing Skids*.
ii. Be set in accordance with the Designer or Suppliers' recommendations or requirements. Where this is not provided, or is unclear, these valves should:
    a. Typically, be set at 100 kPa above the maximum required dosing injection pressure.
    b. Be set at a minimum of 200 kPa regardless of point (a) above. Pump supplier recommendations should always be followed.
iii. Be operator adjustable while in operation.
iv. Include a pressure gauge/transmitter installed upstream to verify operation.

Whether a pressure sustaining valve is installed in the dosing skid or not, an additional pressure sustaining valve must be installed near to the dosing point particularly to encounter pressure and flow fluctuations in the main process line and provide steady chemical flow. Generally, the pressure of that sustaining valve should be set to approximately 50 kPa above the maximum operating pressure of the process line.

11.10 Chemical Return Line

Chemical return line to the dosing/storage tank or saturator should be included to accommodate chemical return from the pump discharge during commissioning, calibration cylinder and pressure relief valve discharge.

When installed, the chemical return line should:

i. Include a separate flanged nozzle/connection on the topside (roof) of each tank/saturator.
ii. Enter the roof of the tank / saturator in a vertical orientation and above the overflow crown height.
iii. Be minimum of pipe size DN 25 mm to prevent blockage.
iv. Chemical return lines should avoid low points and, if possible, transfer upward then with a single slight decline into the tank.
v. Include a section of removable spool to facilitate tank/vessel maintenance.
vi. Include a flushing point to flush the line.

11.11 Carrier Water

Carrier water must be used for fluorosilicic acid system to enhance mixing considering its much higher fluoride content comparing two powder fluoride chemical solutions. Carrier water shall be introduced into the FSA dosing lines as near as possible to the dosing point to minimise build-up area for potential silica scaling in the dosing lines.

Carrier water systems must use potable water or have water quality which is equal to or better than that into which fluoride chemical is being dosed. The water source selected must not deleteriously affect treatment or pose a risk to treated water. The designer shall assess the need of in-line static mixers at the carrier water introduction point or downstream for homogenous mixing with FSA prior to dosing into the main process line.

Fluorosilicic acid mixing with water may result in precipitation of silica in dosing lines and fittings. Mixing acids with water produces exothermic reactions resulting in heat evolution creating an additional hazard. Heat evolution shall be considered when designing FSA dosing systems to ensure personnel safety and material and equipment integrity is maintained.

If a suitable potable water system is not available, a pressurised ring loop from the main can be considered to provide water for carrier water purpose. This shall be treated water taken upstream of a fluoride dosing stage and used within the plant.

Where used, carrier water lines shall:

i. Be fitted with manual isolation valves:
   a. One upstream of all fittings after the water off-take
   b. One downstream of all fittings to allow maintenance.
   c. A third valve at the point of connection to any dosing pump discharge line.
ii. Be fitted with a Y-strainer with minimum mesh of 0.5mm.
iii. Be fitted with a solenoid valve.
iv. Be fitted with a pressure sustaining valve to ensure consistent feed pressure to the dosing system.
v. Be fitted with a flow measurement device with high and low flow alarms. Alarms shall only active when system dosing is active.
vi. Be fitted with an additional non-return valve prior to connection to the chemical dosing line.
vii. Be supplied with a booster pump if the site service water pressure system cannot achieve the necessary dilution ratio.
viii. Shall be capable of providing a minimum dilution ratio of 20:1 of carrier water to dosing chemical. The high dilution ratio is recommended to minimise silica precipitation.
ix. Be designed to shut down the FSA dosing system from any failure of the carrier water system.

In addition to the above requirements, it must be fitted with a double layer of backflow protection between the chemical dosing system and the potable water system using a reduced pressure zone (RPZ) backflow prevention device – only proprietary back flow prevention devices shall be used. Double check valves are not considered adequate to achieve double layer protection. Arrangement must comply with *AS/NZS 3500 – Plumbing and Drainage* and *Queensland Plumbing and Wastewater Code.*

11.12 Dosing Line

A dosing line includes pipework transferring fluoride chemical from the dosing skid to the dosing point. A dosing line shall comply with the requirements of *M-SPE-STD-013 Chemical Dosing Piping.*

A dosing line shall:

i. Be sized following the velocity requirements provided in 0.
ii. Be double contained from the outside of dosing skid boundary. At the lowest point, the outer covering should be fitted with a sight glass with level indication or connected to a pit or a bund or other suitable mechanism to identity any potential leak.
iii. Comprise non-return valves installed immediately upstream of the dosing point.

iv. Include manual isolation valves upstream of dosing spears and downstream of the non-return valve to allow maintenance of individual lines/spears without affecting dosing capability.

v. Include an actuated isolation valve positioned as near as possible to the dosing point for automated isolation and to prevent potential siphoning. This shall comprise the following requirements:

   a. Be upstream of the non-return valve.

   b. Be fitted with open and close position switches.

   c. Be generally “fail to close” type valve.

   d. Appropriate valve opening and closing times need to be considered to start and stop the dosing pump.

   e. The actuated valve shall generally not have an option to be operated in remote or local manual. This is to prevent any risk of fluoride dosing when the plant is offline.

   f. The design shall assess any potential pressure increase in a section of piping from trapped acid solution gasification or thermal expansion due to the closing of actuated valve and diurnal temperature change. Where needed, the design shall include pressure relief arrangements for such scenarios.

vi. Include the ability to flush with water and drain the lines.

A pressure sustaining valve shall be near the injection point to provide dosing stability for pressure fluctuations in the main process line and to reduce the risk of siphoning effects and overdosing. Refer to Section 11.9 for guidance in setting such a pressure sustaining valve.

Consideration should be given to installing a second flowmeter near the dosing point as mentioned in Section 11.8. Installation of a pressure gauge near the dosing point should also be considered to allow pressure monitoring and identification of leaks from dosing lines.

The design shall assess and include appropriate arrangements to contain any foreseeable chemical spills during operations and maintenance of the valves, flowmeters and instruments installed outside the chemical skid near to the dosing points. If the dosing equipment is located inside an enclosure or in a covered dry pit, then a level switch within the enclosure or pit shall be used. This shall be used to identify a chemical leak and, in that event, shut down the dosing pump.

11.12.1 Dosing Quill

A dosing quill or spear shall be used for each dosing line to dose fluoride chemicals where they are injected into the pipes. A dosing quill shall:

i. Include protection from being ejected from the pipeline during operation and extraction.

ii. Be retractable / removable from a pressurised process line. The dosing spear shall pass through a valve which allows process lines to continue in operation while dosing spears are removed for maintenance.

iii. Be installed penetrating 25-50% of the internal diameter of the line being dosed, measured from the pipe wall.

iv. Not be installed immediately downstream of an isolation or modulating valve that may create significant stresses to the assembly during the valve operation.

v. Be fitted with a check valve.

vi. Recommended to have open ended discharge to reduce the chance of blockage from scaling.

vii. Be constructed of polyethylene materials considering operating conditions and installation locations.

viii. Be included in the list of periodic cleaning to remove scaling.

Where dosing spears are used in horizontal pipes and mains that may not always be fully flooded while in operation:

ix. Dosing spears should be installed in the lower half of the pipe, preferably at a 45-degree angle from the bottom part of the pipe, protruding 25-50% of the internal diameter of the pipe.

When dosing is not injected into pipes, provision shall be made to use spray bar or other methods to provide adequate mixing into process water. If additional mixing is necessary, mixing options as provided in Section 11.15 shall be considered.

11.12.2 Buried Pipe

All fluoride chemical dosing pipework required to be installed below ground shall consider the following requirements:

i. Be buried for the minimum distance necessary to minimise the risk of not identifying and finding leaks.

ii. Be double contained. Any double containment pipe or system shall be suitable for burying.

iii. Minimise the use of joints as far as practicable to mitigate the potential for leaking.

iv. Eliminate low points in the chemical pipe as well as dual containment pipe to prevent chemical pooling.

v. Drain to a sump or pit. Pipes shall be run such that dual containment and buried chemical pipes run to a sump or pit for the collection of chemical and can be freely drained at this location.

    a. Sumps and pits shall include a level switch to indicate a leak event which shall trigger a remote alarm.

    b. Sumps and pits shall be covered and sealed (or installed to eliminate ingress of stormwater) with the ability for operators and maintenance personnel to access and view inside for inspection purposes.

    c. Sumps and pits shall be able to accommodate a small submersible pump or similar for draining, or an alternate means of draining shall be proposed.

vi. For both metallic and non-metallic pipes, include a continuous detectable marker tape placed in the trench 350 mm above the pipe, installed in accordance with the manufacturer's guidance. The tape should indicate the pipe content whether by printing the chemical name on the tape or using an agreed colour coding.

vii. It is also required to use above ground markings at a suitable interval and at changes in direction to identify the buried dosing lines.

viii. Buried pipelines design and installation must conform to *AS 2566.1, AS 2566.2* and *M-SPE-STD-013 Chemical Dosing Piping*.

11.12.3 Dosing Pit

A dosing pit shall refer to pits used for dosing into or sampling from any buried pipes.

A dosing pit shall:

i. Be made of concrete (pre-cast or formed in situ), and appropriately sealed to provide chemical protection, leak tightness, and water tightness.

ii. Be readily accessible to operators and maintenance personnel as required for normal operation.

iii. Be designed to allow easy access for pump installation and be fitted with an appropriate power outlet to run the pump.

iv. Include a level switch to indicate ingress of liquid from stormwater or leaking chemicals. Level switches shall:

a. Be installed as low as possible to indicate ingress of liquid.

b. An additional high-high level switch may be necessary to trigger a shutdown at remote sites, or where submersion of the pit equipment, dosing/sampling points and instrument connection points would lead to damage of equipment, contamination of water, or an environmental release.

Where sampling from a Dosing Pit is required, Seqwater's preference is to use an off-take tube or sampling pump to pass process water to an external analyser. This is to reduce the requirement for access into Dosing Pits as far as practicable. Where this would result in excessive sample time delay, instruments may be installed in the Dosing Pit. All analysers and transmitters shall be installed outside of Dosing Pits in appropriate shelters, kiosks, or buildings.

11.13 Skid and Dosing Line Draining and Flushing

The requirements for draining and flushing of dosing skids and dosing lines shall generally comply with *M-SPE-STD-010 Chemical Dosing Skids* and *M-SPE-STD-013 Chemical Dosing Piping*.

The design shall include provisions for suitable water flushing for dosing and tank/saturator return lines and include the provision to flush dosing lines both from the suction and discharge sides of dosing pumps. Drain lines shall be designed to collect flushed water near to dosing points for disposal as the flushed water must not be directed to the process due to adverse impact to water quality.

The design shall consider using the dosing pumps for flushing. The maximum pressure built up in the piping during flushing must be considered in the design considering the site maximum service water pressure.

Check valves on the dosing pump suction lines are generally not recommended as a means to prevent inadvertent service water flow back to chemical dosing tanks/saturators during flushing. Where considered, the pump manufacturer should be consulted for suitable valve types. If selected, the check valves shall include low pressure springs to reduce pump suction side pressure losses. The spring opening pressure should be within the range of 0.1 to 0.2 bar.

The design shall assess the need to keep provisions for chemical cleaning of the dosing line from any potential scaling considering long term applications.

A risk assessment shall be conducted on each step of the adopted flushing procedure to avoid any inadvertent consequence from flushing.

11.14 Dosing Point Location

The design shall identify an appropriate location at the treatment plant for the fluoride dosing point considering the following:

- Achieve adequate mixing with supply water.
- Avoid interference with any other water treatment processes.
- Where a dosing quill is used, it should not be located immediate downstream of an isolation or modulating valve to avoid mechanical stress to the quill as stated in Section 11.12.1.
- Dosing point must be located upstream of any treated water storage reservoir.

11.15 Chemical Mixing

This section refers to hydraulic mixing for ensuring uniform dispersion of fluoride chemicals in treated water. Where needed, the designer shall select the most appropriate mixing mode for the application based on operating conditions, supplier advice and recommendations.

All mixer installations must be effective across the range of operational plant flows for maximum/minimum turndown.

Side steam mixing, recirculation or jet mixing are generally not recommended for fluoride chemicals due to higher maintenance and operational requirement of the pump. Mechanical mixers shall not be used for fluoride chemical mixing into pipes due to higher maintenance and reliability issues.

Where additional mixing is required, static mixers shall be the preferred method of mixing for fluoride chemicals into pipes.

All modes of mixing should generally achieve a coefficient of variation (CoV) of 0.05 or less within five pipe diameters (5D) downstream of the mixer.

11.15.1 Static Mixer

Static mixers shall:

i. Be installed downstream of injection points in accordance with the manufacturer/supplier's requirements for upstream and downstream diameter clearances from injection points and other fixings. Proprietary integrated dosing points are also acceptable.

ii. Be designed to achieve a coefficient of variation (CoV) of at least 0.05 at the mixer outlet across the required process operating range.

iii. Be designed to minimise head loss across the mixer.

iv. Include flanged connections to facilitate easy removal and maintenance or replacement.

v. Include manual isolation valve upstream and downstream of static mixer for maintenance.

Seqwater has a history of chemical deposition in static mixers affecting performance. Static mixers shall therefore include provision for visual monitoring of pressure drop across the static mixer body. Monitoring of pressure drop shall be visible locally, and consideration should be given to making pressure drop visible remotely.

The selection of large static mixers should consider the inclusion of nozzles for a maintenance clean-in-place arrangement to be used for removal of scale and fouling. Physical removal and access for cranes, cradles or similar may be difficult or introduce unnecessary manual handling.

Static mixers may not be suitable for pipes with extremely high turndown ratios. The Designer shall take this into consideration in static mixer selection and may consider alternate mixing methodologies.

Static mixer suppliers shall be consulted for guidance and selection of appropriate mixers.

Refer to *M-SPE-STD-001 General Mechanical Specification* and *M-SPE-STD-013 Chemical Dosing Pipe Specification* for additional detail on fitting requirements.

11.16 Fluoride Analyser

At least one fluoride analyser shall be installed downstream of the dosing point where adequate mixing has been taken place. This fluoride analyser shall be interlocked with the dosing pump as a safeguard against overdosing scenarios.

Seqwater preference is to provide a second fluoride analyser immediately after the outlet of treated water reservoir.

In addition, the design shall assess the need of an additional fluoride analyser for the measurement of background fluoride concentrations where source water shows a high degree of variability.

A feedback control from the dosing point downstream fluoride analyser is generally not recommended considering the complexity of the control and the need for an analyser with high accuracy and reliability. However, where source water shows a high degree of variability in background fluoride concentrations, the designer may consider including a feedback trim functionality from the online fluoride analyser after an appropriate risk assessment.

This Engineering Standard does not specify the type of fluoride analyser, the design and construction of fluoride analyser sample water line and sample hut, refer to *I-SPE-STD-015 Instrumentation* and other relevant Seqwater Standard Specifications for this requirement. It is important to note that Seqwater prefers online monitoring of free fluoride rather than total fluoride.

The design must include HACCP alarms from fluoride analysers following recommendations from Seqwater Water Quality team.

11.17 Dosing Calculations

This section provides the equations for the dosing rate calculations for three fluoride chemicals generally required to determine chemical solution dosing flow rate set points for the control system considering delivered chemical concentration and/or purity. Appendix A provides sample calculations for three fluoride chemicals to illustrate feeder and dosing pump rates using the equations included here.

11.17.1 Sodium Fluoride

Sodium Fluoride (NaF) Powder Daily Usage

The sodium fluoride powder daily usage (kg/day) is calculated based on the process water flowrate (in L/s) and target and background fluoride concentrations (mg/L) as follows:

$$Daily\ NaF\ usage\ \left(\frac{kg}{day}\right) = \frac{(Target\ fluoride\ conc. - Background\ fluoride\ conc.)\left(\frac{mg}{L}\right) \times Process\ water\ flowrate\left(\frac{L}{s}\right) \times 86400\left(\frac{s}{day}\right) \times \left(\frac{1}{1000000}\right)\left(\frac{kg}{mg}\right)}{\left(\frac{Fluoride\ ion\ concentration\ (\%)}{100}\right) \times \left(\frac{NaF\ Purity\ (\%)}{100}\right)} \quad (1)$$

$$Fluoride\ ion\ concentration\ in\ NaF\ (\%) = \frac{molar\ mass\ of\ fluoride}{molar\ mass\ of\ sodium\ fluoride} \times 100 \quad (2)$$

Equation 1 is not required for the control system; this is to calculate daily sodium fluoride demand for saturator supply.

Saturated Sodium Fluoride Solution Dosing Flowrate

The saturated sodium fluoride solution dosing flowrate (L/h) is calculated based on the process water flowrate (L/s), target fluoride concentration (mg/L), background fluoride concentration (mg/L) and saturated sodium fluoride solution concentration (mg/L) as follows:

$$NaF\ solution\ dosing\ flowrate\ \left(\frac{L}{h}\right) = \frac{(Target\ fluoride\ conc. - Background\ fluoride\ conc.)\left(\frac{mg}{L}\right) \times Process\ water\ flowrate\ \left(\frac{L}{s}\right) \times 3600\left(\frac{s}{h}\right)}{Saturated\ NaF\ concentration\ (mg/L) \times \left(\frac{Fluoride\ ion\ concentration\ (\%)}{100}\right) \times \left(\frac{NaF\ Purity\ (\%)}{100}\right)} \tag{3}$$

Note: Sodium fluoride saturated concentration will be constant at 40,000 mg/L or 4% (w/w).

11.17.2 Sodium Fluorosilicate

Sodium Fluorosilicate, $Na_2(SiF_6)$ Screw Feeder Discharge rate

The screw feeder discharge rate (g/min) is calculated based on flow pacing with the total mixing water flow rate to achieve a fixed concentration, usually 0.2% (w/w) or 2,000 mg/L.

The screw feeder rate (g/min) calculation equation is given below considering the total mixing water flow rate (L/h) and solution concentration (mg/L):

$$Feeder\ discharge\ rate\ (g/min) = \frac{Mixing\ Water\ flowrate\ \left(\frac{L}{h}\right) * Na_2(SiF_6)\ concentration\ \left(\frac{mg}{L}\right) * \frac{1}{60}\left(\frac{h}{m}\right) * \frac{1}{1000}\left(\frac{g}{mg}\right)}{\left(\frac{Na_2(SiF_6)\ Purity\ (\%)}{100}\right)} \tag{4}$$

Sodium Fluorosilicate Dosing Flowrate

The sodium fluorosilicate solution dosing flowrate (L/h) is calculated based on the process water flowrate (L/s), target fluoride concentration (mg/L), background fluoride concentration (mg/L) and sodium fluorosilicate solution concentration (mg/L) as follows:

$$Na_2(SiF_6)\ solution\ dosing\ flowrate\ \left(\frac{L}{h}\right) = \frac{(Target\ fluoride\ conc. - Background\ fluoride\ conc.)\left(\frac{mg}{L}\right) \times Process\ water\ flowrate\ \left(\frac{L}{s}\right) \times 3600\left(\frac{s}{h}\right)}{Na_2(SiF_6)\ concentration\ in\ solution\ (mg/L) \times \left(\frac{Fluoride\ ion\ concentration\ (\%)}{100}\right) \times \left(\frac{Na_2(SiF_6)\ Purity\ (\%)}{100}\right)} \tag{5}$$

$$Fluoride\ ion\ concentration\ in\ \ Na_2(SiF_6)\ \ (\%) = \frac{molar\ mass\ of\ fluoride}{molar\ mass\ of\ sodium\ fluorosilicate} \times 100 \tag{6}$$

11.17.3 Fluorosilicic Acid

Fluorosilicic Acid ($H_2(SiF_6)$ Dosing Flowrate

The fluorosilicic acid dosing flowrate (in L/h) is calculated based on the process water flowrate (L/s), target fluoride concentration (in mg/L), background fluoride concentration (mg/L), fluorosilicic acid concentration in supplied chemical (% w/w) and fluorosilicic acid Specific Gravity (S.G.) as follows:

$$H_2(SiF_6)\ dosing\ flowrate\ \left(\frac{L}{h}\right) = \frac{(Target\ Fluoride\ conc. - Background\ fluoride\ conc.)\left(\frac{mg}{L}\right) \times Process\ water\ flowrate\ \left(\frac{L}{s}\right) \times 3600\ \left(\frac{s}{h}\right)}{\left(\frac{H_2(SiF_6)\ concentration\ \left(\%\frac{W}{W}\right)}{100}\right) \times S.G\ \left(\frac{kg}{L}\right) \times\ 1000 * 1000\left(\frac{mg}{kg}\right) \times \left(\frac{Fluoride\ ion\ concentration(\%)}{100}\right)} \tag{7}$$

$$Fluoride\ ion\ concentration\ in\ H_2(SiF_6)\ (\%) = \frac{molar\ mass\ of\ fluoride}{molar\ mass\ of\ fluorosilicic\ acid} \times 100 \tag{8}$$

Carrier water is required for fluorosilicic acid at a minimum dilution ratio of 20:1 and the carrier flow rate will be kept fixed.

Pump Speed

Where required, once the required chemical flowrates are calculated from the above equation, the pump speed is then calculated with the following equation for a particular stroke length (where applicable):

$$Pump\ speed\ (\%) = \frac{Required\ dosing\ flowrate\ (\frac{L}{h})}{Pump\ capacity\ (\frac{L}{h})}\ X\ 100 \qquad (9)$$

The pump speed equation is valid for all 3 fluoride chemicals mentioned above.

11.18 Process Control Narrative

Normal Operation

This process control narrative is for fluoride dosing into a main under remote automatic mode with "Flow pacing with chemical flowmeter feedback", considered to be the only control mode for fluoride dosing.

When initiating the dosing system, the appropriate automatic suction isolation and dosing isolation valves will open.

When initiated, the controller will first calculate the chemical solution dosing flowrate set point (L/h) required to meet the target fluoride concentration (entered in mg/L) based on flow-pacing to the main water flowmeter and fluoride chemical concentration input (see Section 11.17 for dosing calculation equations). It then uses the calibrated pump curves (where available) and the flowrate (process variable, L/h) measured by the dosing skid primary flowmeter as a feedback to achieve the pump speed (control variable) for the set point chemical solution flowrate. The control system will continue to adjust the pump speed to achieve the dynamic chemical solution flow rate set point as required. Where a calibrated linear pump curve is available, the designer should consider including a limit into the feedback control loop output from the chemical flow meter in the order of ± 20%.

When using diaphragm pumps and not fitted with servo motors, an additional parameter of stroke length may need to be accommodated into the calibrated flow curve and pump speed calculation (where used).

Abnormal Operation

Fluoride chemical solution dosing pumps shall trip under the following conditions:

- High-high fluoride concentration or CCP critical limit alarm from main process line fluoride analyser or from treated water reservoir outlet analyser.
- High-high chemical flow rate either form primary or secondary chemical flow meters.
- Flow discrepancy alarm between two chemical flow meters.
- Water flow deviation alarm between two main line water flow meters (where used).
- High-high pressure in the dosing line.
- Low-low level in the tank or saturator.
- High daily draw down chemical volume compared to the theoretical value form either of any two storage tank level transmitters (only for FSA).
- High daily chemical solution consumption compared to the theoretical value from either of any two flowmeters totaliser (only for FSA).

- High-high conductivity from conductivity meter (only for sodium fluorosilicate system).
- Low-low conductivity from conductivity meter (only for sodium fluoride system).
- Level alarm from the dosing line pit and/or near dosing point enclosed cover, as appropriate.
- Fault in any fluoride solution or main water flowmeters.
- Fault and low flow signal from any fluoride analysers.

If a tank reaches a Low-Low level, its respective outlet valve shall be isolated and dosing pump will be stopped, however the system shall still allow dosing using other tanks.

In the event of a trip, the pump will stop operating and the dosing line isolation valve will close to prevent any additional chemical dosing because of siphoning. The pump suction side isolation valve may be required to close depending on the trip condition.

If the chemical flow fails to achieve ±10% of the required flow within a defined period upon triggering a valve position change, an alarm shall be triggered.

12 Chemical Building and Bunds

This section describes chemical building, and bunding requirements for storage, mixing/batching and dosing areas for the three permitted fluoride chemicals.

Where appropriate, generic requirements for all three permitted fluoride chemicals are grouped together and included.

The requirements for buildings and bunds must follow the requirements of *AS 4452 The storage and handling of toxic substances for* sodium fluoride and sodium fluorosilicate powders and *AS 3780 The storage and handling of corrosive substances* for FSA. In addition, the requirements must also comply with the conditions specified in *QLD Water Fluoridation Code of Practice (2021).*

Storage hopper, saturator, mixing and dosing equipment for powder system, as applicable, shall be located inside a building, so far as reasonably practicable. This will prevent moisture ingress which can severely disrupt the operation particularly for sodium fluorosilicate system.

Where suitable, FSA storage tanks should be considered to locate outside under a shelter with open walls to provide ventilation requirements for acid fumes or vapours.

Equipment for fluoride chemicals installed inside a room or building must be kept separate from other water treatment equipment.

12.1 Chemical Building

The design and construction of the fluoride chemical building area, as a minimum, shall consider the following:

i. The building area shall generally be at ground level to allow immediate access, reduce the impact of flooding due to failures of sump pump, and optimise natural ventilation.

ii. Internal layout shall not be cluttered and be designed to allow safe access and facilitate easy cleaning for all of equipment and components inside the storage building.

iii. Adequate ventilation must be provided to mitigate exposure to any vapour/fume or dust in the building as discussed separately in Section 12.1.2.

iv. Where appropriate, particularly for the sodium fluorosilicate system, the chemical building shall be provided with separate dry and wet areas/rooms to limit exposure to fluoride dust to a minimum. To achieve this, bulk storage bags and unloading area can be in the dry room and storage hopper and mixing equipment can be in the wet room.

v. Where required due to height, powder storage hoppers may be allowed to protrude through the roof / ceiling of the chemical building but all attempts shall be taken to minimise the hopper height and keep inside the building. Where needed, appropriate sealing of the building shall be provided to ensure weather tightness. Soft seals (or similar) shall be provided to ensure vibration and movement of the hopper or building does not induce vibration or movement into the other.

vi. The design of the fluoride powder chemical room must prevent any potential for the build-up of powder from air deposition including on roof beams and other surfaces.

vii. The internal walls and ceilings of the fluoridation room must have smooth surfaces, windows without ledges to prevent dust accumulation, and simplify cleaning.

viii. Powder fluoride chemical must not be allowed to escape from the fluoridation room. Doors and walls of the fluoridation room shall have flushes with no gaps, rubber seals in doors and airtight windows shall be considered.

ix. De-humidification systems shall be used within the fluoride powder chemical building particularly for the sodium fluorosilicate system to avoid stored powder bags becoming damp or wet. Air-condition systems should be considered as an alternative, where considered appropriate. Corrosion resistant ducting and fitting materials to fluoride chemicals with sufficient mechanical strength and suitable filters must be used for this application.

x. Chemical bunds must be provided to contain liquid from storage, mixing/batching and dosing equipment. Floor shall be graded towards drain sump with consideration to connect to an external spill/waste tank or waste system. Bund arrangement is discussed separately in Section 12.1.3.

xi. Materials of construction shall be appropriate for fluoride chemicals being stored. The floor and surface of the building shall be designed for protection against chemical attack.

xii. The requirements of electrical switchboards and MCCs inside the fluoridation building must be followed as specified in 7.11.

xiii. Sufficient internal and external lighting to be provided and include the provision for easy access for lamp maintenance/replacement as according to *AS 1680 Interior and Workplace Lighting*.

xiv. Building layout shall be designed to allow separation and isolation of storage bags/pallets, storage hopper, mixing/batching, and dosing equipment from any incompatible chemical and spills and to avoid adverse chemical reactions.

xv. Where the building is in bushfire-prone areas, the requirements of *AS 3959 Construction of Buildings in Bushfire-prone Areas* shall be addressed.

xvi. Safety showers, eye wash facility and hose reels complying with *AS 4775 Emergency Eyewash and Shower Equipment* shall be provided in the building and chemical handling facilities. Relevant general requirements about it have been included in Section 7.15.

12.1.1 Access

The access of the building shall include the following requirements:

i. Access and layout (internal and external) of structures, including buildings and enclosures shall consider the requirements for maintenance and replacement of related assets, especially those which may have lifespans shorter than that of the structures. Designs shall clearly address such future requirements.

ii. If access doors are insufficiently large or internal arrangement does not provide sufficient space, buildings and enclosures shall be designed and constructed to enable the installation, replacement and maintenance of equipment either through the sidewall of the structure, or the roof if the sidewall is not possible.

iii. The distance between the top of any tanks and storage hopper should be a minimum of 0.5m from the roof of any structures in all circumstances, except when the top of storage hopper protrudes through the building roof. Notwithstanding the previous statement, there shall be sufficient space provided between the top of any tanks or hopper and the ceiling of any structures or buildings to allow ergonomic access for expected maintenance to take place.

iv. If an access platform is required, a minimum clearance of 2.2m shall apply between platforms and building ceilings.

v. If chemical storage tanks and dosing systems are installed inside a building or kiosk, all doors shall open outward and be fitted with panic release bars.

12.1.2 Ventilation

Storage and chemical area layouts shall be designed using suitable natural or forced ventilation to:

- Maintain exposure level to any vapour/fume or dust in the workspace below the recommended workplace exposure standard.
- Prevent the accumulation of chemical powder.
- Prevent condensation build up.
- Ensure a safe operating atmosphere.

Mechanical ventilation with an exhaust fan must be provided for indoor installations of FSA storage tanks to remove any potential acid fumes. The additional requirements of the system are:

i. The location of the exhaust fan and room vents shall be chosen to maximise cross flow ventilation of the room.

ii. The exhaust fans and ducts must be acid-fume resistant.

iii. The system shall be designed for continuous operation.

iv. The fan must be vented away from areas that may be accessed outside the fluoridation room.

v. The mechanical ventilation system shall comply with the requirements of *AS 1668.2 The Use of Ventilations and Air-conditioning in Buildings Part 2*.

Depending on the size of fluoridation room, large bag or pail storage area, storage hopper, a similar mechanical ventilation system for the building as described above should be considered for sodium fluoride and sodium fluorosilicate systems if dehumidification or air-conditioning is not provided.

Where storage hoppers, hoppers and tanks are installed inside, dust extraction and vent lines must be directed outside of the building. See details in the respective chapter of specific chemical for this requirement.

Vents and dust extraction lines directed outside of buildings must be vented to a safe location, and preferably through the wall of a building rather than a roof or ceiling to minimise water ingress through seals.

12.1.3 Bund Arrangement

Secondary containment shall be provided for all three fluoride chemicals, in the form of a bund, for bulk storage tanks, mixing/batching tanks, dosing tanks, and saturators.

Fluoride chemical systems shall be installed in a separate bund and separate collection sump from other chemicals.

Each bund shall:

i. Comply with the requirements of this Engineering Standard, *AS 3780 The storage and handling of corrosive substances* for fluorosilicic acid, *AS 4452 Storage and Handling of Toxic Substance* for sodium fluoride and sodium fluorosilicate.

ii. Be preferably a concrete bund, but a HDPE bund is acceptable for small tanks.

iii. Provide minimum separation distance between the tanks in a single bund of 0.6m, and between bund walls and each tank a minimum of 1.0m.

iv. Ensure the top inside edge of the bund from the tank shall not be inside the crest locus limit of 26.5°, as defined in *AS 3780 The storage and handling of corrosive substances.*

v. Account for any liquid jetting / spraying that may arise as a result of a tank or nozzle failures. This may be done through increasing the distance of a tank from a bund wall or increasing the height of the bund wall. Splash screens may also be a viable alternative.

vi. Be designed to withstand the instantaneous dynamic loading effects created by tank failure assuming a tank was full at the time of failure.

vii. Be provided with access such that entry and exit by personnel under both normal and emergency conditions shall be ergonomically safe, no risk of chemical exposure and shall comply with *AS 1657* and *M-SPE-STD-002 Fixed Platforms, Walkways, Stairways and Ladders.* Where a storage tank bund area exceeds 25 m^2, minimum two points of access/egress shall be provided into and out of the bund.

viii. Include open channel collection gutters with grating covers connected to the bund sump for the collection of wash down water, spills, overflow, and scours.

ix. Include wall and floor coatings in accordance with *M-SPE-STD-004 Protective Coatings and WSA 201.*

x. Floor be designed to prevent pooling of chemical or water by providing a suitably finished surface with a gradient toward the Bund Sump of 1:75.

xi. Include a Bund Sump. Refer to Section 12.1.3.2 below.

Every effort should be made to avoid casting pipes through bund walls as this may affect the future leak prevention capability. In addition, the life of a bund is likely considered greater than that of pipes. If casting through bunds is required, particular care must be taken to ensure the lifetime integrity of the asset.

Pipes shall not be cast through the base/floor of a bund.

12.1.3.1 Bund Capacity

Bund capacity shall be not less than 110% of the capacity of the largest vessel located within the bund. If multiple tanks share a common point of failure (such as operating in series, as a combined volume, or sharing a common discharge manifold) or operate as a single storage volume, the bund capacity shall be not less than 110% of the total stored volume of those tanks.

Where bunds are constructed outside and subject to filling with rainwater, bund capacity shall consider rainfall events.

Bund walls for storage tanks located inside or under a shelter should generally be sized to include a freeboard of at least 100mm above the design fill volume and at least 250 mm above the design fill volume located outside.

12.1.3.2 Bund Sump

A low point Bund Sump shall be provided in each bund, to:

- Provide a means of detection of spills or overflows from bulk storage tanks, mixing/dosing tanks and saturators.
- Provide a point of collection or extraction of liquid chemical or powder chemical solution.

Low point sumps should be a minimum of 600 (long) x 400 (wide) x 300 (deep) mm. The bund sump shall:

i. Include a Fibreglass Reinforced Plastic (FRP) grating or other chemical-compatible material sufficient to withstand any weight reasonably expected to be applied during construction, maintenance and operations activities.

ii. Include provision to fit a portable sump pump.

iii. Include instrumentation for level measurement and identification of spills and rainwater preferably using a conductivity meter. See Section 12.1.3.3 below for further detail.

The design shall take into consideration, and clearly define, how a filled bund or sump will be drained in the event of a spill, clean up or scouring activities. This must be in-line with site Emergency Response Plan.

Depending on the site facilities, consideration should be given to include a drainage pipe to transfer to the site waste handling facility (where available) or appropriate connections to transfer to a vacuum truck or to collect to an IBC.

Where the vacuum truck option is selected, the drainage pipe would be expected to extend from the base of the sump to above the bund wall with a suitable mechanical coupling allowing connection.

Where drainage to site waste facility option is selected, the drainage pipework shall include an isolation valve with limit switches with the following:

iv. The isolation valve shall be installed in a valve pit outside of the bund, manually actuated from a safe location and from above ground level. This is to provide operator-initiated release of any fluoride slurry/solution to the designated location.

v. The isolation valve limit switch shall provide an alarm to alert operators if the isolation valve is in the open position for more than a defined period.

If a bulk FSA storage bund is not protected from the ingress of rainfall (by shelter or by other means), then the following shall apply:

vi. Bund sumps should include drainage pipework allowing manual diversion of stormwater to a safe location. Pipework shall:

   a. Divert stormwater to a safe location (after testing).

   b. Be designed with consideration of safely draining chemical in the event of a spill. This may need to consider whether a sump pump is able to recover all chemical, or if a diversion to a CSHT is required to capture residual chemical in a pipe.

   c. Include an isolation valve with a limit switch:

      1. The isolation valve shall be installed in a valve pit outside of the bund, manually actuated from a safe location and from above ground level.

      2. The limit switch shall provide an alarm to alert operators if it is in the open position.

      3. The limit switch shall provide an interlock with fill point SPO to prevent tank filling operation if the valve is not in the closed position.

      4. The design shall consider the risk of spilled chemical passing the isolation valve and ensure suitable materials and valve types for the application.

12.1.3.3 Bund Instrumentation

Liquid fluoride chemical storage or powder solution mixing/dosing or saturator area bund sumps shall include as a minimum a high-level switch (LSH) (ball float or similar) used to generate a high-level alarm (LAH). The switch shall:

i. Provide a local and remote alarm to alert the operator of a high chemical or water level.

ii. Be set to activate at the lowest reasonable level in the sump to avoid spurious trips but still detect valid spills.

iii. Trigger an audible and/or visual alarm at the LCP during FSA chemical delivery or powder chemical unloading, as appropriate.

At sites where, clear visibility of the entire bund may not be available to FSA chemical delivery personnel, or a risk assessment determines an unavoidable risk to personnel, equipment, or the environment, the following additional requirements shall be considered:

i. A high-high-level switch (LSHH):

   a. Used to generate a high-high-level alarm (LAHH).

   b. Used to shutdown filling processes and provide an interlock to any further tank filling operation (with LCP SPO interlock).

Where FSA storage tanks located outside, an additional conductivity probe should be installed in the bund sump to distinguish between rainwater and chemical with suitable alarms in SCADA.

12.2 Fluoride Powder and Chemical Solution Waste Management

12.2.1 Fluoride Powder Spillage Capture

In the event of a spill or leak as part of the large bags or small pails unloading and storage process, an action plan to prevent powder escaping into the fluoridation room and atmospheric discharge shall be implemented.

A spill needs to be contained and controlled to prevent further spillage and spreading into atmosphere, sewers, stormwater drains, basement or confined space.

Dry cleaning is preferred rather than hosing the split powder into a sump or drain. Appropriate personal protective equipment for cleaning and disposing of spills must be provided and used. Dry sweeping of fluoride powder shall not occur, powder need to be cleaned by vacuum fitted with a High Efficiency Particulate Air (HEPA) filter to prevent dust. Mops or wet rags may be used to clean small scale spills or the final clean-up of larger spills.

Empty fluoride compound containers and contaminated fluoride compounds are considered ‘regulated’ and ‘trackable’ waste under the Environment Protection (EP) Regulation. Therefore, they must be disposed in accordance with the regulatory requirements and a Standard Operating Procedure (SOP) must be prepared, documented and implemented.

Empty or contaminated container disposal options may include returning them to the supplier, or disposal through a specific waste disposal contractor considering toxicity of fluoride chemicals to wildlife and humans. Safety Data Sheet (SDS) of powder chemicals, Site Work Instructions for handling of fluoride powder and Emergency Response Plan must be followed for the management of powder spills.

12.2.2 Fluoride Solution Waste Tank

A dedicated fluoride solution waste tank shall be considered for the disposal of fluoride solution for sodium fluoride saturator or sodium fluorosilicate mixing tank cleaning and maintenance or to collect general washdown water after maintenance. Where required from site assessment, the waste tank should be self-contained. The tank needs to be located next to the fluoridation room and installed in a way that gravity transfer (where possible) from the fluoride room bund sump is possible.

The design should include appropriate protection for tank overflow and leakage detection. The design should also ensure appropriate piping and valves to transfer fluoride waste solution from the waste tank to a specific waste disposal contractor fitted out with a vacuum truck. The vacuum truck standing area should be designed in a way that any potential spill during the transfer can be contained for collection with zero discharge to the environment.

12.3 Compressed Air Room

Compressed air may be required to operate air-driven instrumentation and dust filter cleaning system for powder fluoride chemicals.

The compressed air supply system shall include compressors, air receivers and dryers. The air compressor shall be fitted with a filter in the suction side to prevent dust to entrain into the system where applicable.

The compressed air system must be housed in a separate room from the fluoridation room.

The compressed air room design shall ensure a safe working atmosphere for personnel and mitigate the effects of pressure changes and noise levels resulting from the compressor operation and shall comply with requirements in *M-SPE-STD-001 General Mechanical*.

13 Standard Designs

The Standard Designs or P&ID Standard Drawings as shown in Table 13-1 shall be used as the starting design concepts for Sodium Fluoride, Sodium Fluorosilicate, and Fluorosilicic Acid chemical unloading, storage, mixing/batching and dosing systems for all Seqwater works. The standard designs shall not be used for construction.

A project must develop new P&IDs based on the standard designs after incorporating the project specific requirements, and the outcomes from design reviews and appropriate technical hazard studies.

Table 13-1 Standard P&IDs for fluoride unloading, storage, mixing/batching and dosing systems.

Chemical System	Standard Drawing	Description
Fluoride (Sodium Fluoride, Sodium Fluorosilicate and Fluorosilicic Acid)	B-DWG-STD-031	Sheet 1 of 5 - Sodium Fluoride Unloading and Down-flow Saturator System
	B-DWG-STD-032	Sheet 2 of 5 - Sodium Fluoride Unloading and Up-flow Saturator System.
	B-DWG-STD-033	Sheet 3 of 5 - Sodium Fluorosilicate Unloading, Storage and Mixing System.
	B-DEG-STD-034	Sheet 4 of 5 - Fluoride Chemical Dosing System.
	B-DWG-STD-035	Sheet 5 of 5 - Fluorosilicic Acid System.

Note that the standard design P&ID drawing B-DWG-STD-035 (Sheet 5 of 5) for Fluorosilicic Acid System as referenced above has been developed for bulk tanker delivery. If a facility is designed with IBCs, the project shall develop a P&ID drawing showing IBCs with its control and other equipment.

The standard P&ID drawings as referenced in Table 13-1 have been developed following Seqwater *Process Flow Diagram and P&ID Requirements Standard Specification B-SPE-STD-007*, P&ID Legend Sheet Drawings *B-DWG-STD-001 to B-DWG-STD-007 for Symbols, Instrumentation Valve and Motor Details* and *P&ID Drafting Procedure B-PRO-STD-003*.

14 Testing and Commissioning

All fluoride chemical systems shall be tested and commissioned in accordance with the requirements of

i. *B-SPE-STD-003 Commissioning Requirements*
ii. *E-SPE-STD-001 Electrical Design and Construction*
iii. *M-SPE-STD-001 General Mechanical Specification*
iv. *I-SPE-STD-011 Control System Testing*

Testing shall, as a minimum, include:

i. Storage hoppers:
   a. Be tested for pressure and static load testing.
   b. Be tested for flow obstruction test due to ratholing or an arching issue or other blockage related issues.
ii. Hopper vibrator:
   a. Operation sequence – Hopper vibrators shall operate to the specified operational methodology to prevent mechanical damage to the storage hopper and other structures.
   b. Include running time and intensity test, to avoid hopper vibrator operating too long or with high/low intensity and causing powder compaction and deflection in the bottom section.
iii. Tanks and Saturators shall be:
   a. Hydrostatically tested using water, to an appropriate hydrostatic test method by the supplier/manufacturer and relevant standards prior to installation. Test report shall be made available to Seqwater.
   b. If fabricated or constructed on-site. Leak tested prior to any painting, coating, or similar treatments being applied using an appropriate hydrostatic test methodology. A test report shall be made available to Seqwater.
   c. Leak tested using water to full volume, on-site, following installation and prior to commissioning any ancillary systems. This test should be held and successfully demonstrated over a minimum of 24 hours.
iv. Tank liners:
   a. Shall be tested using an approved non-destructive method.
v. Storage tank bund:
   a. Shall be leak tested for a minimum of 48 hrs with potable water. The test should be done before and after installation of all equipment in the bund.
vi. Pipework:
   a. Shall be tested in accordance with the relevant material standards and codes.
   b. Shall be hydrostatically leak tested as per *M-SPE-STD-013 Chemical Dosing Piping.*
vii. Mixing and Dosing systems:
   a. All mixing and dosing systems shall be tested and proved first with water prior to the introduction of fluoride chemicals:
      i. Across the design dosing range.
      ii. Applying all Equipment and Dosing Control Modes.

14.1 Performance Testing

As part of performance testing, the contractor shall demonstrate, as a minimum, compliance of the fluoride chemical system with design intent for the following:

i. Sodium fluoride saturator – feed water able to start and stop as per the design.

ii. Sodium fluoride up-flow saturator - able to achieve a smooth flow of feed water from the distributor through the sodium fluoride bed.

iii. Sodium fluorosilicate unloading and transfer system – able to achieve the specified accuracy for all feed rates across the whole operating range from storage hopper to screw feeder.

iv. Sodium fluorosilicate solution concentration – able to achieve the fixed specified concentration.

v. Sodium fluorosilicate mixing system sequencing and timing.

vi. Service, motive and carrier water delivery pressure and flow rate (where required):

    a. Service water to mixing tank (for sodium fluorosilicate only).

    b. Service water across the water softener system to up-flow/ down-flow saturator.

    c. Wetting cone, eductor and wetting head (for sodium fluorosilicate only).

    d. Carrier water for dosing (for fluorosilicic acid only).

vii. Fluoride chemical dosing:

    a. Required dose rate (L/h) can be achieved across the range of concentrations required to be dosed.

    b. Desired constant dose concentration can be achieved.

    c. All interlocks and trips function as intended.

15 Changes from previous version

This Engineering Standard will be regularly reviewed and updated, including the consideration of requested alterations, in accordance with *Seqwater Procedure X-PRO-STD-004 Development and Review of Asset Standards*. Changes made from the previous version are detailed below (Table 15-1):

Table 15-1 Changes from Previous Version

Section Number	Change
Not applicable	Not applicable (original version)

16 Verification

Compliance with this document may be verified by internal audit.

17 Further Information

For further information please contact the owner of this document.

Appendix A Fluoride Sample Calculations

This appendix contains dosing sample calculations for sodium fluoride, sodium fluorosilicate and fluorosilicic acid with some key data.

A.1. Sodium Fluoride

Chemical Formula: NaF

Formula Weight: 41.99 g/mol

Chemical Purity: Typically deliver in at least 97% (w/w) [as NaF]

pH: 7.6 (saturated solution)

Solubility: 4g/100mL or 4% (w/w)

Classification: Class 6.1 in the Australian Dangerous Goods (ADG) Code

Sample Calculation

Sodium fluoride (NaF) daily usage calculation:

This calculation is used as an indication for the operator on the required sodium fluoride powder based on the process water flowrate. The given data and assumptions are as follows:

- Process water flowrate = 50 L/sec (assumed)
- Target fluoride concentration = 0.8 mg/L (assumed)
- Background water fluoride concentration = 0 mg/L (assumed)
- Molecular weight of fluoride, F = 18.99 g/mol

$$Fluoride\ ion\ concentration\ (\%) = \frac{formula\ weight\ of\ fluoride}{formula\ weight\ of\ sodium\ fluoride} \times 100$$

$$= \frac{18.99\ \left(\frac{g}{mol}\right)}{41.99\ \left(\frac{g}{mol}\right)} \times 100 = 45.2\%$$

$$Daily\ NaF\ usage\ \left(\frac{kg}{day}\right)$$

$$= \frac{(Target\ fluoride\ conc. - Background\ fluoride\ conc.)\ \left(\frac{mg}{L}\right) \times Process\ water\ flowrate\left(\frac{L}{s}\right) \times 86400\ \left(\frac{s}{day}\right) \times \frac{10^{-6}kg}{mg}}{\left(\frac{Fluoride\ ion\ concentration\ (\%)}{100}\right) \times \left(\frac{NaF\ Purity\ (\%)}{100}\right)}$$

$$Daily\ NaF\ usage\ = \frac{(0.8\ - 0)\ \left(\frac{mg}{L}\right) \times\ 50\ \left(\frac{L}{s}\right) \times 86400 \left(\frac{s}{day}\right) \times \frac{10^{-6}kg}{mg}}{0.452 \times\ 0.97} = 7.88\ \left(\frac{kg}{day}\right)$$

Sodium fluoride (NaF) solution flowrate calculation:

The calculation shown below, is used in a control system to determine the required sodium fluoride solution flowrate by the dosing pump based on the required process water fluoride concentration and flowrate.

The solubility of sodium fluoride is 40,000 mg/L or 4 % (w/w) [as NaF] solution concentration.

$$NaF\ solution\ flowrate\left(\frac{L}{h}\right) = \frac{(Target\ fluoride\ conc. - Background\ fluoride\ conc.)\left(\frac{mg}{L}\right) \times Process\ water\ flowrate\left(\frac{L}{s}\right) \times 3600\left(\frac{s}{h}\right)}{Saturated\ NaF\ solution\ conc.\left(\frac{mg}{l}\right) \times \left(\frac{Fluoride\ ion\ concentration\ (\%)}{100}\right) \times \left(\frac{NaF\ Purity\ (\%)}{100}\right)}$$

$$NaF\ solution\ flowrate = \frac{(0.8-0)\left(\frac{mg}{L}\right) \times 50\left(\frac{L}{s}\right) \times 3600\left(\frac{s}{h}\right)}{40000\left(\frac{mg}{l}\right) \times 0.452 \times 0.97} = 8.2\left(\frac{L}{h}\right)$$

A.2. Sodium Fluorosilicate

Chemical Formula: Na_2SiF_6

Formula Weight: 188.05 g/mol

Chemical Purity: Typically delivered in 98% (w/w) [as Na_2SiF_6]

Classification: Class 6.1 in the Australian Dangerous Goods (ADG) Code

Sample Calculation

Sodium fluorosilicate solution flowrate calculation:

The calculation shown below, is used in a control system to determine the required sodium fluorosilicate solution flowrate based on the required process water fluoride concentration and flowrate. The given data and assumptions are as follows:

- Process water flowrate = 1000 L/sec (assumed)
- Target fluoride concentration = 0.8 mg/L (assumed)
- Background water fluoride concentration = 0 mg/L (assumed)
- Molecular weight of fluoride, F = 18.99 g/mol
- $Na_2(SiF_6)$ solution concentration = 2000mg/L or 0.2% (w/w) (assumed)

$$Fluoride\ ion\ concentration\ in\ Na_2(SiF_6)\ (\%) = \frac{formula\ weight\ of\ fluoride}{formula\ weight\ of\ sodium\ fluorosilicate}$$

$$= \frac{18.99\ \times 6\left(\frac{g}{mol}\right)}{188.05\ \left(\frac{g}{mol}\right)} \times 100 = 60.6\%$$

$$Na_2(SiF_6)\ \ solution\ flowrate\left(\frac{L}{h}\right) = \frac{(Target\ fluoride\ conc. - Background\ fluoride\ conc.)\left(\frac{mg}{L}\right) \times Process\ water\ flowrate\left(\frac{L}{s}\right) \times 3600\left(\frac{s}{h}\right)}{Na_2(SiF_6)\ \ solution\ conc.\left(\frac{mg}{L}\right) \times \left(\frac{Fluoride\ ion\ concentration\ (\%)}{100}\right) \times \left(\frac{Na_2(SiF_6)\ \ Purity\ (\%)}{100}\right)}$$

$$Na_2(SiF_6) solution\ flowrate = \frac{(0.8-0)\left(\frac{mg}{L}\right) \times 1000\left(\frac{L}{s}\right) \times 3600\left(\frac{s}{h}\right)}{2000\left(\frac{mg}{L}\right) \times 0.606 \times 0.98} = 2425\left(\frac{L}{h}\right)$$

Sodium fluorosilicate feeder discharge rate calculation:

The calculation shown below is used in a control system to determine the screw feeder rate of sodium fluorosilicate powder. The assumptions are as follows:

- Mixing water flowrate = 2700 L/h (assumed based on above sodium fluorosilicate solution flowrate)

$$Feeder\ discharge\ rate\ \left(\frac{g}{min}\right) = \frac{Mixing\ water\ flowrate\left(\frac{L}{h}\right) \times Na_2(SiF_6)\ solution\ conc.\left(\frac{mg}{L}\right) \times \frac{1}{60}\left(\frac{h}{min}\right) \times \frac{1}{1000}\left(\frac{g}{mg}\right)}{\left(\frac{Na_2(SiF_6)\ Purity\ (\%)}{100}\right)}$$

$$Feeder\ discharge\ rate\ = \frac{2700\left(\frac{L}{h}\right) \times 2000\ \left(\frac{mg}{L}\right) \times \frac{1}{60}\left(\frac{h}{min}\right) \times \frac{1}{1000}\left(\frac{g}{mg}\right)}{0.98} = 91.8\ \left(\frac{g}{min}\right)$$

A.3. Fluorosilicic Acid

Chemical Formula: H_2SiF_6

Formula Weight: 144.09 g/mol

Specific Gravity: 1.18

Chemical Purity: Typically delivered in 20-25% (w/w) [as H_2SiF_6] aqueous acid solution

Classification: Class 8 in the Australian Dangerous Goods (ADG) Code

Sample Calculation

The calculation shown below, is used in a control system to determine the required fluorosilicic acid solution flowrate based on the required process water fluoride concentration and flowrate. The given data and assumptions are as follows:

- Process water flowrate = 1000 L/sec (assumed)
- Target fluoride concentration = 0.8 mg/L (assumed)
- Background fluoride concentration = 0 mg/L (assumed)
- Molecular weight of fluoride, F = 18.99 g/mol
- Fluorosilicic acid concentration in supplied chemical = 23% (w/w) (assumed)

$$Fluoride\ ion\ concentration\ in\ H_2(SiF_6)\ (\%) = \frac{formula\ weight\ of\ fluoride}{formula\ weight\ of\ fluorosilicic\ acid} \times 100$$

$$= \frac{18.99\ \times 6\left(\frac{g}{mol}\right)}{144.09\ \left(\frac{g}{mol}\right)} \times 100 = 79.1\%$$

$$H_2(SiF_6)\ dosing\ \ flowrate\left(\frac{L}{h}\right) = \frac{(Target\ fluoride\ conc.{-}Background\ fluoride\ conc.)\ \left(\frac{mg}{L}\right)\times Process\ water\ flowrate\left(\frac{L}{s}\right)\times 3600\ \left(\frac{s}{h}\right)}{\left(\frac{H_2(SiF_6)\ \ concentration\ \left(\%\frac{W}{W}\right)}{100}\right)\times S.G\ \left(\frac{kg}{L}\right)\times\ 1000*1000\left(\frac{mg}{kg}\right)\times\left(\frac{Fluoride\ ion\ concentration(\%)}{100}\right)}$$

$$H_2(SiF_6)\ dosing\ \ flowrate\ = \frac{(0.8-0\ )\left(\frac{mg}{L}\right)\times 1000\ \left(\frac{L}{s}\right)\times 3600\ \left(\frac{s}{h}\right)}{0.23\ \times\ 1.18\ (\frac{kg}{L})\times 1000 * 1000\left(\frac{mg}{kg}\right)\ \times 0.791} = 13.4\left(\frac{L}{h}\right)$$

Appendix B Fluoride System Typical Interlocks

Table B-1Sodium Fluoride Transfer System Interlocks (Down-flow Saturator or Up-flow Saturator)

Device / Instrument	Cause	Effect	Trip Interlocks	Hardware / Hardwired Interlocks
Vacuum motor	Fault	Vacuum motor interlock		Y
	Power Loss			
Saturator High-High Level Switch	Fault	Interlock powder transfer (i.e., vacuum motor)	Y	
	Power Loss			
	High-High			
Saturator Low-Low Level Switch	Fault	Interlock dosing pump	Y	
	Power loss			
	Low-Low			
Dilution Water Line Solenoid Valve	Fault	Interlock powder transfer (i.e., vacuum motor)	Y	
	Power Loss			
	Fail to open or close within time limit			

Table B-2 Sodium Fluorosilicate unloading and storage Interlocks

Device / Instrument	Cause	Effect	Trip Interlocks	Hardware / Hardwired Interlocks
Unloader safety door position switch	Open	Interlock bag unloading sequence. Stop conveyance system	Y	
Dust extraction line solenoid valve	Close	Interlock bag unloading sequence. stop conveyance system	Y	
Dust Filter Pressure Differential Transmitter	Fault	Stop conveyance system	Y	
	Power Loss			
	High-High Pressure			
Storage Hopper Dust Extraction Fan	Fault	Interlock bag unloading sequence. stop conveyance system	Y	
	Power Loss			

Device / Instrument	Cause	Effect	Trip Interlocks	Hardware / Hardwired Interlocks
Storage Hopper weight transmitter for load cells	Fault	Stop conveyance system	Y	
	Power Loss			
	High-High Weight			
	Low-Low Weight	Interlock opening rotary valve or close rotary valve if it is open.	Y	
Storage Hopper High-High Level Switch	Fault	Stop conveyance system	Y	
	Power Loss			
	High-High Level			
Storage Hopper Low-Low Level Switch	Fault	Interlock opening rotary valve or close rotary valve if it is open.	Y	
	Power Loss			
	Low-Low Level			
Storage Hopper Vibrator	Fault	Interlock opening rotary valve or close rotary valve if it is open.	Y	
	Power Loss			
Storage Hopper knife gate isolation valve	Fail close during mixing sequence	Interlock opening rotary valve or close rotary valve if it is open.	Y	

Table B-3 Sodium Fluorosilicate Mixing System Interlocks

Device / Instrument	Cause	Effect	Trip Interlocks	Hardware / Hardwired Interlocks
Transition Hopper weight transmitter for load cells	Fault	Interlock screw feeder, agitator, and mixing sequence.	Y	
	Power Loss			
	Low-Low Weight			
	High-High Weight	Interlock rotary valve		
Transition Hopper Agitator	Fault	Interlock mixing sequence	Y	
	Power Loss			
	High Motor Current			
	Low Motor Current			

Device / Instrument	Cause	Effect	Trip Interlocks	Hardware / Hardwired Interlocks
Screw Feeder	Fault	Interlock mixing sequence	Y	
	Power Loss			
	LIW Deviation Alarm			
Wetting Cone High Level Switch	Fault	Interlock mixing sequence	Y	
	Power Loss			
	High Level			
Eductor up-stream line flow switch	Fault	Interlock mixing sequence	Y	
	Power Loss			
Motive Water Line Actuated Valve	Fault	Interlock mixing sequence and stop motive water pump.	Y	
	Power Loss			
	Closed			
Motive Water Line Pump (up-stream wetting cone and eductor)	Fault	Interlock mixing sequence	Y	
	Power loss			
	Stop			
Mixing tank make-up water flow switch	Fault	Interlock mixing sequence	Y	
	Power Loss			
	Low Flow			
Dosing Tank Level Transmitter	Fault	Stop dosing pumps and close transfer line actuated valve	Y	
	Power Loss			
	Low-Low Level	Interlock dosing pump	Y	
	High-High level	Interlock mixing sequence	Y	
Dosing Tank High-High Level Switch	Fault	Interlock mixing sequence	Y	
	Power Loss			
	High-High Level			
Dosing Tank Low-Low Level Switch	Fault	Interlock dosing pump, close relevant tank outlet actuated valve	Y	
	Power Loss			
	Low-Low Level			
	Fault		Y	

Device / Instrument	Cause	Effect	Trip Interlocks	Hardware / Hardwired Interlocks
Outlet Dosing Tank Actuated Valve	Power Loss Close	Interlock dosing pump		

Table B-4 Fluorosilicic Acid (FSA) Unloading and Storage Interlocks

Device / Instrument	Cause	Effect	Trip Interlocks	Hardware / Hardwired Interlocks
Fill Line Manual Isolation Valve – Position Limit Switch	Fault Power Loss Limit Switch Closed More than one limit switch open or partially open.	Interlock and isolate power in SPO	Y	
FSA Unloading Area Spill Tank Drain Valve – Position Limit Switch	Fault Power Loss Limit Switch Closed	Isolate power in SPO	Y	
FSA Unloading Area Stormwater Valve – Position Limit Switch	Fault Power Loss Limit Switch Open	Isolate power in SPO	Y	
FSA Spill Holding Tank High-High Level Transmitter	Fault Power Loss High-High level	Isolate power in SPO	Y	
FSA Spill Holding Tank High-High Level Switch	Fault Power Loss High-High level	Isolate power in SPO	Y	
FSA Storage Tank Outlet Actuated Valve	Fault Power Loss Closed	Stop relevant dosing pump	Y	
	Fault Power Loss	Isolate power in SPO	Y	

Device / Instrument	Cause	Effect	Trip Interlocks	Hardware / Hardwired Interlocks
FSA Storage Bund Sump – High-High Level Switch	High-High level detected			
FSA Storage Tank Level Transmitter 1 or 2	Fault	Isolate power in SPO. Interlock dosing pump	Y	
	Power Loss			
	High-High Level	Interlock power in SPO	Y	
	Low-Low Level	Interlock dosing pump .	Y	
	Tank level changes than desired daily maximum.			

Table B-5 Fluoride Dosing System Trips and Interlocks (Note: Interlocks from tanks and saturators already covered in above tables)

Device / Instrument	Cause	Effect	Trip Interlocks	Hardware / Hardwired Interlocks
Conductivity probe	Fault	Interlock dosing pump and interlock sodium fluorosilicate mixing system	Y	
	Power Loss			
	High-High			
Dosing Flowmeter (any of two)	Fault	Interlock dosing pump.	Y	
	Power Loss			
	Flow above setpoint for pre-set period.			
	Flow deviation between two chemical flow meters outside limit			
	Flow meter totalizer – daily chemical consumption is higher than maximum required	Interlock dosing pump (only for FSA)	Y	
	Fault		Y	
	Power Loss			

Device / Instrument	Cause	Effect	Trip Interlocks	Hardware / Hardwired Interlocks
Discharge Pressure Transmitter	High Pressure	Interlock dosing pump, close actuated valve and changeover to standby dosing line and pump		
Dosing Pump	Fault Power Loss Stop	Close relevant dosing line actuated valve. Start standby dosing pump	Y	
Dosing line actuated valve	Fault Power Loss	Interlock dosing pump and close valve.	Y	
Fluoride analyzer (any of two)	Fault Power Loss High- High or CCP critical limit Low or no flow signal from analyser	Interlock dosing pump	Y	
Carrier water solenoid valve (applicable to FSA only)	Fault Power Loss Close	Interlock dosing pump.	Y	
Carrier water flow switch (applicable to FSA only)	Fault Power loss No flow	Interlock dosing pump	Y	
Liquid level switch in dosing line pit or dosing point equipment enclosed cover	Fault Power Loss High liquid level	Interlock dosing pump	Y	
Main Process Flowmeter (any of two)	Fault Power Loss Flow deviation outside limit	Interlock dosing pump	Y	

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