Wendy Collard

From: Wendy Collard
Sent: Wednesday, 5 April 2023 12:57 p.m.
To: [redacted]
Subject: RE: Water Fluoridation
Attachments: WNZ-COP-1.0 Good Practice Guide to Fluoridation of Water Supplies.pdf; Certificate of Analysis - Shimonseki Mitsui Chemicals Inc.pdf

Kia ora

I refer to your Local Government Official Information and Meetings Act request for the following:

Can you please provide details on which chemical fluoride compounds are used to fluoridate Dunedin's water supply.

Where are they sourced from?
The chemical fluoride are sourced from Shimonoseki Mitsui Chemicals, Japan.

Do you always use the same compounds?
Yes, DCC always use Sodium Silicofluoride.

Do you always use the same source?
No, DCC currently source the chemicals from Shimonoseki Mitsui Chemicals, Japan and have used Prayon sourced from Belgium.

Are the concentrations and purity of the materials to be used in fluoridation fully standardised, batch-tested and documented as a legal requirement?
Please find attached Water New Zealand Good Practice Guide for the Fluoridation of Drinking-Water Supplies in New Zealand which includes a reference to standard 'AS/NZS 4020:2018 – Testing of products for use in contact with drinking water'.

Do the fluoridation compounds proposed to medicate the public water supply meet British Pharmaceutical (BP) or United States Pharmaceutical (USP) purity standards and, if not, why not?
Please find attached the Certificate of Analysis from our supplier who have stated that 'Our product conforms to the American Water Works Association standard.

Kā mihi

Wendy Collard
Mana Whakahaere Kairuruku / Governance Support Officer
Governance Group

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Kā mihi

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PO Box 5045, Dunedin 9054
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From: [redacted]
Sent: Tuesday, 14 March 2023 1:58 p.m.
To: Official Information <officialinformation@dcc.govt.nz>
Subject: Water Fluoridation

Hi
Can you please provide details on which chemical fluoride compounds are used to fluoridate Dunedin's water supply.
Where are they sourced from?
Do you always use the same compounds?
Do you always use the same source?
Are the concentrations and purity of the materials to be used in fluoridation fully standardised, batch-tested and documented as a legal requirement?
Do the fluoridation compounds proposed to medicate the public water supply meet British Pharmaceutical (BP) or United States Pharmaceutical (USP) purity standards and, if not, why not?
Thank you

Sent with Proton Mail secure email.

water NEW ZEALAND
The New Zealand Water & Wastes Association Waiora Aotearoa

Water New Zealand

Good Practice Guide for the

Fluoridation of Drinking-Water Supplies in New Zealand

Foreword from the Ministry of Health

Foreword from Water New Zealand

Fluoride is added to drinking water to support against tooth decay. The Health (Fluoridation) Amendment Bill grants the Director-General of Health decision making powers on community water fluoridation. Water suppliers will be required to fluoridate a water supply if directed to do so by the Director-General of Health. Those already fluoridating are required to continue to do so.

This guide has been developed to assist water suppliers design and operation of water fluoridation plants to enable effective addition of fluoride to water supplies in a manner which protects public health, and the operators who maintain them.

Formerly Water New Zealand had published a Code of Practice for Fluoridation of Drinking-water Supplies in New Zealand and the Good Practice Guide for Supply of Fluoride for Use in Water Treatment. Since this time the introduction of the Health (Fluoridation) Amendment Bill, and new Drinking Water Quality Assurance Rules, published by Taumata Arowai, New Zealand's Drinking Water Regulator, both of which have shifted the roles and responsibilities in relation to the fluoridation of drinking water supplies. This good practice guideline has been updated to ensure guidance on the fluoridation of water supplies reflects this shift.

The Code of Practice for Fluoridation of Drinking-water Supplies, authored in 2014 by Beca was developed in conjunction with the Ministry of Health, supported by Victorian Department of Health, and received important contributions from a wide range of water suppliers and industry stakeholders. The guideline specified optimum fluoride levels for drinking-water supplies as defined by the Ministry of Health and the design control limits for fluoridation plants, for safe and effective addition of fluoride into a drinking-water supply. This guideline maintains the fluoride dose and control limits established in the code of practice.

The Good Practice Guide for Supply of Fluoride for Use in Water Treatment was developed to provide purchasers manufacturers and suppliers with minimum requirements for the physical, chemical and testing requirements of fluoride. The Chemical Rules outlined in Taumata Arowai's Drinking Water Quality Assurance Rules, introduce new testing requirements that supersede much of this guideline. Relevant content of the guide has been introduced into this Good Practice Guideline, most importantly Specific Impurity Limits for product testing, which are listed in Appendix A.

Lutra has authored this version of guidance, in consultation with chemical, equipment and water suppliers. The content of this guideline reflects their feedback on the most effective material to achieve the aims of the guide, which is to provide clear and accessible guidance to support the safe and effective design and operation of drinking water fluoridation. We encourage all water suppliers undertaking fluoridation to adopt the good practices outlined in these guidelines.

Gillian Blythe

Chief Executive Officer

Acknowledgements

This Guideline has been authored by Iain Rabbits of Lutra, with support from Ciara Hyland. The guide draws on Lutras experience designing fluoridation plants across New Zealand. Sean Rolleston at IXOM and Mark Harrison at ChemFeed provided practical advice on products and material that fed into the guides development. Noah Hensley of Taumata Arowai, provided guidance on how fluoride will be managed under the new regulatory reigime. John MacAndrew and Derek Crawford of Dunedin City Council provided suggestions on the types of information needed by water suppliers to manage fluoride dosing at water treatment plants.

Review of the document has been provided by [TBC following responses to review].

The guide draws on previous documents published by Water New Zealand. Importantly the dosing, control set in Code of Practice for Fluoridation of Drinking-water Supplies of Fluoride for Use in Water Treatment. The Good Practice Guide for Supply impurity limits have also informed this guide.

The document structure and content have also been adopted based on the Fluoride Code of Practice. We acknowledge the significant contribution the authors made in establishing safe water supply fluoridation practices in New Zealand. The Code of Practice was authored by Andrew Watson, then working for Beca, was supported and informed by the Ministry of Health, the Victorian Department of Health, and received important contributions from a wide range of water suppliers and industry stakeholders.

Product impurity limits set in the Good Practice Guide, and outlined in Appendix A of this document, were calculated by Chris Nokes, then employed by ESR, with review of several water and chemical suppliers.

Water New Zealand wishes to acknowledge the authors of this document, previous fluoridation guidance, and the many contributors to past and present versions of their guides for their contribution to ensuring the safe and effective fluoridation of New Zealand's water supplies.

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Nomenclature

Terms	Description
DWQAR	Drinking Water Quality Assurance Rules
GV	Guideline Value
HFA	Hydrofluorosilicic Acid
HAZOP	Hazard and operability study
I/O	Input/output
IBC	Intermediate bulk containers
MAV	Maximum Allowable Value
ML/D	Megalitres per day
m^3/h	Cubic meters per hour
MoH	Ministry of Health
$Na_2[SiF_6]$	Sodium silicofluoride
NaF	Sodium fluoride
HDPE	High-density polyethylene
TADWS	Taumata Arowai Drinking Water Standards 2022
cPVC	Chlorinated polyvinyl chloride
PID	Proportional–Integral–Derivative
PVC	Polyvinyl chloride
SiD	Safety in Design
SIL	Specific impurity limit
WTP	Water Treatment Plant

1 Introduction

The good practice guide to fluoridation of drinking-water supplies in New Zealand specifies good and safe practice approach to the design and operation of water fluoridation plants. The aim is to ensure all sites storing a fluoride source are operated safely and that fluoride is added effectively to drinking-water supplies.

This guide covers the design, storage and delivery control of three fluoride sources:

- Liquid hydrofluorosilic acid (HFA)
- Dry powder sodium fluoride (NaF)
- Dry powder sodium silicofluoride ($Na_2[SiF_6]$)

This guide to good practice is applicable to all new and existing fluoride plants from the date of publication.

1.1 Objectives

The purpose of this guide is as follows:

- Detail the design requirements of the good practice fluoride systems.
- Detail dosing control for consistent fluoride concentrations in treated water.
- Measure compliance and detail minimum preventative measures to protect supply from exceeding MAVs as listed in the Taumata Arowai drinking water assessment.

The good practice guide is structured as follows:

- Section 2: Chemical Selection
- Section 3: Legislation and Standards
- Section 4: Design and Operational Considerations
- Section 5: Hydrofluorosilicic Acid (HFA)
- Section 6: Sodium Fluorosilicate ($Na_2[SiF_6]$)
- Section 7: Saturated Systems (NaF)

2 Chemical Selection

2.1 Fluoride Chemicals

Table 1 – Chemical Selection is an overview of key design considerations for suppliers investing a new fluoridation system. Other considerations may include the availability of chemical in a particular region. For example, at the time of writing, HFA is not available in bulk in the South Island.

The selection of chemical and system must be done on a risk-based approach.

Table 1 – Chemical Selection Considerations

Chemical	Sodium Fluoride (NaF)	Sodium Silica Fluoride (Na_2SiF_6)	Hydrofluorosilicic acid (HFA)	
System Type:	Bottle saturator system	Vacuum Loaded Hopper System	IBC/Drum	Bulk
Recommended Flow Ranges	≤ 5 MLD	>5 MLD	Any range	Any range
Operator Handling	No requirement to come into contact with product	Opening of powder bags. Increased risk to personnel. Due to powder escape	Transfer of product to storage tank. Increased risk to personnel	No requirement to come into contact with product
Vapour Handling	No issues	No issues	Storage system vented to lute seal and/or vented outside	Storage system vented to lute seal and/or vented outside
Delivery	5 kg sealed bottles	Delivered as 25 kg paper bags. Bags damaged in transit or storage may leak SSF.	1000L IBC or 200L drum.	3,000L – 20,000L delivery
Storage of Product	Minimal additional requirements	Air conditioning required. Product MUST be kept in dry environment	No issues	No issues
Product Quality	No issues	Varying quality of SSF may affect the calibration of the screw feeder	No issues	No issues

Chemical	Sodium Fluoride (NaF)	Sodium Silica Fluoride (Na_2SiF_6)	Hydrofluorosilicic acid (HFA)	
Maintenance	Few Issues. Saturator tank may require emptying for cleaning. Disposal of fluoride powder and saturated solution may be a problem.	Emptying SSF hoppers in a safe manner can be difficult	HFA flushing and maintenance requires careful attention in terms of ventilation and managing leaks	HFA flushing and maintenance requires careful attention in terms of ventilation and managing leaks

2.2 Chemical Quality Control

Water suppliers should request a quarterly report on the fluoride chemicals supplied. The specific impurity limits (SIL) are shown in Appendix A. Regardless of the SIL, no parameter must exceed the MAV in the drinking water.

3 Legislation and Standards

Current legislative requirements must be met in all plants. This is the minimum standard acceptable under law. This section outlines legislative requirements of relevance to the management of a water fluoridation.

3.1 Health (Fluoridation of Drinking Water) Amendment Act 2021

'The Health (Fluoridation of Drinking Water) Amendment Act 2021 shifted decision-making on fluoridation from water suppliers to the Director-General of Health. The change allows for a nationally consistent approach to community water fluoridation based on its well-established health benefits.

Water suppliers will be required to fluoridate a water supply if directed to do so by the Director-General of Health. Those already fluoridating are required to continue to do so.

In deciding whether to make a direction to fluoridate, the Director-General of Health is required to consider:

- scientific evidence on the effectiveness of adding fluoride to drinking water in reducing the prevalence and severity of dental decay
- whether the benefits of adding fluoride to drinking water outweigh the costs, including consideration of local oral health status, population numbers, and financial cost.

3.2 Water Services Act 2021

The Water Services Act provides a drinking water regulatory framework to ensure that safe drinking water supplies are provided to consumers. Thee act gives Taumata Arowai the legal authority to carry out its duties as New Zealand's dedicated water regulator. Taumata Arowai are the water services regulator for Aotearoa New Zealand, responsible for developing regulatory instruments (such as Rules, Standards and Acceptable Solutions).

Taumata Arowai publish Drinking Water Standards and Drinking Water Quality Assurance Rules. The Drinking Water Quality Assurance Rules (Rules) set out what drinking water suppliers need to do to comply with key parts of the Drinking Water Standards and the Water Services Act 2021 and set monitoring requirements that apply to fluoride.

3.3 Water Services (Drinking Water Standards for New Zealand) Regulations 2022

These regulations, which come into force on 14 November 2022, set the Drinking Water Standards for New Zealand. The standards set limits for the concentration of determinands in drinking water. The limits are referred to as maximum acceptable values (MAVs) including Fluroide. The MAVs for any determinand must not be exceeded at any time.

3.4 Other Legislative Requirements

Other legislative requirements of relevance to the management of a water fluoridation scheme include:

- Health Act 1956 (2007)

- Health and Safety at Work Act 2015
- Health and Safety at Work (Hazardous Substances) Regulation 2017
- General Risk And Workplace Management Regulations 2017.
- Local Government Act 2002

3.5 Applicable Standards

Standards provide good practice in general terms but do not supersede the legal requirements.

Standards for storage and handling of fluoride include:

- NZS/AS 1319-1994 Safety signs for the occupational environment
- AS 1345-1995 Identification of the contents of pipes, conduits and ducts
- AS/NZS 1715-1994 Selection, use and maintenance of respiratory protective devices
- AS 3780:2008 The storage and handling of corrosive substances (class 8 and 6)
- AS/NZS 4020:2018 Testing of products for use in contact with drinking water
- ISO 9001:2000, ISO 14001:2004, HACCP Quality management and hazard control system
- AS/NZS 4452:1997 The storage and handling of toxic substances
- AS/NZS 4801:2001 Occupational health and safety management systems––
- NZS 5807:1980 Code of practice for industrial identification by colour, wording or identification

This guide provides additional recommendations for the safe design, construction and operation of fluoride dosing systems over and above those in the legislation and guides listed above. For example, requirements for the fill point arrangement are listed in the Health and Safety at Work (Hazardous Substances) Regulation 2017, AS 3780:2008 The storage and handling of corrosive substances (class 8 and 6) and in this document. The requirements for the number and location of safety showers are detailed in AS 3780:2008 and are therefore not repeated here.

4 Design and Operational Considerations

Before any fluoride plant is designed or operated, the requirements of the legislation must be understood and incorporated into the design and operation of the plant. This includes (but not limited to):

- Occupational health and safety
- HAZOP and Safety in Design
- Environmental safety
- Risk assessments
- Drinking water safety
- Emergency response
- Waste disposal
- Container disposal
- O&M Manuals
- Standard operating procedures

The good practice listed in the sections below does not absolve the legal responsibilities of the designer, owner or operator of the fluoride dosing plant.

The operations staff must be adequately trained to handle the fluoride chemical and understand the risks, mitigations, and response actions.

The control of the fluoride system must be clearly documented such that it is easily understood by operations staff, programmers and engineers.

The recording and reporting requirements for monitoring of fluoride dosing is clearly detailed in the Drinking Water Quality Assurance Rules. Each of the methods for determining fluoride dose should be reported.

4.1 Concentration of Fluoride in Water

The purpose of fluoridation is to adjust the natural fluoride content of drinking water to the optimum level to provide a dental health benefit. The target concentration of fluoride in treated water is between 0.7 and 1.0 mg/L.

The selected dosing concentration and the basis for the selection (including allowance for the fluoride concentration in the raw water) should be included in the Water Safety Plan. The drinking-water supplier should maintain a historical record of the fluoride concentration in the raw water to ensure an appropriate allowance is made for the fluoride concentration in determining the dosing concentration. The fluoride concentration in the raw water should be analysed at an appropriate frequency for the expected variability.

4.2 Safeguards

Overdosing of fluoride chemicals can lead to adverse health effects. To prevent overdosing, there are two primary protections:

1. Fluoride dosing cannot start until a positive flow is detected by the flowmeter in the main line where fluoride is dosed and the flow switch in that same line. This prevents fluoride being dosed into a static water line.

2. The fluoride dose is triple validated using:

a. The loss of fluoride in the hopper or the volume of liquid dosed over a period divided by the water treated during that time.

b. The amount of chemical being dosed by the dosing pumps into the flow being dosed.

c. The final fluoride analyser.

Protection 1 is true for all types of fluoride dosing system. Protection 2 is defined in the following sections.

5 Hydrofluorosilicic Acid (HFA) Design

5.1 Piping and Instrumentation Diagram

A piping and instrumentation diagram (P&ID) of the HFA dosing system is attached in Appendix B.

For HFA bulk delivery is always preferred.

5.2 HFA Bulk Delivery Area Design

The HFA bulk delivery area is shown in Figure 1.

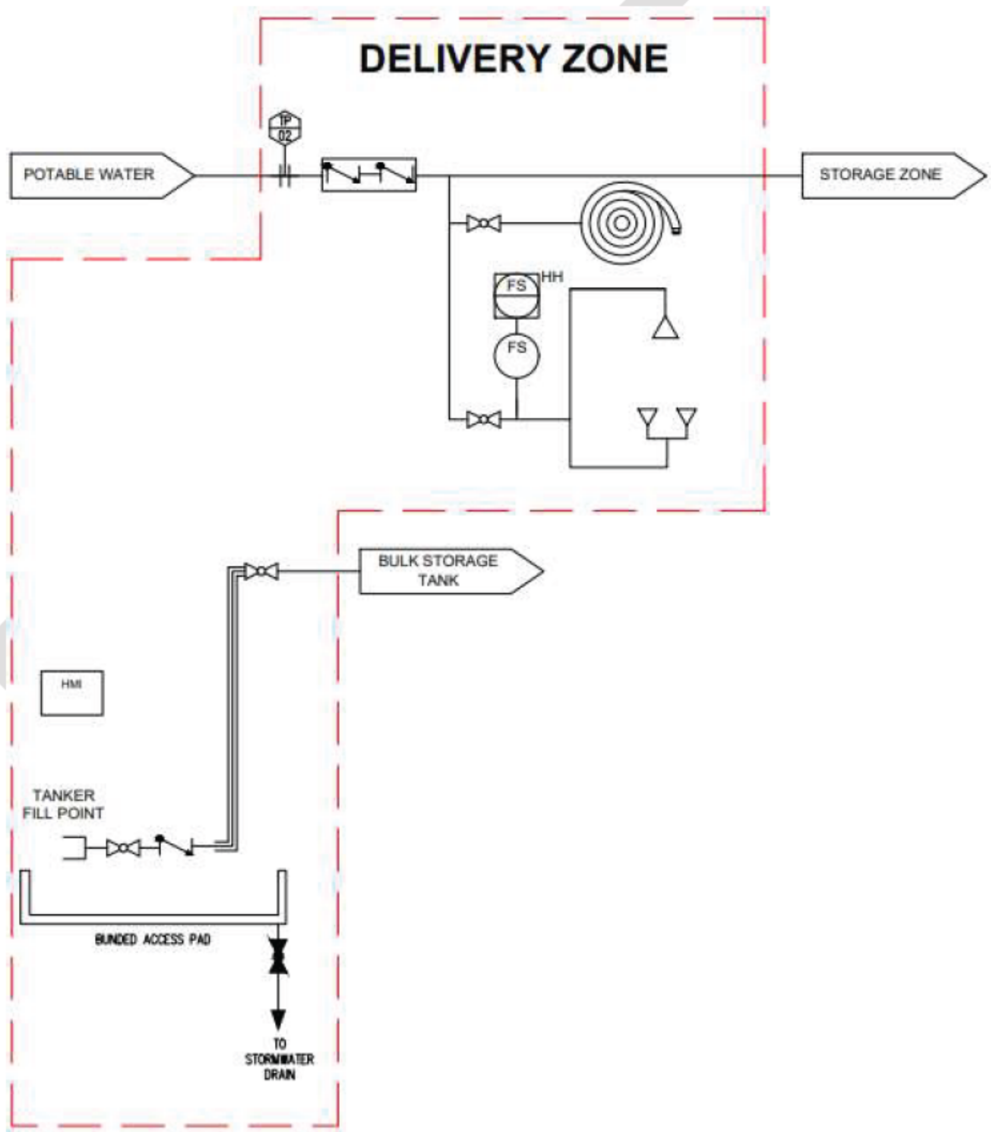


Figure 1: P&ID Section - HFA Bulk Delivery Zone.

5.2.1 Equipment

The equipment required for HFA bulk delivery is described in the equipment schedule in Table 2.

Table 2 – HFA Bulk Tank Delivery Equipment Schedule

Item Description	Quantity	Material / Type	Size	Unit
Tanker access[1]	-	Suitable roading or concrete	Inside radius, 12	m
			Outside radius, 25	m
Delivery bund volume[2]	1	Concrete	In accordance with AS3780:2009	L
HFA cam-lock connection	1	Hastelloy	50	mm
Delivery process line	As required from distance camlock to bulk tank	Double contained - PVC	50	mm
Human machine interface (HMI) (at the camlock)	1	-	-	
Manual valves[3]	1	PVC	50	mm
Non-return valves[3]	1	PVC	50	mm
Safety shower	1			
Reduced pressure zone device	1	Brass or stainless steel		
Flushing hose connection	1			

Notes:

(1) Tankers should be able to drive on and off site without reversing

(2) Access pad should connect to the rain/stormwater drain valve, closed on delivery

(3) Valves will be at minimum as shown. The number required is site-specific, depending on line length and connection requirements.

5.2.2 Tanker Delivery Description

Typically, bunds shall be at least 20 metres where B-train deliveries are to be received. This needs to be confirmed with the supplier.

The maximum compartment size for a bulk delivery is typically 7,500 litres. The delivery bund will be sized in accordance with AS3780:2009.

The minimum bulk delivery is 3000 litres. The minimum tank size is therefore 5000 litres for bulk delivery. Bulk tank sizing is detailed in Section 5.4.2.

Tanker access should be designed such that there is no requirement to back the tanker to get into the fill point or to get off site.

The tanker should be able to be clear of the public road before stopping to open gates or otherwise access site.

The delivery point camlock should be located between 800mm and 1000mm above ground level.

The tanker delivery point is located on the left-hand side (front-facing) of the tanker.

Where the delivery pipework is not contained within the delivery bund or the bulk tank bund, it should be double contained.

The HFA delivery point shall be isolated from other delivery points with key access to the delivery point. Where there are multiple delivery points, separate cabinets around the fill-point and level display for each tank is good practice.

The tank contents shall be displayed at the fill point and shall be shown in litres.

The safe fill level (90%) shall be displayed in litres at the fill point. For tanks larger than 10,000 litres, 95% may be used as the safe fill level.

The maximum fill level (100%) shall be displayed in litres at the fill point.

An audible and visual alarm at the fill point will be triggered at the safe fill level and at the maximum fill level. A silence button for the audible and visual alarm will be placed at the fill point.

Delivery standard operating procedures (SOPs) should be developed with the chemical supplier for delivery. These should include as a minimum:

- Stormwater isolation
- Spill/leakage response
- QA to ensure the right chemical is delivered into the correct tank
- Delivery connection
- Chemical transfer including stop levels at safe fill volume and maximum fill volume.
- Delivery flushing and disconnection
- Partial delivery
- Other safety information
- Communications between delivery and site staff

5.3 Intermediate Bulk Container (IBC) and 200 Liter Drum Delivery Design.

The HFA IBC delivery area is shown in Figure 2 below.

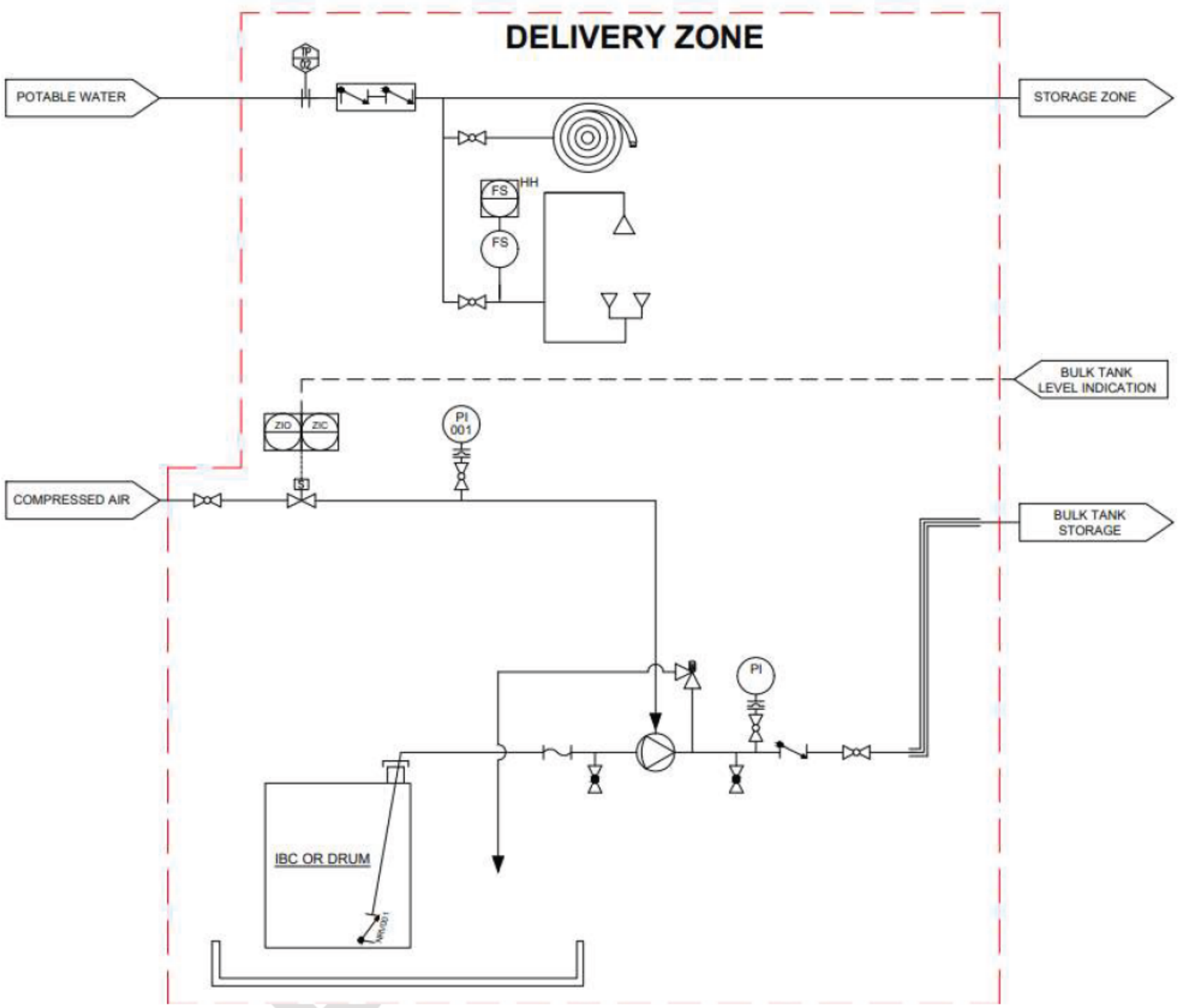


Figure 2: P&ID Section - HFA IBC Delivery Zone.

5.3.1 Equipment

The equipment required for HFA bulk delivery is described in the equipment schedule in Table 3.

Table 3 – HFA IBC Delivery Equipment Schedule

Item Description	Quantity	Material / Type	Size	Unit
Delivery process line	Length as required	Double contained - PVC	50	mm
Human machine interface (HMI) (at the camlock)	1	-	-	
Manual valves[1]	1	PVC	50	mm
Transfer pump[2]	1	Air-diaphragm	-	
Non-return valves[1]	1	PVC	50	mm
Safety shower	1			
Reduced pressure zone device[3]	1	Brass or stainless steel		
Flushing hose connection	1			
Suction hose with IBC connection	1		50	mm

Notes:

(1) Valves will be at minimum as shown. Number required is site specific, depending on line length and connection requirements.

(2) If air diaphragm transfer pump is used a compressed air system will be required.

(3) RPZ may be present onsite at a separate drinking water service connection

5.3.2 IBC Delivery Description

Delivery of IBCs and drums to site is normally by Hiab or tail lift truck. The movement of IBCs around site is by fork truck or pallet lifter. Drums should be picked up either on a pallet or with a specific drum lifting attachment. The floor surface shall be suitable to enable movement for the lifting device chosen.

The fork truck or pallet lifter will deliver the IBC or drums into a bunded area for decanting the IBC or drum into the bulk storage tank. Using davits, cranes or other devices to move IBCs or drums is not preferred. The bunded area should be sized to contain 110% of the largest container. Strip drains that drain into a tank, that allow unfettered access by the fork truck or pallet lifter are preferred. However, the placing of IBCs or drums within a bund by a fork truck is also acceptable.

HFA should not be dosed directly from the drum or IBC.

HFA will be transferred from the IBC or drum to the bulk tank using a transfer pump and suction lance.

The tank contents shall be displayed at the fill point and shall be shown in litres.

The safe fill level (90%) shall be displayed in litres at the fill point. For tanks larger than 10,000 litres, 95% may be used as the safe fill level.

The maximum fill level (100%) shall be displayed in litres at the fill point.

A visual alarm at the fill point will be triggered at the safe fill level and at the maximum fill level. A safe fill level override button will be placed at the fill point. This will cancel the visual alarm. A silence button for the maximum fill level audible and visual alarm will be placed at the fill point.

The transfer pump can be an air driven diaphragm pump or a motorised pump. The pump shall be interlocked (either by stopping the pump motor or shutting off the air supply as shown on the P&ID) with the safe fill level of the tank and the maximum fill level of the tank. The pump shall stop at the safe fill level with visual indication for the operator. If a small amount is left in the IBC or drum that is less than the difference between the safe fill level and the maximum fill level, the safe fill level may be overridden at the fill point. The maximum fill level must not be overridden.

The bulk tank will be sized at minimum 1500 L for IBCs or 300 litres for drum deliveries.

The system shall be designed to deliver a complete IBC or drum to the bulk storage tank. Residual HFA unable to be transferred via the transfer line will be labelled and moved to a separate disposal area. Disposal or replacement of IBCs is coordinated through the chemical supplier.

The transfer pump shall be installed over a bund.

The delivery transfer line will be fitted with pressure relief, and necessary valves and piping supports. Relief lines will direct either to the suction side of the pump or drain to the surface of the bund. Where an air diaphragm pump is used, the pipework should be designed to withstand the stall pressure of the pump. In this case, a pressure relief valve may be omitted.

5.4 Storage Area Design

The HFA storage area is shown in Figure 2.

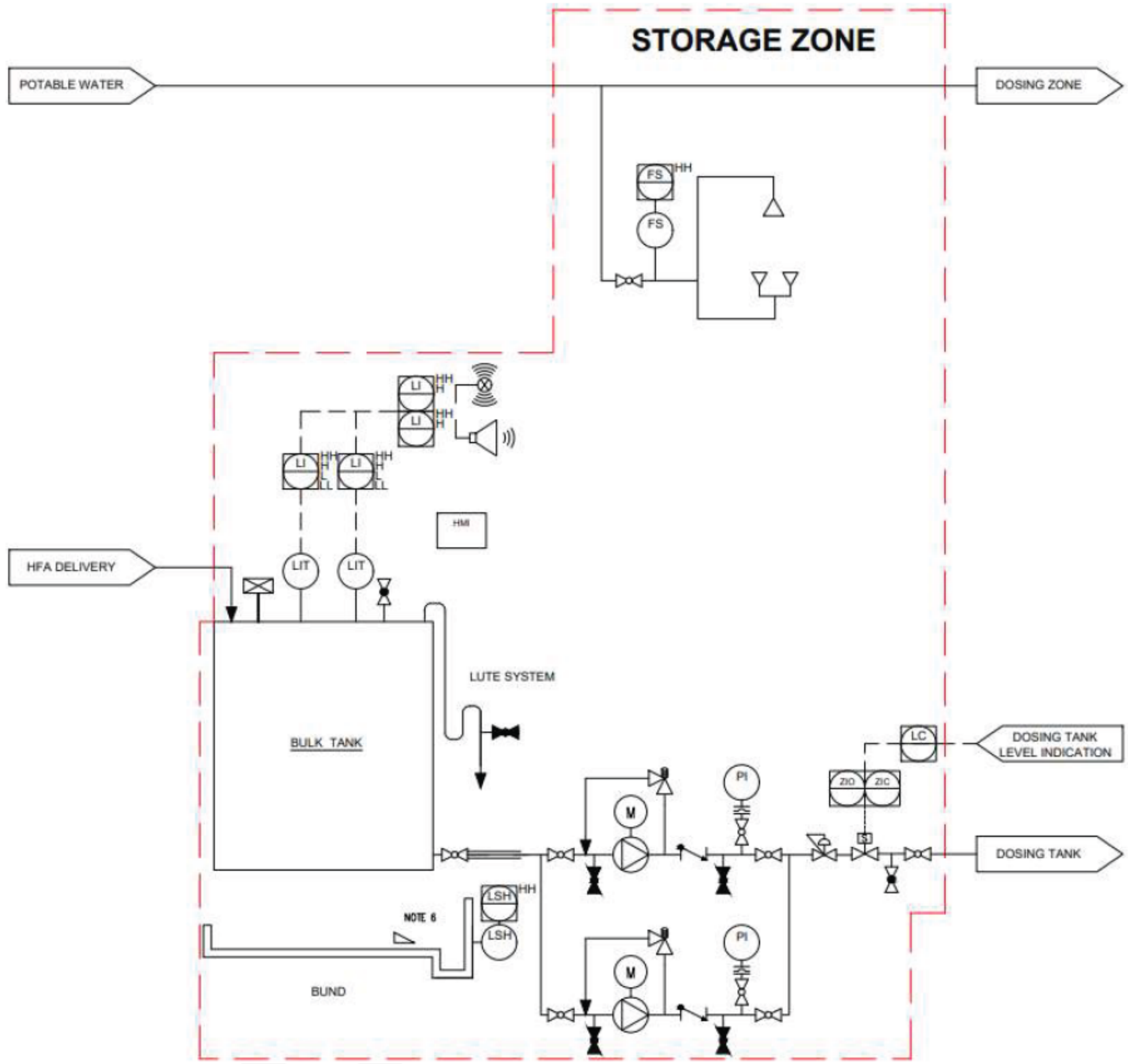


Figure 3: P&ID Section - HFA Bulk Tank Storage Zone.

5.4.1 Equipment

The equipment required for HFA storage is described in the equipment schedule in Table 4.

Table 4 – HFA Storage Equipment Schedule

Item Description	Quantity	Material / Type	Size	Unit
Bulk storage tank[1]	1	HDPE		L
Level transmitter[2]	2	Analogue		
Lute seal	1	HDPE		
Bulk tank drain valve	1	PVC	>38	mm
Storage tank bunk	1	Lined concrete[3]	≥ 110% of bulk tank	L
Bund high-level switch	1	Digital	-	
Motorised transfer pump[4]	2 (duty/standby)	Variable-speed, air or motor driven.	-	
Dosing tank inlet solenoid valve	1	PVC	50	mm
Pressure relief valve	2	(rating dependent on pump and line)		
Pressure sustaining valve	2	PVC	50	mm
Pressure gauge	2	Mechanical		
Safety shower	1	-		

Notes:

(1) Bulk tank sizing detailed in Section 3.4.2.

(2) Two non-contact level transmitters are preferred. This allows for instrument discrepancy to be detected. Local display of tank contents required.

(3) Lining needs to be suitable for HFA.

(4) Pump size depending on pressure requirements and daily capacity specific to each WTP.

5.4.2 Bulk Tank Sizing

The bulk tank should be sized based on the delivery method and the required storage. The minimum required storage should be based on 30 days storage of HFA.

This can be calculated as follows:

Equation 1: HFA Bulk Tank Sizing

$$V = \frac{[Q * D]}{1000} * \frac{1}{[C * \rho]} * \tau$$

Where:

V = required storage volume (litres)

Q = maximum plant flow rate (m^3/day)

D = required dose (g/m^3)

C = % HFA as fluoride (typically 16-18%)

ρ = Specific gravity (typically 1.22)

τ = storage time (days)

Example:

Plant flow (Q) is 8 ML/D = 80,000 m^3/day

Required dose (D) is 0.8 g/m^3

% fluoride (C) is 17% as fluoride

Specific gravity (ρ) is 1.22

Storage time (τ) is 30 days.

$$V = \frac{[80,000 * 0,8]}{1000} * \frac{1}{[0.17 * 1.22]} * 30$$

30 days storage of HFA is 9257 litres.

Therefore select 10,000 litre tank.

HFA has a shelf life of two years and therefore larger volumes can be stored without detriment. If other chemicals are delivered in bulk to site, it is recommended that HFA is also delivered in bulk.

5.4.3 Bulk Tank Selection

There are two primary types of bulk tank: self-bunded or double-skinned tanks, and conventional bunded single-skin storage tanks.

A comparison of single-skinned and self-bunded tanks are outlined in Table 5.

Table 5 – Storage Tank Design Considerations

Category	Self-bunded (double-skinned) storage tanks	Single skinned storage tanks
Draw-off	Requires HFA drawn through the top tank. High self-priming suction head required.	Draw off from the bottom of the tank
Bund construction	Reduces groundworks and construction necessary for a conventional bund. Reduces overall footprint	Requires 110% storage volume in the surrounding bund with necessary drainage.
Overflow	Ability to see a tank overflow is severely restricted	Tank overflow obvious
Venting	Bund and tank vented together and may be easily vented outside	Tank overflow will require a lute seal if installed inside a building to prevent vapour being released within the building.

5.4.4 HFA Storage Description

Bulk storage tanks should be stored outside where possible. The bund of the storage tank is sloped towards a sump for drainage collection. The bund shall be fitted with a high-level switch.

The bulk tank is fitted with two non-contact level transmitters used for monitoring, triggering operator responses and reading validation.

At the top of the bulk tank a single vent line is connected. Where tanks are installed inside, the vent shall discharge to a safe location outside the building.

The overflow shall discharge to the bund. Where an overflow discharges inside a building, it should be filled with lute seal to prevent vapour entering the building. The lute seal shall be a double U bend at the bottom of the overflow. The bottom of the U bed shall be filled with water to prevent vapour escape.

Two transfer pumps (duty/standby) draw from the bulk tank and deliver HFA to the dosing tank. The duty transfer pump will start when the dosing tank low level is triggered and stop when the dosing tank high level is triggered.

Changeover of the pumps will be automated on faults or by operator selection.

The transfer pumps are installed within a bunded area outside of the bulk tank storage bund.

The delivery transfer line will be fitted with pressure relief, non-return, flushing valves and manual pressure gauges as indicated in Figure 3 and Table 2. Relief lines may either direct over-pressured HFA to the storage tank, or the suction side of the transfer pumps.

Relief lines shall be fitted with a portion of clear pipework to allow visual inspection of a relief valve operating.

On a low level in the dosing tank, the solenoid valve opens, and the duty transfer pump starts. On high level in the dosing tank, the duty transfer pump stops, and the solenoid valve closes.

5.5 Dosing Area Design

The HFA dosing area is shown in Figure 4.

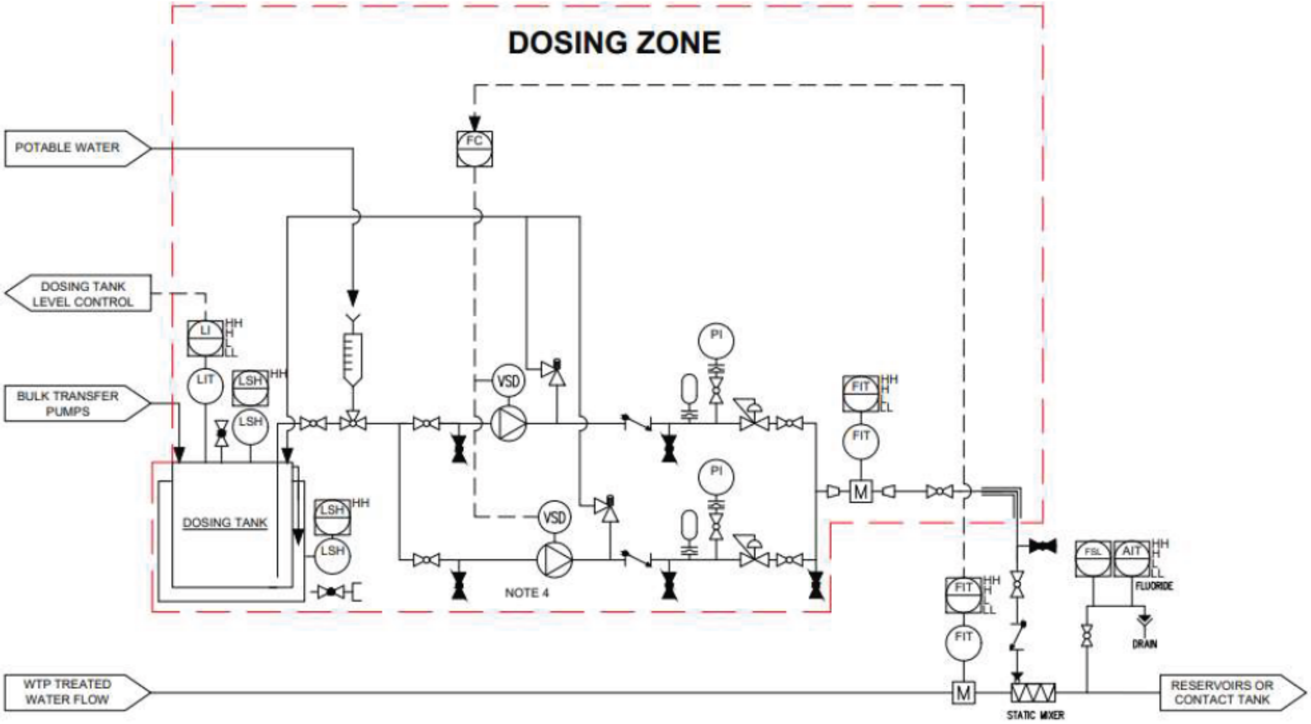


Figure 4: P&ID Section - HFA Dosing Zone.

5.5.1 Equipment

The equipment required for HFA dosing is described in the equipment schedule in Table 6.

Table 6 – Fluoride Dosing Process Design Parameters

Item Description	Quantity	Material / Type	Size	Unit
Dosing tank[1]	1	Double contained HDPE	Note 1	L
Level transmitter	1	Analogue		
High-level switch	2	Digital		
Dosing pumps[2]	2 (duty/standby)	Diaphragm	Note 2	L/h
Calibration tube / dose timer	1	Acrylic plastic or PVC		L
Pulsation dampener[2]	2	PVC or stainless steel		
Non-return valve	1	PVC		mm
Pressure relief valve	2	Rating dependent on pump and line	-	

Item Description	Quantity	Material / Type	Size	Unit
Pressure sustaining valve	2	PVC		
Isolation valves	6			
Fluoride dose flowmeter	1	Analogue		
Plant water flow meter	1	Analogue		
Plant water flow switch	1	Digital		
Fluoride analyser	1	Analogue		
Fluoride analyser flow switch	1	Analogue		
Dosing point	1	Quill/mixer		

Notes:

(1) Dosing tank sizing detailed in Section 3.5.2.

(2) Pump type and size depending on pressure requirements and daily capacity specific to each WTP.

5.5.2 Dosing Tank Sizing

The dosing tank should be sized based on the daily volume of HFA required. The maximum required storage should be based on 24 hours storage of HFA at maximum plant flow and maximum dose. This can be calculated as follows:

Equation 2: Dosing Tank Sizing

$$V = \frac{[Q * D]}{1000} * \frac{1}{[C * \rho]}$$

Where:

V = required storage volume (litres)

Q = maximum plant flow rate (m^3/day)

D = required dose (g/m^3)

C = % HFA as fluoride (typically 16-18%)

ρ = Specific gravity (typically 1.22)

Example:

Plant flow (Q) is 80 ML/D = 80,000 m^3/day

Required dose (D) is 0.8 g/m^3

% fluoride (C) is 17% as fluoride

Specific gravity (ρ) is 1.22

$$V = \frac{[80{,}000 * 0{,}8]}{1000} * \frac{1}{[0.17 * 1.22]}$$

Therefore 1 day storage of HFA is 309 litres.

Tanks of a smaller size are acceptable.

The dosing tank must be bunded, either self-bunded or conventional bund is acceptable.

The dosing tank is fitted with a non-contact level transmitter and high-level switch.

The dosing tank bund shall be fitted with a high-level switch.

5.5.3 HFA Dosing Description

Two fluoride dosing pumps (duty/standby) pump out of the dosing tank and pump to the dose-point. The dose pumps will be bunded separately from the dosing tank.

On the discharge side of the pumps, pulsation dampeners should be fitted to minimise pulsation within pipelines and at the dose point. Note, that modern solenoid dose pumps do not normally require pulsation dampeners, but each installation must undergo an appropriate safety review.

The dose pumps will be limited to 110% of the maximum flow rate required to deliver maximum dose at maximum flow conditions.

At the HFA dose point, a static mixer should be installed to facilitate sufficient mixing of HFA and treated water.

Downstream of the fluoride dose point all treated water needs to flow into a tank or reservoir. On cases of high fluoride, at the tank/reservoir the water supply shall be drained to waste, and the fluoride system stopped.

A fluoride analyser is installed downstream of the dose-point after sufficient mixing but before the tank or reservoir. If a fluoride analyser does not have an in-built flow verification, the fluoride analyser sample lines is equipped with a flow switch. This provides verification of sufficient flow to the analyser.

The fluoride residual set-point is measured by a fluoride analyser.

The fluoride dosing pumps shall be flow paced to the treated water meter in the WTP. The HFA dosing line is equipped with a flow meter which will provide dose verification.

A required dose-rate to achieve a residual in the treated water is determined by the following.

Equation 3: Dosing Pump Sizing

$$Q_f = \frac{[Q * D]}{1000} * \frac{1}{[C * \rho]}$$

Where:

Q_f = Dose pump/s HFA flowrate (L/h)

Q = plant flow rate (m^3/h)

D = required dose (g/m^3)

c = % HFA as fluoride (typically 16-18%)

ρ = Specific gravity (typically 1.22)

Example:

Plant flow (Q) in hours is 80 ML/D = 80,000 m^3/day (24 hours) = 3,333 m^3/hr

Required dose (D) is 0.8 g/m^3

% fluoride (C) is 17% as fluoride

Specific gravity (ρ) is 1.22

$$Q_f = \frac{[3{,}333 * 0.8]}{1000} * \frac{1}{[0.17 * 1.22]}$$

Required HFA dose rate (Q_f) to achieve a residual is 12.9 L/h. This will be verified by the flowmeter.

5.5.4 Fluoride Dose Verification

There are three independent verifications of a fluoride, all of which are displayed continuously.

The applied dose is calculated based on the following:

- Calculated dosing tank level change (delta V)
- Calculated residual from dosing line flowmeter and;
- Residual measured at fluoride analyser.

If any of the above exceed a fluoride concentration of 1.0 mg/L, a high alarm is raised.

If any of the above exceed a fluoride concentration of 1.2 mg/L, a high-high alarm is raised, and the fluoride system is shut down.

The following sections outlines the methods for residual calculations

5.5.4.1 Calculated Change in Dosing Tank Volume

The tank level shall be monitored continuously and used to calculate an expected residual dose. This shall be calculated as follows:

Equation 4: Dose Verification, Dosing Tank Volume Used

$$D = \frac{[\delta V * C * \rho * 1000]}{Q}$$

Where:

D = fluoride dose (g/m^3)

δV = change in volume over the last 60 minutes (litres)

C = % HFA as fluoride (typically 16-18%)

ρ = Specific gravity (typically 1.22)

Q total plant flow volume over the last 60 minutes m^3.

Example:

Assuming a change in volume of 12 litres (δV) in the last 60 minutes

Plant flow (Q) is 3,000 m^3 in the last 60 minutes

%HFA (C) is 17% as fluoride

Specific gravity (ρ) is 1.22

$$D = \frac{12 * 0.17 * 1.22 * 1000}{3{,}000}$$

The dose is therefore 0.83 g/m^3.

Note, during a fluoride transfer, the calculation shall be held for the duration of the transfer and restarted on completion of the transfer based on the new level in the tank.

For the daily dose the flow total and the change in level of the dosing tank during transfer shall be ignored.

A daily average dose shall also be calculated using the flow total for 24 hours and the total volume of fluoride dosed.

5.5.4.2 Calculated Fluoride Dose Residual

The dose rate is monitored at the pumps and confirmed by the fluoride flowmeter. The monitored flow is converted into a dose as follows:

Equation 5: Dose Verification, HFA Dosing Flow

$$D = \frac{[Q_f * C] * 1000 * \rho}{Q}$$

Where:

D = fluoride dose (g/m^3)

Q = plant flow rate (m^3/h)

Q_f = Dose pump/s HFA flowrate (L/h)

C = % HFA as fluoride (typically 16-18%)

ρ = Specific gravity (typically 1.22)

Example:

Plant flow (Q) is 8 ML/D = 80,000 m^3/day = 3,333 m^3/hr

HFA Flow (Q_f) is 12.9 L/h

% fluoride (C) is 17% as fluoride

Specific gravity (ρ) is 1.22

$$D = \frac{[12.9 * 0.17] * 1000 * 1.22}{3333}$$

Calculated dose is 0.8 g/m^3

5.6 Alarm List

A sample alarm list for WTP HFA fluoridation control is presented in Table 7. Critical control points for fluoridation compliance is attached in 0.

Table 7 – Storage Tank Design Considerations

Alarm	Alarm Priority	Value	Delay (s)[1]	Action
High High Fluoride Analyser	Critical	1.3 mg/l	5	Fluoride dosing and WTP plant shut down
High Fluoride Analyser	Warning	1.0 mg/l	300	Warning only
Low Fluoride Analyser	Warning	0.7 mg/l	300	Warning only

Alarm	Alarm Priority	Value	Delay (s)[1]	Action
Fluoride Analyser Fault	Critical		5	Fluoride dosing plant shut down.
Fluoride dosing plant running and no sample flow to fluoride analyser	Critical		5	Fluoride dosing plant shut down.
Calculated Fluoride Dose High (From Dose Tank Volume Used)	Critical	1.3 mg/l	30	Fluoride dosing plant shut down.
Calculated Fluoride Dose Low (From Dose Tank Volume Used)	Warning	0.7 mg/l	300	Warning only
Calculated Fluoride Dose High (From Fluoride Flowmeter)	Critical	1.3 mg/l	30	Fluoride dosing plant shut down.
Calculated Fluoride Dose Low (From Fluoride Flowmeter)	Warning	0.7 mg/l	300	Warning only
Telemetry Failure From Instruments	Critical			Fluoride dosing plant shut down.
Fluoride Bulk Tank Level at Safe Fill Level	Warning	90%	300	Audible and visual alarm at the fill point If IBC or drum filling then shutdown fill pump.
Fluoride Bulk Tank Level Low	Warning	10%	300	Warning only.
Fluoride Bulk Tank Level High High	Critical	95%	30	Audible and visual alarm at the fill point If IBC or drum filling then shutdown fill pump
Fluoride Bulk Tank Bund High Level	Critical			Fluoride dosing plant shut down.
Fluoride Bulk Tank Level Transmitter Fault (x2)	Critical			Fluoride dosing plant shut down.
Duty And Standby Transfer Pump Failure	Critical			Fluoride dosing plant shut down.
Fluoride Dosing Tank Level High	Warning	85%	300	Warning only
Fluoride Dosing Tank Level Low	Critical	10%	30	Fluoride dosing plant shut down.
Fluoride Dosing Tank Level High High	Critical	95%	5	Fluoride dosing plant shut down.
Duty And Standby Dosing Pump Failure	Critical			Fluoride dosing plant shut down.

Alarm	Alarm Priority	Value	Delay (s)[1]	Action
Fluoride Dosing Tank Internal Bund High Level	Critical			Fluoride dosing plant shut down.
Fluoride Dosing Tank Level Transmitter Fault	Critical			Fluoride dosing plant shut down.

Notes:

(1) Delay values are indicative only. Delay values should be set after a risk assessment.

6 Sodium Silicofluoride ($Na_2[SiF_6]$) Design

6.1 Piping and Instrumentation Diagram

A piping and instrumentation diagram (P&ID) of the sodium silicofluoride dosing system is attached in Appendix C.

6.2 Sodium Silicofluoride Loading

This sodium silicofluoride delivery and loading area is shown in Figure 5 below.

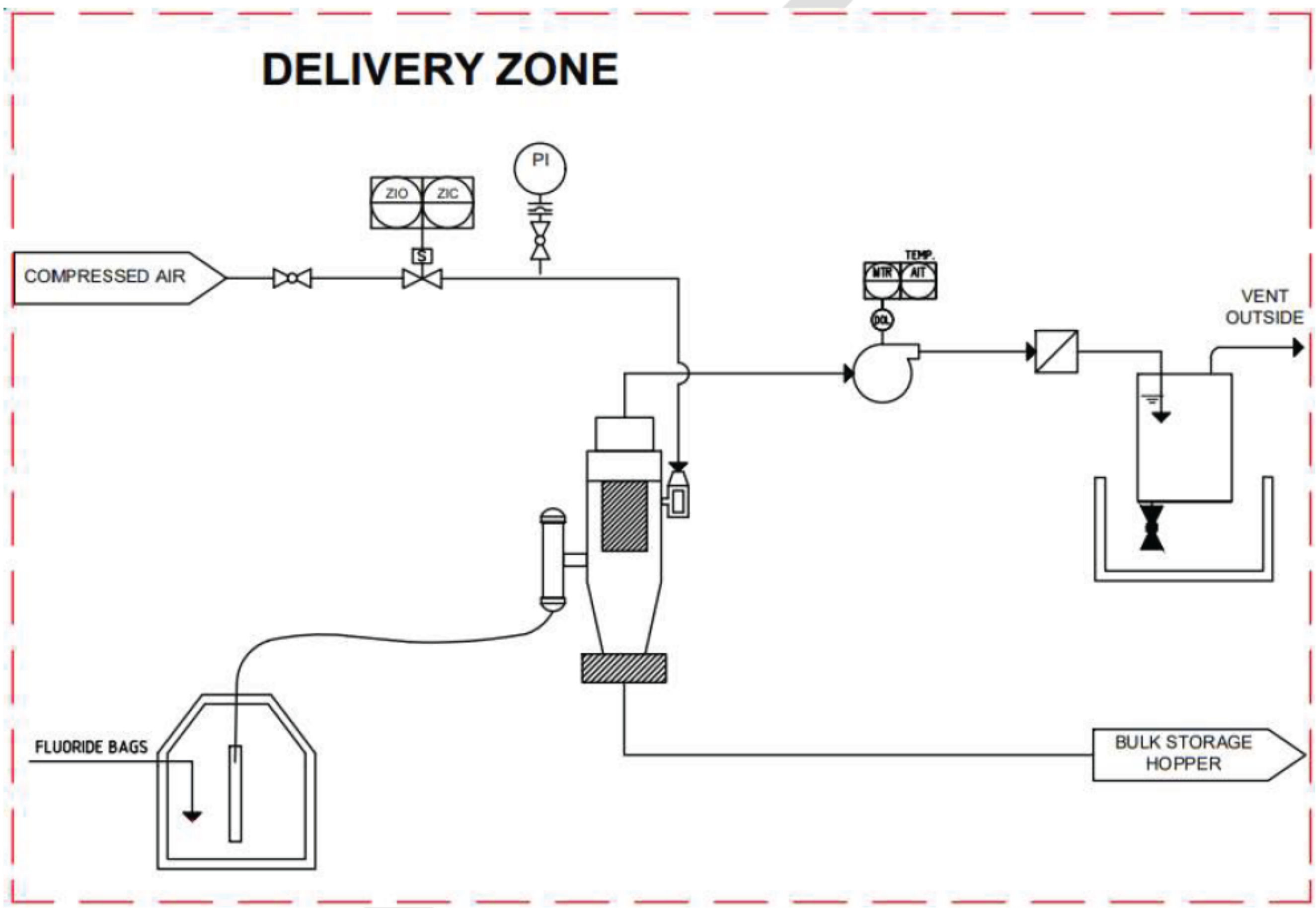


Figure 5: P&ID Section - $Na_2[SiF_6]$ Delivery and Loading Zone.

6.2.1 Equipment

The equipment required for $Na_2[SiF_6]$ delivery and loading described in the equipment schedule in Table 8.

Table 8 – $Na_2[SiF_6]$ Delivery and Loading Equipment Schedule

Item Description	Quantity	Material / Type	Size	Unit
Vacuum Loader System[1] A loader system will incorporating the following equipment, sizes and materials are designed to appropriately from dosing requirements.				
Vacuum pump	1			
SSF filters	1			
Cleaning mechanism/s				
Vent trap tank	1			
Vacuum hose	1			

Notes:

(1) This is normally a proprietary item.

6.2.2 Delivery Description

All appropriate PPE is used in the entirety of the delivery procedure. PPE is listed in the chemical safety data sheet and within the relevant regulations and standards.

Sodium silicofluoride will be delivered to site in 25kg bags. Up to 500 kgs of dry sodium silicofluoride may be delivered on a single pallet delivery (20 bags) (TBC by supplier). The supplier delivery is normally by Hiab or tail lift truck.

25 kg sodium silicofluoride bags are retained on the delivery pallet in a designated storage room. The storage room is separate to the fluoride dosing room.

To minimise chemical degradation, the storage room is temperature-controlled (nominally 20 °C) with minimisation of humidity within the storage room. Within the storage room a delivery log, denoting logged delivery history, is made clearly visible to operators. The log may be online and trigger chemical re-supply.

The transfer of 25kg bag/s around site and to the fluoride dosing room should minimise manual handling. A pallet jack or forklift should be used to move multiple bags where possible.

Sodium silicofluoride bags, still sealed, are lifted into the fluoride loading system within the make-up room.

Prior to opening the bag, the vacuum line and pump must be switched-on. All silicofluoride is sucked through the vacuum line and directed to the loader.

All discharge from the vacuum loader system is directed through a bag filter and separate steel mesh filter towards the vent trap. The vent trap is filled to a static water level where the exhaust outlet nozzle diffuses through the water. The trap's outlet vent is directed outside.

When bags are loaded, the operator will be required to follow the standard operating procedure (SOP). The procedures for this include but is not limited to the following:

- Personal Protective Equipment (PPE)
- Spill/leakage response
- Manual Lifting
- Dust control
- Housekeeping
- Pallet moving
- Chemical transfer including stop levels at safe fill volume and maximum fill volume.
- Delivery flushing and disconnection
- Other safety information
- Communications between delivery and site staff

6.3 Sodium Silicofluoride Storage

The $Na_2[SiF_6]$ storage area is shown in Figure 6.

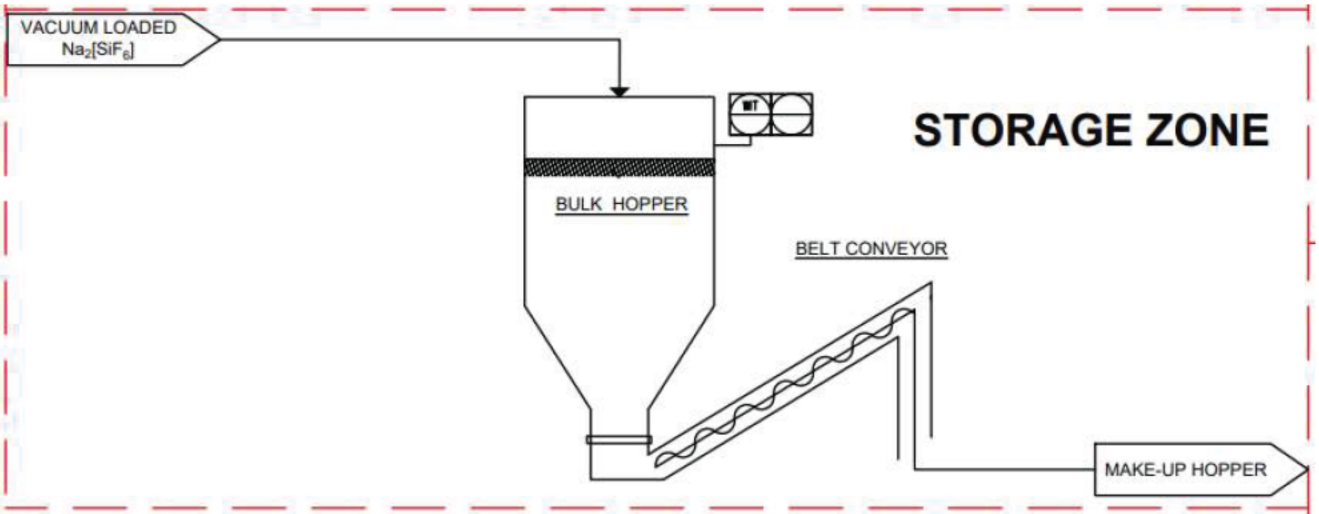


Figure 6: P&ID Section - $Na_2[SiF_6]$ Storage.

6.3.1 Equipment

The equipment required for $Na_2[SiF_6]$ delivery and loading described in the equipment schedule in Table 9.

Table 9 – $Na_2[SiF_6]$ Storage Equipment Schedule

Item Description	Quantity	Material / Type	Size	Unit
Bulk Hopper	1	Stainless or Painted steel	See Section 6.3.2	L
Screw Conveyor	1	Mechanical		
Load Cells	2	Analogue		

6.3.2 Bulk Hopper Sizing

Sizing of the bulk tank should account for delivery frequency, operator hands-on time and the required dose rate.

To minimise loading requirements a minimum of a week's storage is advised.

The determination of the bulk hopper size required is calculated as follows:

Equation 6: Sodium Silicofluoride Bulk Hopper Sizing (kgs)

$$m_p = \frac{[Q * D]}{1000} * \frac{1}{[s * C_{AF}]} * \tau$$

Where:

m_p = required sodium silicofluoride powder (kg)

Q = maximum plant flow rate (m^3/day)

D = required dose (g/m^3)

s = purity of fluoride powder in solution (Refer to quarterly chemical supplier reports)

C_{AF} = % active fluoride in powder

τ = storage time (days)

Example:

Plant flow (Q) is 80 ML/D = 80,000 m^3/day

Required dose (D) is 0.8 g/m^3

% Active strength (C_{AF}) is 59.4%

Purity of $Na_2[SiF_6]$ (s) powder delivered is 98%

Frequency of loading between batches (τ) is 7 days

$$m_p = \frac{80{,}000 * 0.8}{1000} * \frac{1}{[0.594 * 0.98]} * 7$$

Bulk hopper will be required to store 746 kg (~30 bags) of $Na_2[SiF_6]$.

Equation 7: Sodium Silicofluoride Bulk Hopper Sizing (litres)

$$V = \frac{m}{\rho_p}$$

Where:

V = required storage volume (litres)

ρ_p = Bulk density of dry sodium silicofluoride powder (kg/L)

m = required storage weight (kgs)

Example:

Bulk hopper (m) weekly requirement is 746 kgs

Bulk density is ~1.4 kg/L

$$V = \frac{746}{1.4}$$

A bulk tank volume of 533 L is required.

A bulk hopper sized to 600 L with a minimum rating of 800 kg is appropriate for this system.

6.3.3 Sodium Silicofluoride Storage Description

Vacuum loaded $Na_2[SiF_6]$ is transferred into the bulk hopper.

The bulk hopper is fitted with two contact load cells used for monitoring, triggering refill responses, and reading validation.

A fixed-speed mechanical screw conveyor facilitates powder transfer from the base of the bulk hopper to the make-up hopper. The screw conveyor is triggered off/on through load cell readings in the make-up hopper.

6.4 Sodium Silicofluoride Solution Make-up

The $Na_2[SiF_6]$ batch make-up zone is shown in Figure 7 below.

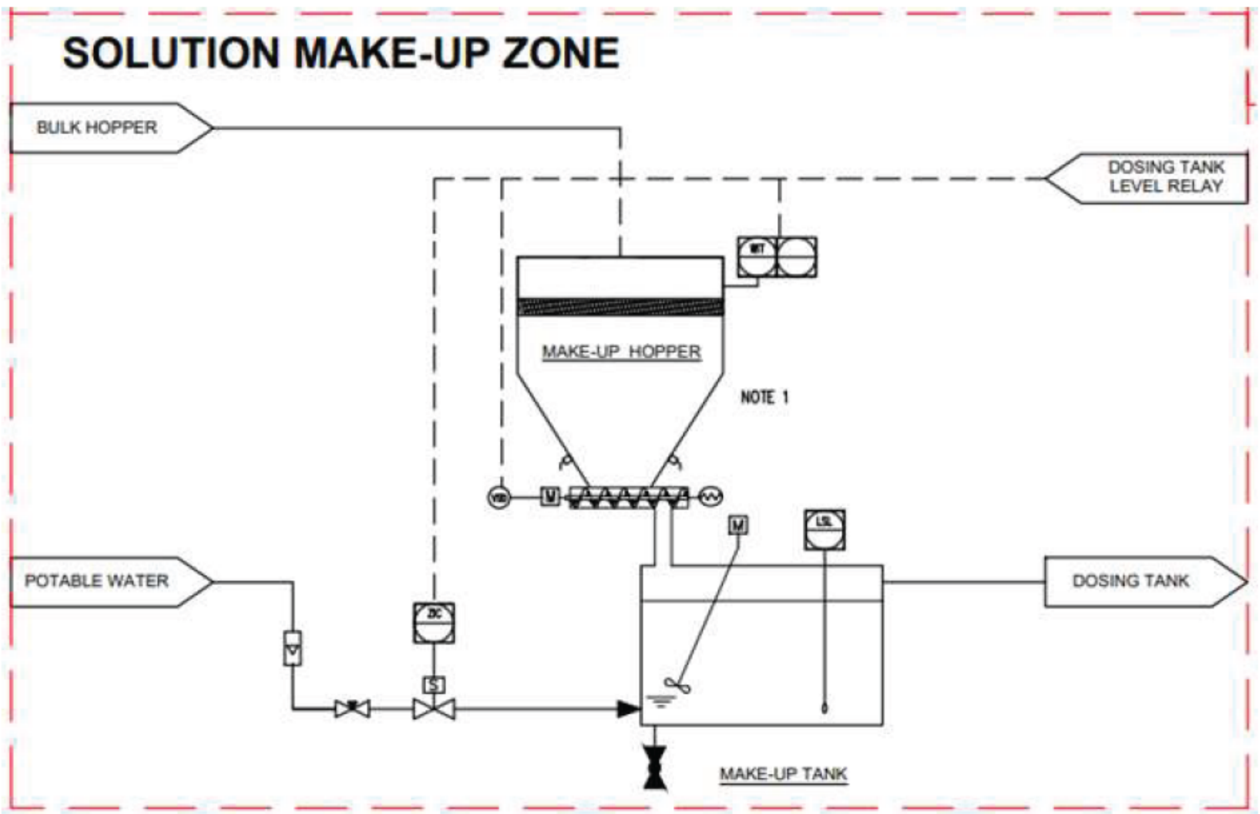


Figure 7: P&ID Section – Sodium Silicofluoride Make-up.

6.4.1 Equipment

The equipment required for $Na_2[SiF_6]$ batch make-up is described in the equipment schedule in Table 10.

Table 10 – Sodium Silicofluoride Make-up Equipment Schedule

Item Description	Quantity	Material / Type	Size	Unit
Make-up Hopper	1	Painted Steel	Dependant on dosing requirements	
Batch tank	1	HDPE and PE		

Item Description	Quantity	Material / Type	Size	Unit
Service water connection line	1			
Rotameter	1	Analogue		
Manual flow setting valve	1			
Solenoid isolation valve	1			
Level switch	2	Digital		
Load cells	2	Analogue		
Mixer/stirrer	1	Electric		
Screw feeder	1	Mechanical		

6.4.2 Make-up Hopper Dosing Tank Sizing

For make-up hopper sizing refer to Section 6.3.2, Equation 6 and Equation 7. A recommended residence time (τ) is 1 day.

6.4.3 Sodium Silicofluoride Solution Make-up Description

The $Na_2[SiF_6]$ solution batching will be controlled by the automated plant control system/s.

The make-up hopper is fitted with two load cells used for fluoride compliance monitoring, triggering operator responses, and reading validation.

On low weight, a signal will be relayed to the loading screw conveyor to load make-up hopper. On high weight reading conveyor is switched-off.

The recorded make-up hopper weight change via the load cells will be used for fluoride dose verification, Section 6.5.3.

The outlet of the make-up hopper connects to a screw feeder, The feeder transfers fluoride from the make-up hopper to the make-up tank. Feeder control is linked to dosing tank level triggers.

A mixer runs continuously in the make-up tank.

The make-up tank overflows to the dosing tank. The make-up tank control is triggered from high and low levels in the dosing tank (see Section 6.5). On a low level in the mixing tank, the water solenoid valve opens, and the metering screw starts at a fixed speed. Water flows into the make-up tank and is mixed with the fluoride from the metering screw. The make-up tank overflows to the dosing tank. When the dosing tank gets to high level the screw feeder stops and the water solenoid valve closes.

6.4.4 Solution Make-up Control

The addition of water and powder is outlined in the following equation:

Equation 8: Sodium Silicofluoride Powder Batching

$$m_f = \frac{C_s \cdot Vf}{s * C_{AF}}$$

Where:

V_f = Batch Volume (L) as service water added

C_s = Desired solution fluoride strength (%)

s = purity of $Na_2[SiF_6]$ (Refer to quarterly chemical supplier reports)

C_{AF}= % active fluoride in $Na_2[SiF_6]$ powder (59.4 %)

m_f = mass of powder required (kg)

Example:

Batch Volume (V_f) is 1 m^3= 1000 Litres

Desired solution strength (C_s) is 0.2% $Na_2[SiF_6]$

Purity of $Na_2[SiF_6]$ (s) powder delivered is 98%

Active fluoride (C_{AF}) in $Na_2[SiF_6]$ 59.4%

$$m_f = \frac{[0.002 * 1000]}{[0.594 * 0.98]}$$

Required powder mass (m_f) to make a desired batch strength is 3.3 kg.

The rate of fluoride addition should be approximately proportional to the water flow rate based on the following calculation:

Equation 9: Screw Feeder Rate

$$\dot{m}_f = C_s * Q_w$$

Where:

$\dot{m}_f$ = Powder flow rate (kg/hr)

Q_W = Service water flow rate (L/hr)

C_s = Desired solution fluoride strength (%)

Example:

Service water flow rate (Q_W) is 3000 L/hr

Desired solution strength (C_s) is 0.2% Na2[SiF6]

$$\dot{m}_f = 0.002 * 3000$$

Rate of powder mass ($\dot{m}_f$) addition to make a desired batch strength is 6 kg/hr. However, as long as the correct mass of SSF is added to the correct volume of water, the actual rates of addition are not critical.

6.4.5 Make-up Tank Sizing

As a guide the make-up tank volume should be at least twice the dosing tank volume. Key control in this system is the draw off from the dosing tank. The dose tank sizing for an appropriate system is outlined in Section 6.5.2.

6.5 Sodium Silicofluoride Dosing Area Design

The sodium silicofluoride dosing area is shown in Figure 8 below.

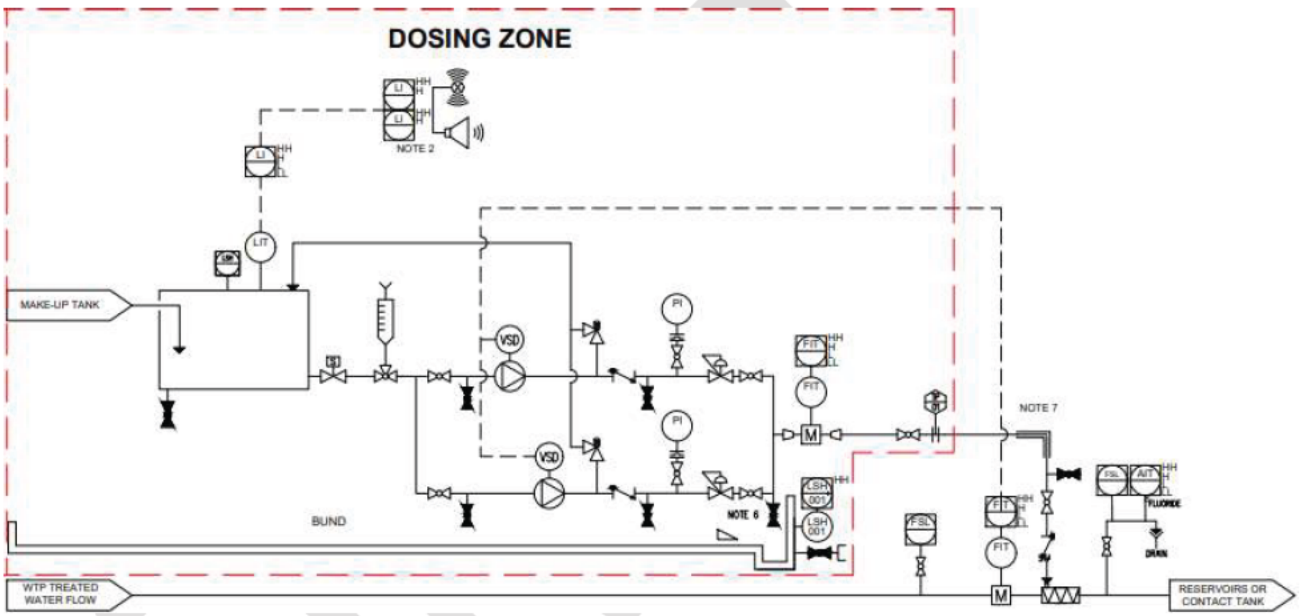


Figure 8: P&ID Section - $Na_2[SiF_6]$ Dosing Zone.

6.5.1 Equipment

The equipment required for HFA dosing is described in the equipment schedule in Table 11Table 6.

Table 11 – Sodium Silicofluoride Dosing Process Design Parameters

Item Description	Quantity	Material / Type	Size	Unit
Dosing tank[1]	1	HDPE	Note 2	L
Level transmitter	1	Analogue		
High-level switch	2	Digital		
Dosing tank bunk[1]	1	Lined concrete	≥ 110% of bulk tank	L
Bund high-level switch	1	Digital	-	

Item Description	Quantity	Material / Type	Size	Unit
Dosing pumps[3]	2 (duty/standby)	Diaphragm	Note 1	L/h
Calibration tube / dose timer	1	Acrylic plastic or PVC		L
Pulsation dampener[2]	2	PVC or stainless steel		
Non-return valve	1	PVC		mm
Pressure relief valve	2	Rating dependent on pump and line	-	
Pressure sustaining valve	2	PVC		
Fluoride dose flowmeter	1	Analogue		
Isolation valves	6			
Plant water flow meter	1	Analogue		
Plant water flow switch	1	Digital		
Fluoride analyser	1	Analogue		
Fluoride analyser flow switch	1	Analogue		
Dosing point	1	Quill/mixer		

(1) If using a double skinned dosing tank a separate bund is not required.

(2) Dosing tank sizing is detailed in Section 6.5.2.

(3) Pump type and size depending on pressure requirements and daily capacity specific to each WTP.

6.5.2 Dosing Tank Sizing

The dosing tank should be sized based on the daily volume of $Na_2[SiF_6]$ solution required. The maximum required storage should be on 24 hours storage of $Na_2[SiF_6]$ solution at maximum plant flow and maximum dose. This can be calculated as follows:

Equation 10: Sodium Silicofluoride Dosing Tank Sizing

$$V = \frac{[Q * D]}{1000} * \frac{1}{[C_p * s * C_{AF} * \rho]} * \tau$$

Where:

V = required storage volume (litres)

D = fluoride dose (g/m^3)

Q = plant flow rate (m^3/h)

C_p = % $Na_2[SiF_6]$ powder in solution

s = purity of $Na_2[SiF_6]$ (Refer to quarterly chemical supplier reports)

C_{AF}= % active fluoride in $Na_2[SiF_6]$ powder (59.4 %)

ρ = Specific gravity

τ = storage time (days)

Example:

Required dose (D) is 0.8 g/m^3

Plant flow (Q) is 8 ML/D = 8,000 m^3/day

$Na_2[SiF_6]$ powder (C_p) in solution is 0.2% w/v

Purity of $Na_2[SiF_6]$ (s) powder delivered is 98%

Active fluoride (C_{AF}) in $Na_2[SiF_6]$ 59.4%

Specific gravity of solution (ρ) is 1

Storage time (τ) is 1 day.

$$V = \frac{[8{,}000 * 0.8]}{1000} * \frac{1}{[0.002 * 0.98 * 0.594 * 1]} * 1$$

Therefore 1-day of storage of $Na_2[SiF_6]$ solution is 5,496 litres. This is the maximum size of the dosing tank. Tanks of a smaller size are acceptable.

The dosing tank must be bunded. Either a self-bunded tank or conventional tank and bund is acceptable.

The dosing tank is fitted with a non-contact level transmitter.

The dosing tank bund shall be fitted with a high-level switch.

6.5.3 $Na_2[SiF_6]$ Dosing Description

Two fluoride dosing pumps (duty/standby) pump out of the dosing tank and pump to the dose-point. The dose pumps will be bunded and may be bunded separately from the dosing tank.

On the discharge side of the pumps, pulsation dampeners should be fitted to minimise pulsation within pipelines and at the dose point. Note, that modern solenoid dose pumps do not normally require pulsation dampeners, but each installation must undergo an appropriate safety review.

The dose pumps will be limited to 110% of the maximum flow rate required to deliver maximum dose at maximum flow conditions.

A calibration cylinder is provided to accurately calibrate the metering pump against the dosing conditions.

At the $Na_2[SiF_6]$ solution dose point, a static mixer should be installed to facilitate sufficient mixing of $Na_2[SiF_6]$ solution and treated water.

Downstream of the fluoride dose point all treated water needs to flow into a tank or reservoir. In cases of high fluoride, at the tank/reservoir the water supply shall be drained to waste, and the fluoride system stopped.

A fluoride analyser is installed downstream of the dose-point after sufficient mixing but before the tank or reservoir. If a fluoride analyser does not have an in-built flow verification, the fluoride analyser sample lines is equipped with a flow switch. This provides verification of sufficient flow to the analyser.

The fluoride residual set-point is measured by a fluoride analyser.

The fluoride dosing pumps shall be flow paced to the treated water meter in the WTP. The $Na_2[SiF_6]$ dosing line is equipped with a flow meter which will provide dose verification.

A required dose-rate to achieve a residual in the treated water is determined by the following:

Equation 11: Sodium Silicofluoride Dosing Pump Flow Rate

$$Q_f = \frac{[Q * D]}{1000} * \frac{1}{[C_p * C_s * s * \rho]}$$

Where:

Q_f = Dose pump/s fluoride flowrate (L/h)

Q = plant flow rate (m^3/h)

D = fluoride dose (g/m^3)

Q = plant flow rate (m^3/h)

C_p = % fluoride powder in solution

s = purity of fluoride powder in solution (Refer to quarterly chemical supplier reports)

C_{AF}= % active fluoride in powder

ρ = Specific gravity

Example:

Plant flow (Q) is 8 ML/D = 8,000 m^3/day = 333 m^3/hr

Required dose (D) is 0.8 g/m^3

$Na_2[SiF_6]$ powder (C_p) in solution is 0.2% w/v

Purity of $Na_2[SiF_6]$ (s) powder delivered is 98%

Active fluoride (C_{AF}) in $Na_2[SiF_6]$ 59.4%

Specific gravity of solution (ρ) is 1

$$Q_f = \frac{[333 * 0.8]}{1000} * \frac{1}{[0.002 * 0.98 * 0.594 * 1]}$$

Required $Na_2[SiF_6]$ dose rate (Q_f) to achieve a residual is 228 L/h. This will be verified by the flowmeter.

6.5.4 Fluoride Dose Verification

There are three independent verifications of a fluoride, all of which are displayed continuously.

The applied dose is calculated based on the following:

- Make up hopper weight change (delta W)
- Calculated residual from dosing line flowmeter and;
- Residual measured at fluoride analyser.

If any of the above exceed a fluoride concentration of 1.0 mg/L, a high alarm is raised.

If any of the above exceed a fluoride concentration of 1.3 mg/L, a high-high alarm is raised, and the fluoride system is shut down.

The following sections outlines the methods for residual calculations

6.5.4.1 Calculated Change in Make-up Hopper Weight

The make-up hopper weight shall be monitored continuously and used to calculate an expected residual dose. This shall be calculated as follows:

Equation 12: Dose Calculation based on Make-up Hopper Weight Loss

$$D = \frac{[\delta W * C_p * s * C_{AF}]}{Q}$$

Where:

D = fluoride dose (g/m^3)
δW = change in weight over the last 60 minutes (g)
Q = total plant flow volume (m^3) in last 60 minutes
C_p = % fluoride powder in solution
s = purity of fluoride powder in solution (refer to quarterly chemical supplier reports)
C_{AF}= % active fluoride in powder

NaF Example:

Assuming a change in weight of 1.38 kgs (1380 g) (δW) in the last 60 minutes
Plant flow (Q) in last 60 minutes 1,000 m^3
Purity of $Na_2[SiF_6]$ (s) powder delivered is 98%
Active fluoride (C_{AF}) in $Na_2[SiF_6]$ 59.4%
Storage time (τ) is 1 day.

$$D = \frac{1380 * 0.98 * 0.594}{1000}$$

Calculated dose is 0.8 g/m^3

Note, during a bulk hopper powder transfer, the calculation shall be held for the duration of the transfer and restarted on completion of the transfer.

For the daily dose, the flow total, and the change in the weight of the dosing tank during transfer shall be ignored.

A daily average dose shall also be calculated using the flow total for 24 hours and the total volume of fluoride dosed.

6.5.4.2 Calculated Fluoride Dose Residual

The dose rate is monitored at the pumps and confirmed by the fluoride flowmeter. The monitored flow is converted into a dose as follows:

Equation 13: Dose Calculation based on Dosing Flow

$$D = \frac{[Q_f * C_p * s * C_{AF}] * 1000 * \rho}{Q}$$

Where:

Q_f = Dose pump/s fluoride flowrate (L/h)

Q = plant flow rate (m^3/h)

D = fluoride dose (g/m^3)

Q = plant flow rate (m^3/h)

C_p = % fluoride powder in solution

s = purity of fluoride powder in solution (refer to quarterly chemical supplier reports)

C_{AF}= % active fluoride in powder

ρ = Specific gravity

Example:

Dose pump flow rate (Q_f) = 200 L/hr

Plant flow (Q) is 8 ML/D = 8,000 m^3/day = 333 m^3/hr

$Na_2[SiF_6]$ powder (C_p) in solution is 0.2% w/v

Purity of $Na_2[SiF_6]$ (s) powder delivered is 98%

Active fluoride (C_{AF}) in $Na_2[SiF_6]$ 59.4%

Specific gravity of solution (ρ) is 1

Storage time (τ) is 1 day.

$$D = \frac{[200 * 0.002 * 0.98 * 0.594] * 1000 * 1}{333}$$

Calculated dose is 0.70 g/m^3

6.6 Alarm List

A sample alarm list for WTP $Na_2[SiF_6]$ fluoridation control is presented in Table 12 Critical control points for fluoridation compliance is attached in 0.

Table 12 – Sodium Silicofluoride Alarm List

Alarm	Alarm Priority	Value	Delay (s)[1]	Action
High High Fluoride Analyser	Critical	1.3 mg/l	5	Fluoride dosing and WTP plant shut down
High Fluoride Analyser	Warning	1.0 mg/l	300	Warning only
Low Fluoride Analyser	Warning	0.7 mg/l	300	Warning only
Fluoride Analyser Fault	Critical		5	Fluoride dosing plant shut down.
Fluoride dosing plant running and no sample flow to fluoride analyser	Critical		5	Fluoride dosing plant shut down.
Recorded Weight Change High (From Make-up Hopper Load Cell)	Critical	1.3 mg/l	30	Fluoride dosing plant shut down.
Recorded Weight Change Low (From Make-up Hopper Load Cell)	Warning	0.7 mg/l	300	Warning only
Calculated Fluoride Dose High (From Fluoride Flowmeter)	Critical	1.3 mg/l	30	Fluoride dosing plant shut down.
Calculated Fluoride Dose Low (From Fluoride Flowmeter)	Warning	0.7 mg/l	300	Warning only
Telemetry Failure From Instruments	Critical			Fluoride dosing plant shut down.
Fluoride Make-up Hopper Level at Safe Fill Weight	Critical			Stop conveyor belt
Fluoride Make-up Tank Level at Safe Fill Level				
Fluoride Make-up Tank Level at Safe Fill Level	Warning	90%	300	Audible and visual alarm at the fill point .
Fluoride Make-up Tank Level Low	Warning	10%	300	Warning only.
Fluoride Make-up Tank Level High High	Critical	95%	30	Audible and visual alarm at the fill point

Alarm	Alarm Priority	Value	Delay (s)[1]	Action
Fluoride Bulk Tank Bund High Level	Critical			Fluoride dosing plant shut down.
Fluoride Make-up Tank Level Transmitter Fault (x2)	Critical			Fluoride dosing plant shut down.
Belt Conveyor Failure	Critical			Fluoride dosing plant shut down.
Screw Feeder Failure	Critical			Fluoride dosing plant shut down.
Fluoride Dosing Tank Level High	Warning	85%	300	Warning only
Fluoride Dosing Tank Level Low	Critical	10%	30	Fluoride dosing plant shut down.
Fluoride Dosing Tank Level High High	Critical	95%	5	Fluoride dosing plant shut down.
Duty And Standby Dosing Pump Failure	Critical			Fluoride dosing plant shut down.
Fluoride Dosing Tank Internal Bund High Level	Critical			Fluoride dosing plant shut down.
Fluoride Dosing Tank Level Transmitter Fault	Critical			Fluoride dosing plant shut down.

Notes:

(1) Delay values are indicative only. Delay values should be set after a risk assessment.

7 Sodium Fluoride Saturator Systems Design

7.1 Sodium Fluoride Delivery

5 kg sodium fluoride bottles are delivered to site by chemical supplier. Multiple bottles will usually be delivered to site on pallets. Delivery is normally by Hiab or tail lift truck. Bottles are connected directly into the sealed loader in the make-up tank. Operators should have no direct contact with the sodium fluoride.

Storage of 5 kg bottles should be monitored for temperature, checked for abrasions to bottle exterior and stored in a temperature-controlled dry room.

Emptied bottles will be labelled and moved to a separate disposal area. Disposal of bottles should be coordinated through the chemical supplier.

It is noted that sodium fluoride is not currently used in NZ in deliveries above the 5kg bottles. However, should sodium fluoride be delivered in 25 kg bags a vacuum system may be used to load the saturator. This is the same arrangement as the vacuum system inSection 6.2. Noting here, the vacuum loader will feed directly into the saturator rather than a bulk storage hopper.

7.2 Make-up zone

The saturated solution make-up area is shown in Figure 9 below.

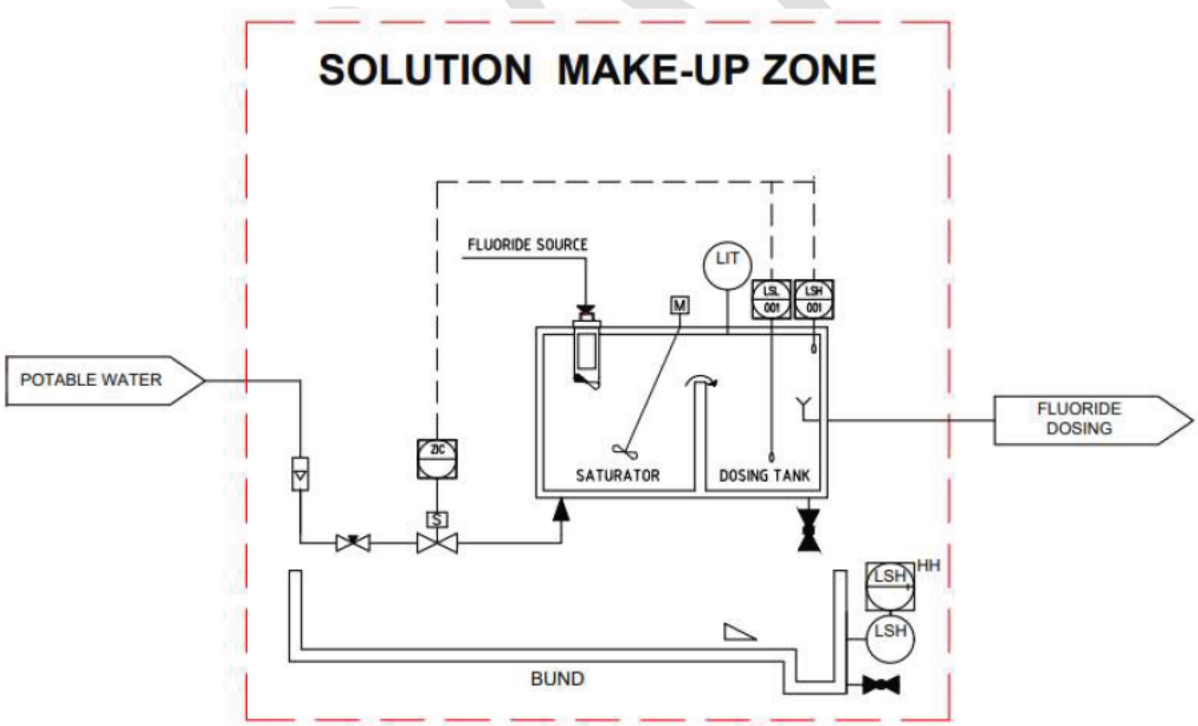


Figure 9: P&ID Section – Saturated Solution Make-up.

7.2.1 Equipment

The equipment required for saturated solution make-up is described in the equipment schedule in Table 13.

Table 13 – Saturated Solution Make-up Equipment Schedule

Item Description	Quantity	Material / Type	Size	Unit
Saturator	1			L
Internal baffle overflow	1			mm
Level transmitter	1	Analogue		
Saturators drain valve	1			mm
Dosing tank high level switch	1	Digital		
Dosing tank low level switch	1	Digital		
Bund high-level switch	1	Digital	-	
Saturator water solenoid valve	1			mm
Variable area flow meter and rate setting valve	1	Mechanical		
Safety shower	1	-		

A single tank may be used for both saturation and dosing if adequately separated by a baffle or split into multi-tank compartments. A designated saturator and separate dosing tank is also acceptable.

The tank is fitted with a single level transmitter over the dosing tank side of the baffle and is used for monitoring, triggering automated plant responses and reading validation.

A saturated solution of sodium fluoride is to be maintained at 4.0 % NaF in water.

As temperature decreases the solubility concentration decreases. Note site specific operational conditions during design. If the service water temperature is significantly below 10 °C temperature range requirements an increased dose rate is required meet residual requirements.

Excess fluoride chemical is loaded into the saturator and slowly dissolves into the water in the saturator creating a saturated solution. An excess of fluoride chemical must be maintained at all times to ensure a saturated solution.

Over time, insoluble material in the saturator will need to be removed. Following equipment vendor recommendations on fluoride bed turnover in the saturator and dosing tank component cleaning will minimise the risk of variations in solution strength. Cleaning on all auxiliary equipment must be outlined in site specific standard operating procedures (SOP).

The saturator water control is triggered from high- and low-level switches in the dosing tank. On a low level in the dosing tank, the water solenoid valve into the saturator opens. Water flows into the bottom of the saturator and pushes the saturated solution into the dosing tank. The water introduced then saturates with fluoride prior to the next transfer.

To turn over the fluoride bed on the bottom of the tank a stirrer either manually (with the tank still sealed) or an electric stirrer is provided on the saturator tank. The manufacturers recommendations on the frequency of this fluoride bed turnover should be followed. Typically, once a week is recommended to ensure full saturation is maintained.

7.2.2 Service Water

The hardness of the service water should be less than 60mg/L as $CaCO_3$. If the hardness is greater than this, a water softener will be required to prevent scaling of the saturator.

7.2.3 Dosing Tank Sizing

The dosing tank should be sized calculated as follows:

Equation 14: Dosing Tank Sizing

$$V = \frac{[Q * D]}{1000} * \frac{1}{[C_p * s * C_{AF} * \rho]} * \tau$$

Where:

V = required storage volume (litres)
D = fluoride dose (g/m^3)
Q = plant flow rate (m^3/h)
C_p = % fluoride powder in solution
s = purity of fluoride powder in solution (refer to quarterly chemical supplier reports)
C_{AF}= % active fluoride in powder
ρ = Specific gravity

NaF Example:

Required dose (D) is 0.8 g/m^3
Plant flow (Q) is 4.8 ML/D = 200 m^3/hour
Saturated NaF (C_p) in solution is 4.0% w/v
Purity of NaF (s) powder delivered is 98%
Active fluoride (C_{AF}) in NaF 43.9%
Specific gravity of solution (ρ) is 1
Storage time (τ) is 1 day.

$$V = \frac{[200 * 0.8]}{1000} * \frac{1}{[0.04 * 0.98 * 0.439 * 1]} * 1$$

9.3 L of 4% will be required for a continual daily dose of NaF to achieve residual requirements.

A maximum dosing tank size of 10L would be required for this system.

7.2.4 Saturator Sizing

As a general convention the saturator should be at least twice the size of the dosing tank.

7.3 Dosing Zone

The saturated solution dosing area is shown in Figure 10 below.

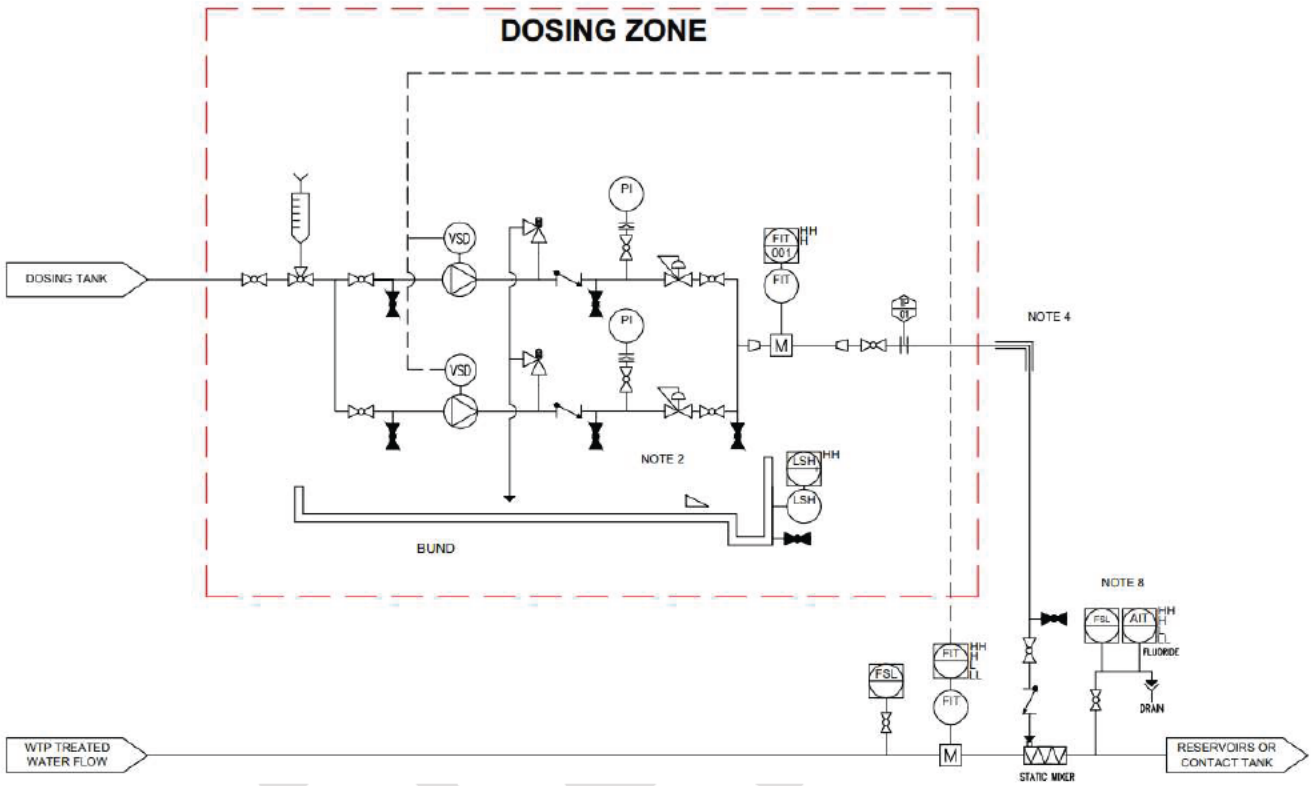


Figure 10: P&ID Section – Saturated Solution Dosing.

7.3.1 Equipment

The equipment required for saturated system dosing is described in the equipment schedule in Table 14

Table 14 – Saturated Solution Dosing Equipment Schedule

Item Description	Quantity	Material / Type	Size	Unit
Bund	1	Concrete	Note 1	L
High-level switch	2	Digital		
Dosing pumps[1]	2 (duty/standby)	Diaphragm	Note 2	L/h
Calibration tube / dose timer	1	Acrylic plastic or PVC		L
Pulsation dampener[2]	2	PVC or stainless steel		
Non-return valve	1	PVC		mm

Item Description	Quantity	Material / Type	Size	Unit
Pressure relief valve	2	Rating dependent on pump and line	-	
Pressure sustaining valve	2	PVC		
Isolation valves[4]	6			
Fluoride dose flowmeter	1	Analogue		
Plant water flow meter	1	Analogue		
Plant water flow switch	1	Digital		
Fluoride analyser	1	Analogue		
Fluoride analyser flow switch	1	Analogue		
Dosing point	1	Quill/mixer		

Notes:

(1) Bund may be shared with the dosing tank

(2) Pump type and size depending on pressure requirements and daily capacity specific to each WTP.

(3) Pulsation dampers may not be required depending on the installation and pump type.

(4) Isolation valves as required

7.3.2 Dosing Description

A calibration cylinder is provided to accurately calibrate the metering pump.

Two fluoride dosing pumps (duty/standby) pump out of the dosing tank and pump to the dose-point. The dose pumps may be bunded separately from the dosing tank.

On the discharge side of the pumps, pulsation dampeners should be fitted to minimise pulsation within pipelines and at the dose point. Note, that modern solenoid dose pumps do not normally require pulsation dampeners, but each installation must undergo an appropriate safety review.

The dose pumps will be limited to 110% of the maximum flow rate required to deliver maximum dose at maximum flow conditions.

At the fluoride dose point, a static mixer should be installed to facilitate sufficient mixing of fluoride chemical and treated water.

Downstream of the fluoride dose point all treated water needs to flow into a tank or reservoir. On cases of high fluoride, at the tank/reservoir the water supply shall be drained to waste, and the fluoride system stopped.

A fluoride analyser is installed downstream of the dose-point after sufficient mixing but before the tank or reservoir. If a fluoride analyser does not have an in-built flow verification, the fluoride analyser sample lines is equipped with a flow switch. This provides verification of sufficient flow to the analyser.

The fluoride dosing pumps shall be flow paced to the treated water meter in the WTP. The dosing line is equipped with a flow meter which will provide dose verification.

A required dose-rate to achieve a residual in the treated water is determined by the following.

Equation 15: Dose Rate Calculation

$$Q_f = \frac{[Q * D]}{1000} * \frac{1}{[C_p * s * C_{AF} * \rho]}$$

Where:

Q_f = Dose pump/s fluoride flowrate (L/h)

Q = plant flow rate (m^3/h)

D = fluoride dose (g/m^3)

Q = plant flow rate (m^3/h)

C_p = % fluoride powder in solution

s = purity of fluoride powder in solution (Refer to quarterly chemical supplier reports)

C_{AF}= % active fluoride in powder

ρ = Specific gravity

NaF Example:

Required dose (D) is 0.8 g/m^3

Plant flow (Q) is 2 ML/D = 2,000 m^3/day = 83 m^3/hr

NaF powder (C_p) in solution is 4% w/v

Purity of NaF (s) powder delivered is 98%

Active fluoride (C_{AF}) in NaF 43.9%

Specific gravity of solution (ρ) is 1

Storage time (τ) is 1 day.

$$Q_f = \frac{[83 * 0.8]}{1000} * \frac{1}{[0.04 * 0.98 * 0.439 * 1]}$$

Required NaF dose rate (Q_f) to achieve a residual is 3.9 L/h. This will be verified by the flowmeter.

7.3.3 Fluoride Dose Verification

There are three independent verifications of a fluoride, all of which are displayed continuously.

The applied dose is calculated based on the following:

- Calculated dosing tank level change (delta V)
- Calculated residual from dosing line flowmeter and;
- Residual measured at fluoride analyser.

If any of the above exceed a fluoride concentration of 1.0 mg/L, a high alarm is raised.

If any of the above exceed a fluoride concentration of 1.3 mg/L, a high-high alarm is raised, and the fluoride system is shut down.

The following sections outlines the methods for residual calculations

7.3.3.1 Calculated Change in Dosing Tank Volume

The tank level shall be monitored continuously and used to calculate an expected residual dose. This shall be calculated as follows:

Equation 16: Dose Calculation based on Dosing Tank Volume Change

$$D = \frac{[\delta V * C_p * s * C_{AF} * \rho]}{Q}$$

Where:

D = fluoride dose (g/m^3)

δV = change in volume over the last 60 minutes (litres)

Q = plant flow over the last 60 minutes (m^3)

C_p = % fluoride powder in solution

s = purity of fluoride powder in solution (refer to quarterly chemical supplier reports)

C_{AF}= % active fluoride in powder

ρ = Solution density

NaF Example:

Assuming a change in volume of 4 litres (δV) in the last 60 minutes
Plant flow (Q) is 2 ML/D = 83 m^3 in last 60 minutes
NaF powder (C_p) in solution is 4.0 % w/v
Purity of NaF (s) powder delivered is 98%
Active fluoride (C_{AF}) in NaF 43.9%
Density of solution (ρ) is 1000 g/L

.

$$D = \frac{4 * 0.04 * 0.98 * 0.439 * 1000}{83}$$

The dose is therefore 0.82 g/m^3.

Note, when water solenoid is open, the calculation shall be held for the duration of the transfer and restarted on closed condition of the water solenoid valve. Calculation continued based on the new level in the tank.

For the daily dose the flow total and the change in level of the dosing tank during transfer shall be ignored.

A daily average dose shall also be calculated using the flow total for 24 hours and the total volume of fluoride dosed.

7.3.3.2 Calculated Fluoride Dose Residual

Equation 17: Dose Calculation based on Dosing Flow

The dose rate is monitored at the pumps and confirmed by the fluoride flowmeter. The monitored flow is converted into a dose as follows:

$$D = \frac{[Q_f * C_p * s * C_{AF}] * \rho}{Q}$$

Where:

Q_f = Dose pump/s fluoride flowrate (L/h)

Q = plant flow rate (m^3/h)

D = fluoride dose (g/m^3)

Q = plant flow rate (m^3/h)

C_p = % fluoride powder in solution

s = purity of fluoride powder in solution (Refer to quarterly chemical supplier reports)

C_{AF}= % active fluoride in powder

ρ = Solution density

NaF Example:

Plant flow (Q) is 2 ML/D = 2,000 m^3/day = 83 m^3/hr

Dose pump/s flow (Q_f) is = 4 L/hr

NaF powder (C_p) in solution is 4.0% w/v

Purity of NaF (s) powder delivered is 98%

Active fluoride (C_{AF}) in NaF 43.9%

Density of solution (ρ) is 1000 g/L

$$D = \frac{[4 * 0.04 * 0.98 * 0.439] * 1000}{83}$$

Calculated residual achieved is 0.83 g/m^3

7.4 Alarm List

A sample alarm list for WTP saturated system fluoridation control is presented in Table 7. Critical control points for fluoridation compliance is attached in 0.

Table 15 – Saturated System Alarm List

Alarm	Alarm Priority	Value	Delay (s)[1]	Action
High High Fluoride Analyser	Critical	1.3 mg/l	5	Fluoride dosing and WTP plant shut down
High Fluoride Analyser	Warning	1.0 mg/l	300	Warning only
Low Fluoride Analyser	Warning	0.7 mg/l	300	Warning only
Fluoride Analyser Fault	Critical		5	Fluoride dosing plant shut down.
Fluoride dosing plant running and no sample flow to fluoride analyser	Critical		5	Fluoride dosing plant shut down.
Calculated Fluoride Dose High (From Dose Tank Volume Used)	Critical	1.3 mg/l	30	Fluoride dosing plant shut down.
Calculated Fluoride Dose Low (From Dose Tank Volume Used)	Warning	0.7 mg/l	300	Warning only
Calculated Fluoride Dose High (From Fluoride Flowmeter)	Critical	1.3 mg/l	30	Fluoride dosing plant shut down.
Calculated Fluoride Dose Low (From Fluoride Flowmeter)	Warning	0.7 mg/l	300	Warning only
Telemetry Failure From Instruments	Critical			Fluoride dosing plant shut down.
Fluoride Dosing Bund High Level	Critical			Fluoride dosing plant shut down.
Fluoride Level Transmitter Fault	Critical			Fluoride dosing plant shut down.
Fluoride Dosing Tank Level High	Warning	85%	300	Warning only
Fluoride Dosing Tank Level Low	Critical	10%	30	Fluoride dosing plant shut down.
Fluoride Dosing Tank Level High High	Critical	95%	5	Fluoride dosing plant shut down.

Alarm	Alarm Priority	Value	Delay (s)[1]	Action
Duty And Standby Dosing Pump Failure	Critical			Fluoride dosing plant shut down.
Fluoride Dosing Pump Bund High Level	Critical			Fluoride dosing plant shut down.
Fluoride Dosing Tank Level Transmitter Fault	Critical			Fluoride dosing plant shut down.

Notes:

(1) Delay values are indicative only. Delay values should be set after a risk assessment.

Appendix A Specific Impurity Limits

Commercially available hydrofluorosilicic acid, sodium fluoride, and sodium silicofluoride are not known to contribute significant quantities of contaminants that adversely affect the potability of drinking water.

Table A1 Specific Impurity Limits for metallic and metalloid determinands and boron with MAVs set in the Drinking-water Standards for New Zealand 2005 (Revised 2008)

Determinand	MAV (mg/L)	mg of Determinand per kg of Product		
		hydrofluorosilicic acid[1]	*sodium fluoride*	*sodium silicofluoride*
Antimony	0.02	270	880	1,190
Arsenic	0.01	130	440	590
Barium	1.5	20,100	65,800	89,100
Boron	2.4	32,200	105,200	142,600
Cadmium	0.003	38	135	180
Chromium	0.05	670	2,190	2,970
Copper	2	26,900	87,800	119,000
Lead	0.01	130	440	590
Manganese	0.4	5,400	17,600	23,800
Mercury	0.006	77	266	360
Nickel	0.08	1,080	3,500	4,800
Selenium	0.04	520	1760	2,360
Uranium	0.03	405	1,320	1,785

[1] The specific impurity levels for hydrofluosilicic acid are calculated using the lowest permitted percentage purity of the commercial product, i.e. 17%.

The SILs in Table A1 are calculated using the following equation:

$$SIL\ (mg/kg) = \frac{MAV\ (mg/litre) \times 10^6\ (mg/kg) \times P \times FF}{MD\ (mg/litre) \times SF}$$

Where SIL = Specific Impurity Limit

MAV = Maximum Acceptable Value of the impurity determinand set in the Drinking-water Standards for New Zealand 2005 (Revised 2008),

MD = Maximum Dose of fluoride

SF = Safety Factor

P = Percentage (w/w) of pure compound in the product

FF = Fraction of the weight of the pure compound due to fluoride (= (the atomic weight of F x the number of fluorine atoms in the molecule) / the molecular weight of the molecule)

The SILs are calculated based on:

1. the maximum acceptable value (MAV) for each determinand taken from the Drinking-Water Standards for New Zealand July 2022.
2. a maximum dose (MD) of 1 mg of fluoride ion/litre of water – the upper bound of the Ministry of Health's recommended concentration range for fluoride in fluoridated water supplies
3. a safety factor (SF) of 10, which reflects the view that no more than 10 percent of a MAV should be contributed by a given impurity in a water supply chemical.

Inclusion of a determinand in Table A.1 is not an indication that the products are expected to contain the impurity, or, if present, that the impurity will occur near its calculated SIL.

A 2 Example Specific Impurity Limit Calculations

Specific Impurity Limits (SILs) are calculated based on a maximum dose (MD) of 1 mg of fluoride ion/litre of water and the maximum acceptable value (MAV) for each determinand taken from the Drinking-water Standards for New Zealand 2022. The safety factor (SF) used in these calculations is 10, which reflects the view that no more than 10 percent of a MAV should be contributed by a given impurity in a water supply chemical.

The SILs, expressed as the weight of impurity in mg per kg of product, are determined using the following equation:

$$SIL\ (mg/kg) = \frac{MAV\ (mg/litre) \times 10^6\ (mg/kg) \times P \times FF}{MD\ (mg/litre) \times SF}$$

Where SIL = Specific Impurity Limit

MAV = Maximum Acceptable Value of the impurity determinand set in the Drinking-water Standards for New Zealand 2005 (Revised 2008),

MD = Maximum Dose of fluoride

SF = Safety Factor

P = Percentage (w/w) of pure compound in the product

FF = Fraction of the weight of the pure compound due to fluoride (= (the atomic weight of F x the number of fluorine atoms in the molecule) / the molecular weight of the molecule)

An example calculation is as follows:

Arsenic: MAV = 0.01 mg/litre

MD = 1.0 mg/litre

SF = 10

For a 17% w/w H_2SiF_6 (HFA) solution, this SIL equates as follows:

$$SIL\ (As) = \frac{0.01 \times 10^6 \times 0.17 \times 113.99\ (6 \times \text{atomic weight of F})}{1.0 \times 10 \times 144.09\ (\text{molecular weight of HFA})}$$

= 130 mg As/kg HFA product (rounded)

For a 97% NaF product, this SIL equates as follows:

$$SIL\ (As) = \frac{0.01 \times 10^6 \times 0.97 \times 19.00\ (\text{atomic weight of F})}{1.0 \times 10 \times 41.99\ (\text{molecular weight of NaF})}$$

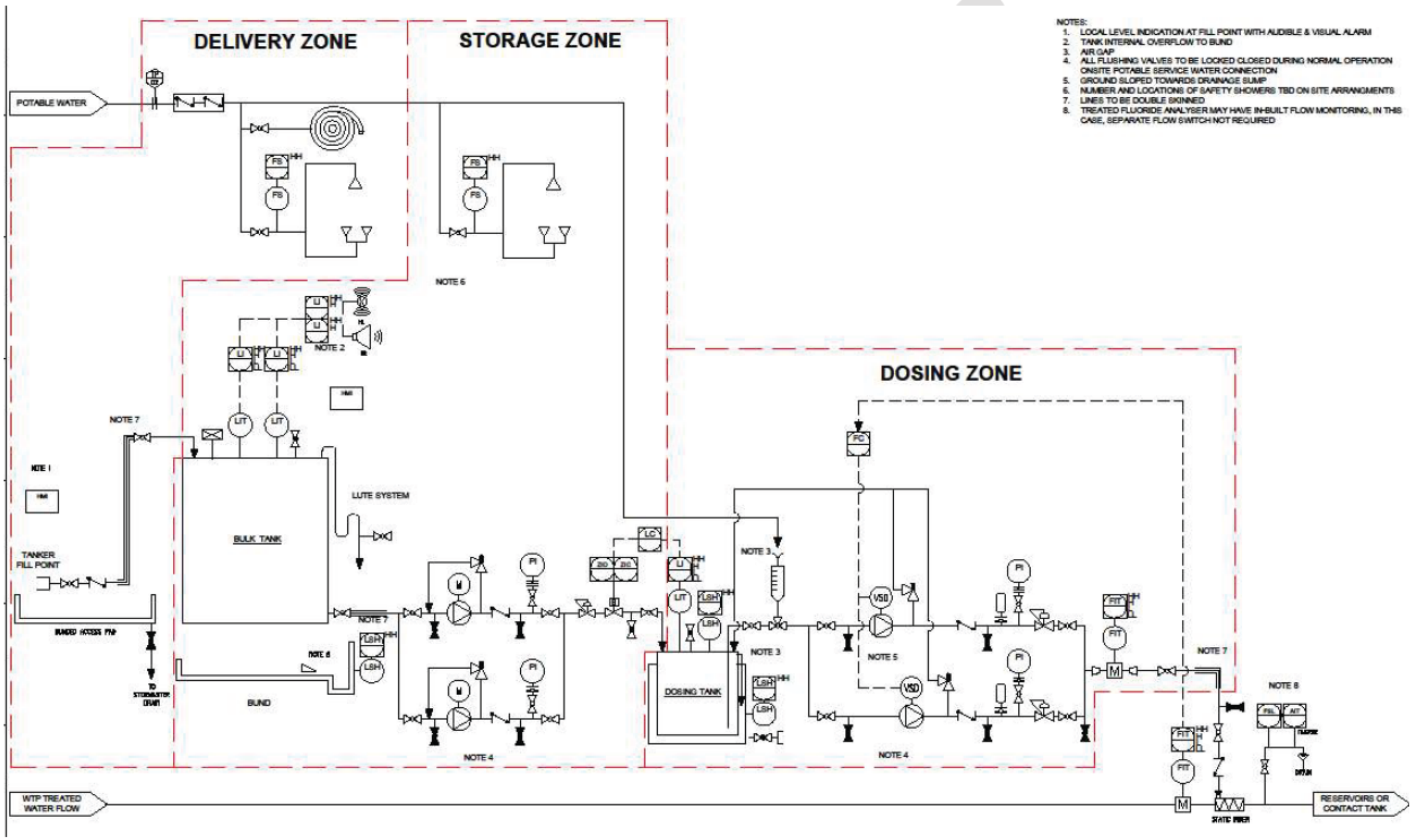
= 440 mg As/kg of NaF product (rounded)

For a 98% Na_2SiF_6 product, this SIL equates as follows:

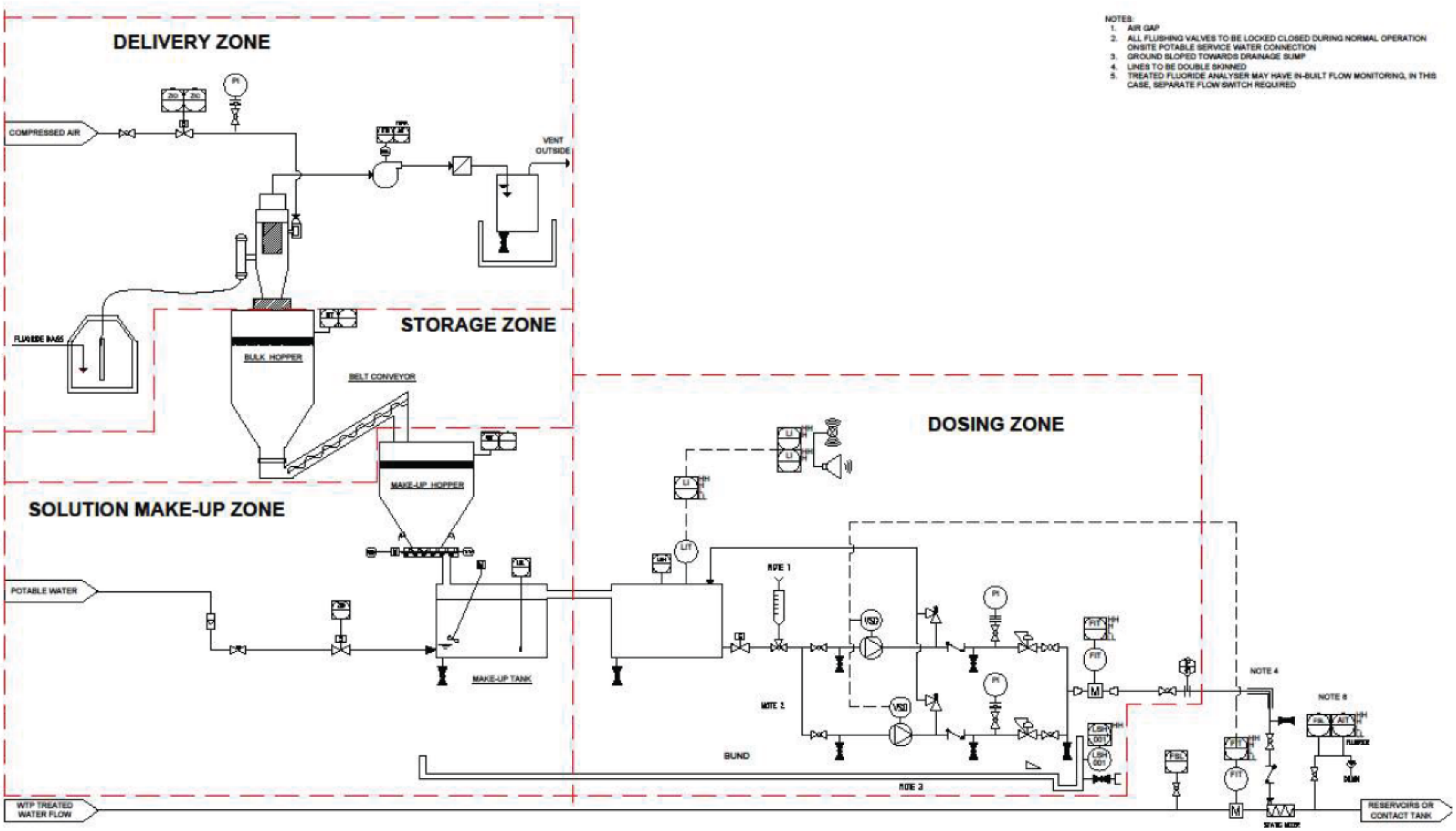
$$SIL\ (As) = \frac{0.01 \times 10^6 \times 0.98 \times 113.99\ (\text{atomic weight of F})}{1.0 \times 10 \times 188.06\ (\text{molecular weight of } Na_2SiF_6)}$$

= 590 mg As/kg of Na_2SiF_6 product (rounded)

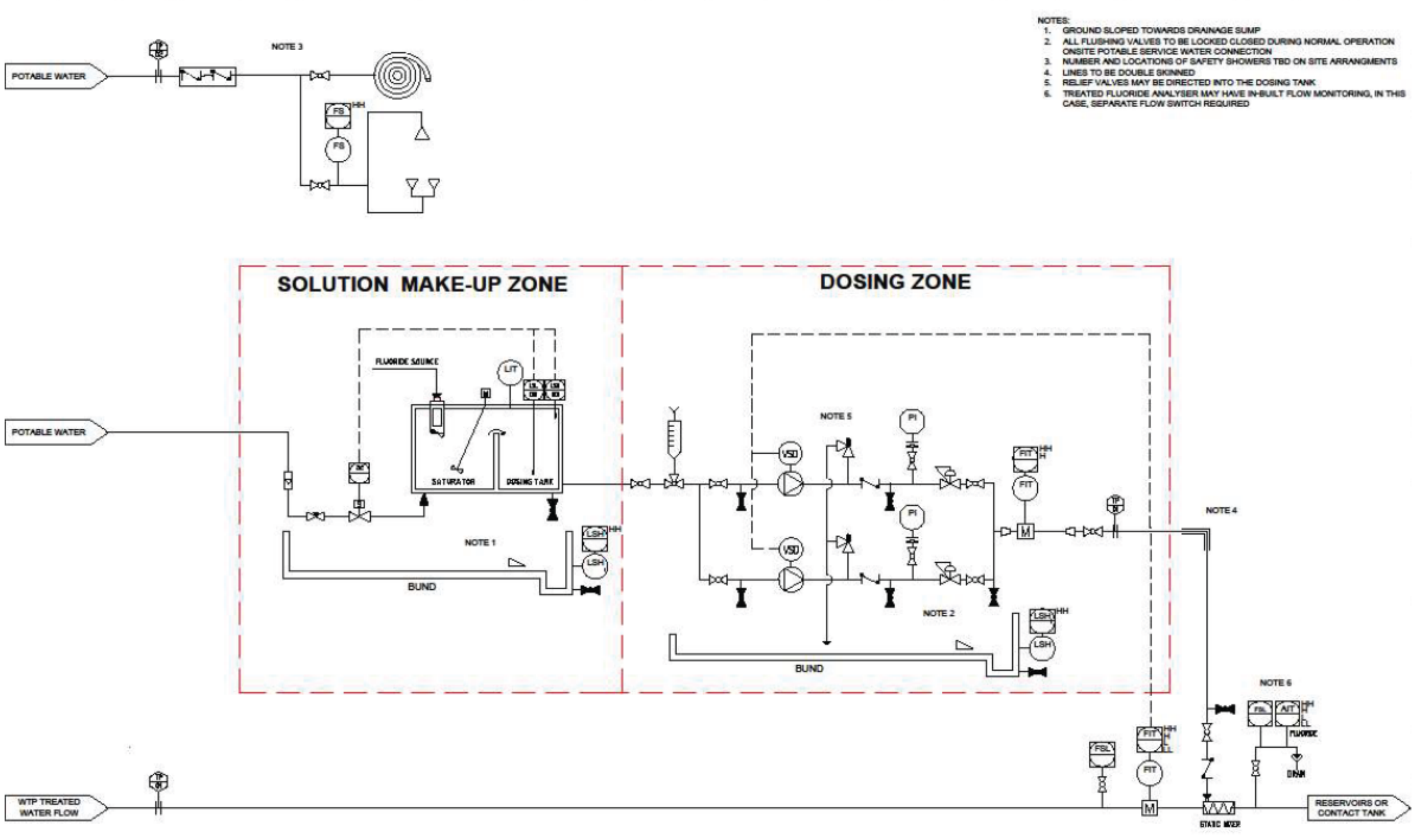
Appendix B Hydrofluorosilicic Acid Piping and Instrument Diagram



Appendix C Sodium Silicofluoride Piping and Instrumentation Diagram



Appendix D Sodium Fluoride Piping and Instrumentation Diagram



Appendix E Critical Control Points

A critical control point (CCP) is defined as a point or step in a process where controls can be applied and a hazard prevented, eliminated, or reduced to acceptable levels.

Fluoride Critical Control Point

Process objectives

- To provide a consistent fluoride residual to the network reticulation.
- Ensure the fluoride residual within the treated water does not exceed the maximum allowable value (MAV) of 1.5 mg/L as defined in the Taumata Arowai Drinking Water Standards.

Operational monitoring of fluoride residual.	
What	Fluoride concentration in mg/L.
When	Continuous, 7 days per week. Daily compliance reporting period.
Where	▪ The fluoride analyser, located downstream of the fluoride dose point, or; ▪ The change in volume calculation, at the dosing tank, or; ▪ The fluoride dosing calculation at the dosing line flowmeter.
How	Online fluoride analyser within vendor-supplied specifications
Who	Plant control system
Records	Online Compliance Historian, Log Book

Process performance criteria at the monitoring point:		**Action required**
Target Range:	Fluoride residual Between 0.7mg/l and 1.0 mg/l	▪ Operator to monitor trends to be aware of potential issues. Review any discrepancies. ▪ Operator to review fluoride control and dosing systems periodically
Action Limits:	Fluoride residual: Below 0.7mg/l OR Between 1.0 and 1.3 mg/l	▪ Operator to verify fluoride analyser, and calibrate if required ▪ Operator to check dose rate, analyser utilising the three verification methods: ○ Fluoride flowmeter, conversion to dose equation ○ Daily cumulative change in dosing tank volume against cumulative plant flow. ○ Fluoride analyser ▪ Operator to record issue in plant diary or log ▪ Operator to confirm correct % fluoride content and specific gravity values are entered in control system. ▪ If problem unresolved, Operator to notify supervisor

.

Criti cal Limit s:	Fluoride residual:> 1.3 mg/L	▪ Fluoride plant will automatically shutdown prior to 1.5 mg/L limit. ▪ Operator to confirm plant has been shut down and supply has been isolated in treated water reservoirs/contact tank. ▪ WTP plant water supply isolated until fluoride dosing offline and affected water has been discharged or tested whether within MAV specification. ▪ Fluoride dosing may be restarted when known cause has been diagnosed and rectified. ▪ Operator to notify supervisor and management.

The process performance criteria should link with the monitoring section of your plan.

Before productions starts:

- Monitoring equipment must be checked and calibrated.
- Supplier must ensure that the people responsible for monitoring checks are trained and competent to assess fluoride in drinking water.
- Ensure that fluoride sourced for treatment is suitable for drinking water and has sourced from a reputable supplier.
- Cross-check fluoride by independent laboratory.

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To find out what New Zealand Health professionals think about fluoridation see:

www.fluoridefacts.govt.nz

New Zealand Dental Association www.nzda.org.nz

National Fluoridation Information Service www.rph.org.nz

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Issue Date Dec.09.2021

CERTIFICATE OF ANALYSIS

Product Name SODIUM SILICOFLUORIDE
LotNo. 210822
Delivery Quantity 17,550 KG

Item	Unit	Result	Specification
Sodium Fluorosilicate	%w/w	99.5	98 min.
Fluoride(Total)	%w/w	60.3	59.4 min.
Water Insoluble Residue	%w/w	0.01	0.5 max.
Moisture (air)	%w/w	0.09	0.5 max.
Antimony (Sb)	mg/kg	<0.1	100 max.
Arsenic (As)	mg/kg	<0.1	100 max.
Barium (Ba)	mg/kg	<0.1	100 max.
Beryllium (Be)	mg/kg	<0.1	100 max.
Cadmium (Cd)	mg/kg	<0.1	50 max.
Chromium (Cr)	mg/kg	0.3	100 max.
Copper (Cu)	mg/kg	<0.1	100 max.
Lead (Pb)	mg/kg	<0.1	100 max.
Mercury (Hg)	mg/kg	<0.1	20 max.
Nickel (Ni)	mg/kg	0.4	100 max.
Selenium (Se)	mg/kg	<0.1	100 max.
Thallium (Tl)	mg/kg	<0.1	100 max.
40 sieve (0.420mm)	—	Pass	98 min. passing
325 sieve (0.044mm)	—	Pass	25 max. passing
Chlorine(Cl)	mg/kg	<20	
Iron(Fe)	mg/kg	2.2	
Loss on Drying at 105℃	%w/w	0.09	
Solubility in Water at 17.5℃	%w/w	99.8	

We hereby certify that test result above is conformable to AWWA Standard.

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Issue Date Dec.09.2021

CERTIFICATE OF ANALYSIS

Product Name SODIUM SILICOFLUORIDE
LotNo. 210823
Delivery Quantity 3,450 KG

Item	Unit	Result	Specification
Sodium Fluorosilicate	%w/w	99.5	98 min.
Fluoride(Total)	%w/w	60.3	59.4 min.
Water Insoluble Residue	%w/w	0.01	0.5 max.
Moisture (air)	%w/w	0.09	0.5 max.
Antimony (Sb)	mg/kg	<0.1	100 max.
Arsenic (As)	mg/kg	<0.1	100 max.
Barium (Ba)	mg/kg	<0.1	100 max.
Beryllium (Be)	mg/kg	<0.1	100 max.
Cadmium (Cd)	mg/kg	<0.1	50 max.
Chromium (Cr)	mg/kg	0.3	100 max.
Copper (Cu)	mg/kg	<0.1	100 max.
Lead (Pb)	mg/kg	<0.1	100 max.
Mercury (Hg)	mg/kg	<0.1	20 max.
Nickel (Ni)	mg/kg	0.4	100 max.
Selenium (Se)	mg/kg	<0.1	100 max.
Thallium (Tl)	mg/kg	<0.1	100 max.
40 sieve (0.420mm)	—	Pass	98 min. passing
325 sieve (0.044mm)	—	Pass	25 max. passing
Chlorine(Cl)	mg/kg	<20	
Iron(Fe)	mg/kg	2.2	
Loss on Drying at 105℃	%w/w	0.09	
Solubility in Water at 17.5℃	%w/w	99.8	

We hereby certify that test result above is conformable to AWWA Standard.