# Code of practice for fluoridation of drinking water supplies

## Second edition

*Health (Fluoridation) Act 1973*

VICTORIA State Government | Health and Human Services

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# Foreword

*Healthy Mouths, Healthy Lives: Australia's national oral health plan 2015–2024* has been endorsed by all state and territory governments and identifies the extension of water fluoridation as a key public health measure. I am pleased that currently 90 per cent of Victorians have access to fluoridated drinking water. Research consistently shows that access to fluoridated water from an early age is associated with less tooth decay in young children and adults.

Tooth decay is a largely preventable disease affecting children and adults and can cause considerable pain and suffering. There is reliable evidence that a very small amount of fluoride in drinking water helps to prevent tooth decay. Fluoride in drinking water acts like a constant repair kit that neutralises the effect of acids that cause decay and helps to repair damage before it becomes permanent.

The delivery of this proven public health measure requires strong partnerships with water agencies and commitment to the ongoing responsibility to ensure the addition of fluoride to drinking water is safe and effective. The *Code of practice for fluoridation of drinking water supplies, Second edition* specifies the requirements for water fluoridation plants to ensure delivery of fluoridated drinking water safely and effectively. This edition provides an update to the first edition, published in 2009, and considers advances in technology, best practice measures and water sector operational experience.

The Department of Health and Human Services is pleased to partner with the water sector to improve public health outcomes.

**Kym Peake**
Secretary
Department of Health and Human Services

# Contents

# 1 Introduction

The *Health (Fluoridation) Act 1973* (the Act) regulates the safe and effective addition of fluoride into drinking water supplies in Victoria. The *Code of practice for fluoridation of drinking water supplies, Second edition* (the code of practice) supports the Act and has been designed to help water agencies prepare submissions for proposed fluoridation plants. This second edition of the code of practice replaces the first edition published in 2009.

The code of practice adopts a risk-based approach, with the aim of ensuring that water fluoridation plant design and operation achieves the optimum fluoride concentration while protecting against overdosing. The code of practice describes the requirements for complying with the provisions of the Act and for the safe design and effective operation of a fluoridation plant.

Fluoridation of drinking water supplies requires a preventive risk management approach, a foundation of the *Safe Drinking Water Act 2003* (SDWA) and the *Australian drinking water guidelines* (NHMRC 2011). The code of practice embeds this approach in the design and operation of fluoridation plants and prepares for the integration of these plants into a water agency's overall water quality risk management system as required under the SDWA.

## 1.1 Objective

The overall objective of the code of practice is to provide for the safe and effective addition of fluoride into a drinking water supply.

This will be achieved by specifying:

- the optimum fluoride concentrations for drinking water supplies and the design control limits for fluoridation plants
- the minimum requirements for the safe and effective addition of fluoride chemicals to drinking water supplies, covering the design and operation of a fluoridation plant
- monitoring and reporting requirements for the proposed fluoridation plant.

## 1.2 Scope

The code of practice outlines the design, construction, commissioning, approval and operating requirements of water fluoridation plants.

It applies to all works undertaken on water fluoridation plants in Victoria, and integrates the management of water fluoridation with the SDWA by requiring that a water agency:

- includes water fluoridation in its risk management plan under s.7 of the SDWA
- applies the audit, notification and reporting requirements of the SDWA to water fluoridation.

## 1.3 Abbreviations and terms

The following abbreviations and terms are used throughout the code of practice.

| | |
|---|---|
| the Act | *Health (Fluoridation) Act 1973* |
| ADWG | Australian drinking water guidelines (NHMRC 2011, updated 2017) |
| the code of practice | *Code of practice for fluoridation of drinking water supplies, Second edition* (Department of Health and Human Services 2018) |
| drinking water | as defined in the *Safe Drinking Water Act 2003* |
| the department | Victorian Department of Health and Human Services<br>Reference to the Department of Health and Human Services includes the statutory functions of the Secretary as described in the *Health (Fluoridation) Act 1973* and the Safe *Drinking Water Act 2003*. |
| EPA Victoria | Environment Protection Authority Victoria |
| fluoride concentration | the total amount of fluoride present regardless of its form, expressed in milligrams per litre ( mg/L) |
| fluoridation plant | the building and equipment required for fluoridation of drinking water, including chemical storage areas, dosing and control equipment, safety equipment and other fixtures used for, or associated with, the purpose of fluoridation. |
| must/should | The word 'must' identifies a mandatory requirement for compliance.<br>The word 'should' refers to practices that are advised or recommended but are not mandatory. |
| NATA | National Association of Testing Authorities |
| NHMRC | National Health and Medical Research Council |
| PLC | Programmable logic controller |
| risk management plan | as defined in the *Safe Drinking Water Act 2003* |
| SCADA | Supervisory control and data acquisition |
| SDWA | *Safe Drinking Water Act 2003* |
| water agency | a water supply authority as defined in the *Health (Fluoridation) Act 1973*<br>any water supplier or water storage manager as defined in the SDWA |
| water sampling locality | as defined in the Safe Drinking Water Regulations 2015 |
| water supplier | The SDWA uses the term 'water supplier' as equivalent to a 'water supply authority' under the Act or, in the case of Melbourne Water Corporation, the term 'water storage manager'. |

# 2 Regulatory framework

## 2.1 Legislation

The code of practice should be read in conjunction with the following legislation governing the fluoridation of drinking water supplies.

### 2.1.1 Health (Fluoridation) Act 1973

The *Health (Fluoridation) Act 1973* regulates the fluoridation of drinking water supplies in Victoria.

The Act includes requirements for:

- a water agency required to add fluoride to a water supply under its control
- procedures to be followed before adding fluoride to a water supply.

A water agency may also decide to fluoridate a water supply of its own accord. Regardless, s. 6 of the Act provides a procedure before adding fluoride to a water supply which must be followed. This includes the requirements for:

1) a water agency to submit plans, specifications and information regarding the proposed plant
2) the department to provide a written notice specifying the concentration and fluoride chemical to be used for the water supply
3) a water agency to, in accordance with the department's notice, regulate the fluoride concentration and only add the fluoride chemical specified.

The code of practice details:

- the requirements a water agency must meet when submitting a proposed plant for the department's consideration under s. 6 of the Act
- specifications for designing a plant to assist in regulating the fluoride concentration added to a water supply.

### 2.1.2 Safe Drinking Water Act 2003

The SDWA and Safe Drinking Water Regulations 2015 make provision for the supply of safe drinking water in Victoria and require water agencies to:

- adopt a catchment-to-tap risk management approach
- meet drinking water quality standards
- disclose information to the department and to the public.

This is consistent with the risk management approach set out in the ADWG.

In Victoria, water agencies must prepare and implement risk management plans that include risks relating to the amount and purity of chemicals added to drinking water and controlling any residue or by-product in drinking water. Through these requirements the SDWA also governs the ongoing management of fluoridation plants.

### 2.1.3 Other legislation

Other legislative requirements relevant to managing a water fluoridation plant include:

- *Environment Protection Act 1970*
- *Occupational Health and Safety Act 2004*
- *Dangerous Goods Act 1985*
- *Building Act 1993*
- *Planning and Environment Act 1987*
- *Public Health and Wellbeing Act 2008.*

## 2.2 Roles and responsibilities

### 2.2.1 Department of Health and Human Services

The department is responsible for administering the Health (Fluoridation) Act, the SDWA and associated regulations.

Under the Act, the Secretary to the Department of Health and Human Services, or their delegate, may:

- require a water agency to add fluoride to a drinking water supply for dental health purposes (s. 5(1))
- approve a proposed plant by specifying the fluoride concentration, the fluoride chemical and the public water supply to which fluoride is to be added by a water agency (s. 6)
- provide funding for the net capital costs and expenses (s. 8).

Before approving the proposed fluoridation plant, the department reviews the plans and specifications submitted and determines the ability of a water agency to operate the plant safely and effectively. This includes carrying out a technical appraisal of the plant to determine compliance with the code of practice. Approval of the plant may also provide direction to a water agency on related matters such as the requirement to update its water quality risk management plan under the SDWA.

### 2.2.2 Water agency

A water agency may decide to fluoridate a drinking water supply for dental health purposes.

Under the Act a water agency must:

- add fluoride to a water supply when required by the department (s. 5)
- before adding fluoride to any water supply, submit plans, specifications and information to the department for consideration (s. 6(1))
- in accordance with s. 6(3) of the Act
  - regulate the fluoride concentration to ensure the maximum concentration does not exceed the direction of the department under s. 6(2)
  - not add fluoride in any other form than that directed by the department under s. 6(2).

Water agencies must follow the procedure to fluoridate described in section 2.3 of this code of practice.

Water agencies are responsible for designing, installing and operating the fluoridation plant in accordance with the code of practice and all relevant legislative requirements. Communication with the department is required at all stages of the project.

A water agency must not begin testing the plant using the fluoride chemical or introduce fluoride to the drinking water supply until the department's written approval has been provided under s. 6(2) of the Act.

A water agency must ensure the water fluoridation plant is managed to meet the requirements of s. 6(3) of the Act and in accordance with the provisions of the SDWA. Specifically, a water agency must ensure the water fluoridation plant is integrated into the risk management plan for a drinking water supply. Where a water agency supplies or proposes to supply fluoridated drinking water to another water agency, the risk management plan of each water agency must incorporate the plant.

A water agency must develop a communications plan in consultation with the department and in accordance with any guidance issued by the department in relation to introducing fluoride to a water supply.

## 2.3 Procedure to fluoridate

The procedure to fluoridate is described in Figure 1. The main elements of the procedure are:

1. Feasibility study
2. Design and assessment
3. Pre-commissioning and technical appraisal
4. Departmental approval
5. Fluoride commissioning
6. Operations, maintenance and fluoride audit.

**A water agency must not introduce fluoride to the drinking water supply until written approval by the department has been provided.**

### 2.3.1 Feasibility study

When a water agency has decided to, or has been required to, fluoridate, they must first do a feasibility study to determine the viability of the fluoridation plant at the proposed water treatment plant and drinking water supply.

The feasibility study will provide the basis for the planning, design and specifications of the proposed fluoridation plant. It should consider options for the appropriate fluoride chemical, type of dosing system, existing water treatment plant infrastructure, current plant limitations and other factors such as any supply agreements with key customers. It should also include cost estimates for site works, buildings, plant and equipment, construction and installation.

The water agency should discuss the findings of the feasibility study with the department before beginning plant design. The department will use the feasibility study to confirm the design criteria and discuss any viability issues with the proposed plant.

The feasibility study should forecast the water agency's net capital costs and expenses associated with installing the plant and may be used to inform funding agreements with the department under s. 8 of the Act.

### 2.3.2 Design and assessment

A water agency must design the fluoridation plant in accordance with the code of practice and discuss with the department, as early as practicable:

- any identified deviations from the code of practice
- any design and control alternatives to the requirements in the code of practice.

The department will consider if the design ensures an equivalent or greater level of safety as required by the code of practice. The outcomes of the department's consideration should be incorporated in the detailed design.

Section 6.1 of the code of practice details the requirements for submitting documentation, plans and specifications for the proposed fluoridation plant for the department's review. The detailed design will form part of this submission and must include an assessment of the detailed design and controls system against the requirements of the code of practice. If a water agency, or its contractor, subsequently amends the detailed design, these amendments must also be provided in the documentation submitted to the department.

### 2.3.3 Pre-commissioning and technical appraisal

Following construction completion, the fluoridation plant must undergo a technical appraisal to inform the department's approval before using any fluoride chemical at the plant.

At least eight weeks before commissioning the plant, a water agency must submit the documentation, plans and specifications detailed in section 6.1 of this code of practice. The department will then arrange for the technical appraisal to be conducted by suitably qualified individuals. This technical appraisal aims to determine the plant's compliance with the code of practice and includes consideration of all documentation submitted as well as a plant site inspection.

The technical appraisal may include recommendations that are critical to the safe and reliable operation of the plant. Items identified as critical to the safe addition of fluoride will need to be rectified before the department will give approval and before fluoride dosing can commence. The technical appraisal may also include conditions for implementing the recommendations.

A water agency may begin dry commissioning and wet commissioning with non-fluoridated water before the department's approval. Wet commissioning with fluoride chemicals is strictly not permissible. Any significant modifications resulting from the non-fluoride commissioning process must be discussed with the department.

### 2.3.4 Departmental approval

Pursuant to s. 6(2) of the Act, the department will consider all submitted documentation including any amendments to plans and specifications and the technical appraisal. Based on this information and a water agency's responses to recommendations highlighted in the technical appraisal, the department will decide whether to approve the addition of fluoride into the drinking water supply.

### 2.3.5 Fluoride commissioning

Once a water agency receives the department's written approval, it may begin final wet commissioning with fluoride.

When the commissioning is complete, and before adding fluoride into the drinking water supply, a water agency must provide written confirmation to the department that:

- the fluoridation plant has been installed in accordance with the final plans and specifications
- the control system, including any critical control points, critical limits, alarms and corrective actions have been tested and verified as per the commissioning plan.

This written confirmation from a water agency to the department is required to assure the department that commissioning of the fluoridation plant has been completed in accordance with the commissioning plans previously submitted for departmental approval.

### 2.3.6 Operations, maintenance and fluoride audit

Upon receiving the department's acknowledgement of the completion of fluoride commissioning, a water agency may fluoridate the water supply.

A water agency must ensure that:

- the fluoridation plant is operated in accordance with the plans and specifications approved by the department
- management of the plant is incorporated into the risk management plan as required under the SDWA

Within 12 months of beginning fluoride dosing, the department will undertake a fluoride audit by suitably qualified individuals. This audit will verify that the recommendations of the technical appraisal and the approval have been implemented. A written notice will be given to the water agency once the department is satisfied all recommendations arising from the fluoride audit have been addressed.

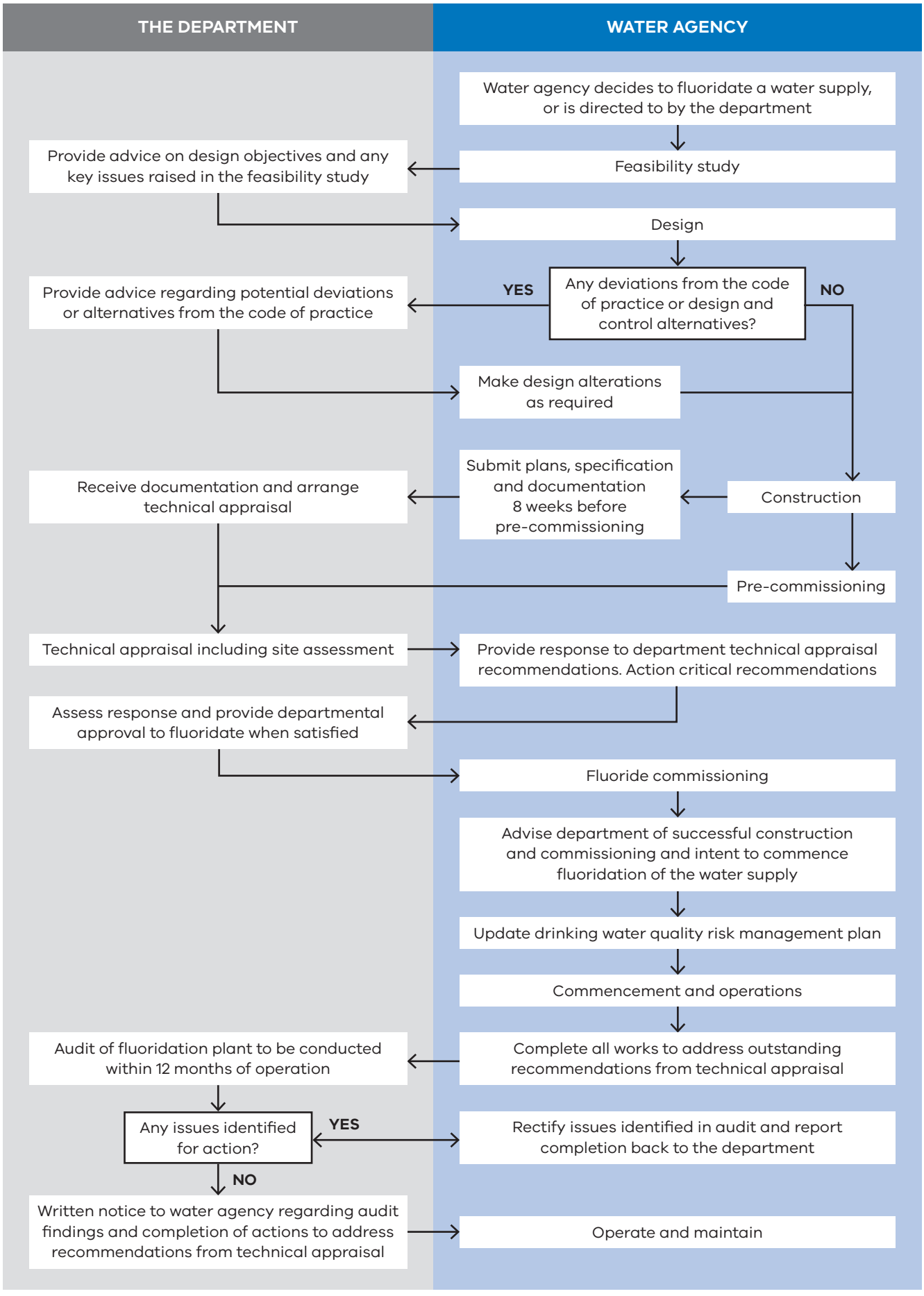
## 2.4 Other requirements

### 2.4.1 Plant and dose control modifications

A water agency must consult the department before:

- replacing equipment or items within a fluoridation plant that change the sizing of the equipment or affect existing dose control measures, such as interlocks or SCADA controls
- making upgrades or changes to the fluoridation plant that may affect the dose control including, for example, modifications to day tanks or dosing pumps, change of fluoride chemical or changes to overall plant flow
- undertaking modifications or maintenance activities that will require a significant plant shutdown.

## Figure 1: Procedure to fluoridate



The department will review the proposed modifications and determine the requirements in consultation with the water agency. The department will assess the proposed changes in relation to public health and the continued safe and effective operation of the modified fluoridation plant.

For any modifications to the dose control system, a water agency should prepare and implement a change management plan, prior to returning the plant online, to verify the modification results in the intended outcome with no adverse consequence.

### 2.4.2 Plant replacement and decommissioning

If a water agency decides to replace the existing fluoridation plant with a new fluoridation plant, it must consult with the department and discuss the proposed replacement plan. The plan should detail the project timeframe and potential shutdown periods to affected drinking water supplies during the plant changeover. From a public health perspective, the impact on the rolling annual average of the fluoride concentration in drinking water for affected water sampling localities should be minimised.

The replacement fluoridation plant's construction plan should follow the steps outlined in section 2.3 Procedure to fluoridate.

The decommissioning and removal of the existing fluoridation plant and equipment should consider all other relevant legal requirements, including those relating to health and safety, construction and demolition, waste disposal, future use of the site, buildings or equipment and disposal of redundant materials and equipment. Any decommissioning activity must include a site-specific assessment of the activities.

### 2.4.3 Extended plant shutdown periods and recommissioning

Where the addition of fluoride has ceased for more than 30 consecutive days, the water agency should prepare an appropriate recommissioning plan for the fluoridation plant.

Recommissioning should include:

- verification of control system calculations, critical control responses and control actions
- verification of fluoridation chemical quality
- verification of fluoride dosing controls and equipment performance (pump dose rates, instrument readings and scaling)
- change management processes for off-site alarm responses
- confirmation of critical control points, critical limits and alarms.

Following recommissioning, the water agency must advise the department that the fluoridation plant has been restarted in accordance with its recommissioning plan and verified to continue to operate in accordance with the plans and specification approved by the department. Any proposed changes to the plans and specification previously approved must be discussed with the department before returning the fluoridation plant online.

### 2.4.4 Public communications

Where fluoride is being introduced to a water supply for the first time, a water agency must prepare a communications plan in consultation with the department and in accordance with any guidance issued by the department. This communications plan should be prepared following the feasibility study.

# 3 Safety in design

## 3.1 Approach

For water fluoridation, safety in design encompasses:

- drinking water safety
- occupational health and safety
- environmental safety.

The safety in design process includes applying a risk management framework early in the design process to eliminate or minimise the risk to public health, the environment and to ensure occupational health and safety throughout the life of the fluoridation plant. The process encompasses all phases of plant design, including facilities, hardware, systems, equipment, products, tooling, materials, energy controls, layout and configuration.

A safe design process, together with a formal safety management system and safety practices, procedures and training, is critical for achieving the level of confidence required for risk management.

The overall safety of the fluoridation plant must be managed in accordance with industry best practice and with:

- *Occupational Health and Safety Act 2004*
- *Dangerous Goods Act 1985,* Dangerous Goods (Storage and Handling) Regulations 2012
- relevant quality and risk-based management systems such as ISO 9001, ISO 14001 or Hazard Analysis and Critical Control Point (HACCP) principles
- local standards such as the *Australian and New Zealand Risk management standard* (AS/NZS 4360), AS/NZS 4452 *The storage and handling of toxic substances,* AS 3780 *The storage and handling of corrosive substances* and AS 61882 *Hazard and operability studies (HAZOP studies) – application guide*
- Australian Safety and Compensation Council's *Guidance on the principles of safe design for work*
- *Environment Protection Act 1970.*

## 3.2 Drinking water safety and public health

The performance objective is to ensure the design, construction, installation, operation and maintenance of the fluoridation plant protects public health by:

- maintaining the optimum fluoride concentration in the drinking water supply
- preventing an overdose of fluoride
- implementing chemical quality assurance processes to guarantee the chemical purity of the fluoride chemical added to the drinking water supply.

Controls for managing risk to drinking water safety, as identified through the site-specific risk assessment, must be incorporated in a water agency's drinking water risk management plan as required under the SDWA.

## 3.3 Occupational health and safety

Occupational health and safety measures to consider in the design and operation of a fluoridation plant include:

- safety in design to ensure a safe working environment and safe working practices
- effective control measures to mitigate risks as identified by a risk assessment
- adequate training for plant operators as to the hazards associated with the fluoride chemical
- updating the Material Safety Data Sheet (MSDS) for the fluoride chemical in the operation manual
- ensuring the MSDS is accessible by keeping a copy close to where the chemical is used so operators can refer to it
- ensuring that pipework and tanks used for storing and distributing fluoride chemicals comply with the relevant standards, and that these are distinguishable from other plant pipework (for example, by colour-coding and labelling)

- installing and arranging equipment so that handling and operation meets workplace health and safety requirements
- keeping water fluoridation separate from other water treatment plant equipment in a separate building or fluoridation room
- protecting control panels, such as electrical control panels for the fluoridation plant, from short circuiting, malfunction and corrosion (for fluorosilicic acid plants, control panels should be located outside the fluoridation room)
- ensuring that the atmosphere of any areas where fluoride chemicals are stored or used is safe for workers, and providing ventilation and dust extraction appropriate for the selected chemical (refer to the fluoride chemical's MSDS for information on air changes per hour; 10 air changes per hour is often used as a design basis)
- supplying and maintaining appropriate personal protective equipment and providing training for mandatory operator use of protective equipment
- ensuring availability of emergency eyewash and showers where fluoride chemicals are stored and handled, along with regular testing procedures.

In relation to occupational safety and the handling and storage of dangerous goods, the Occupational Health and Safety Act, the Dangerous Goods Act and associated regulations have precedence over this code of practice. If clarification is required, WorkSafe Victoria will provide the defining interpretation.

The health and safety measures listed above provide a basis for a water agency to assess the control measures it should use to manage occupational and safety risks associated with fluoridation plants. The control measures listed are not exhaustive and their use in no way implies that this is sufficient to comply with the above mentioned legislation.

## 3.4 Environmental safety

In the management of the fluoridation plant and ancillary equipment and activities, a water agency must not cause environmental harm. For the design and operation of a fluoridation plant, the relevant environmental state legislation, standards, quality guidelines and protection measures as set out in the state environment protection policies must be followed.

### 3.4.1 Spills and leaks

A water agency must ensure the fluoridation plant and equipment are designed and operated to minimise the risk of fluoride chemical spills or leaks. Any spills or leaks must be contained and must not come into contact with or be stored with incompatible chemicals.

Where fluorosilicic acid is used, appropriate bunding and other measures (such as drip trays) must be provided to contain any spillage. The design of bunding must enable the safe removal of any spillage and be consistent with the EPA Victoria's guideline *Bunding (Publication 347.1)* and relevant Australian standards. In designing the fluoridation plant, locating all elements containing concentrated fluorosilicic acid in the storage bund area may be an effective way of reducing environmental risks.

Operating procedures must include measures for:

- managing spills and leaks of the fluoride chemical, including in-built detection devices, surveillance, corrective actions and remedial works
- notification and reporting to the appropriate authorities.

Fluoride piping should be visible so that it can be easily inspected for integrity. Where pipes are not visible, leak detection measures or secondary confinement must be in place.

### 3.4.2 Release to the atmosphere

Where dry fluoride chemicals are used, measures must be implemented to control airborne dust particles. This includes designing the plant to prevent the escape of airborne dust particles into the fluoridation room and atmospheric discharges.

Dry sweeping of dry fluoride chemicals should not occur. If dry chemicals are spilt, they should be cleaned using a low-pressure hose or a vacuum that is fitted with a high-efficiency particulate air (HEPA) filter to prevent dust exposure. Operators must use appropriate personal protective equipment.

### 3.4.3 Waste disposal

Waste containing fluoride must be managed in accordance with the Environment Protection (Industrial Waste Resource) Regulations 2009. Wastes include fluoride chemical, chemical packaging, plant and equipment that have been in direct contact with fluoride chemical.

A water agency must document and implement an environmental waste disposal plan for fluoride chemical spills and leaks, contaminated fluoride chemicals and fluoride chemical containers.

# 4 Design

## 4.1 Design criteria

### 4.1.1 Legislation, regulations, guidelines, standards and codes

The water agency must ensure the fluoridation plant complies with the relevant legislative requirements, guidelines, standards and codes in design, construction and operation. These include, but are not limited to:

- Acts of Parliament (refer to section 2.1)
- AS 1319 *Safety signs for the occupational environment*
- AS 1345 *Identification of the contents of pipes, conduits and ducts*
- AS 2845.2 *Water supply – Backflow preventions devices Part 2: Registered air gaps and registered break tanks*
- AS 3780 *The storage and handling of corrosive substances*
- AS/NZS 1715 *Selection, use and maintenance of respiratory protective equipment*
- AS/NZS 4020 *Testing of products for use in contact with drinking water*
- AS/NZS 4360 *Risk management*
- AS/NZS 4452 *The storage and handling of toxic substances*
- AS/NZS 4801 *Occupational health and safety management systems – Specification with guidance for use*
- *Australian code for the transport of dangerous goods by road and rail*
- *Australian drinking water guidelines* (ADWG) 2011
- *Building code Australia* (BCA)
- *Code of practice for the storage and handling of dangerous goods 2013*
- Dangerous Goods (HCDG) Regulations 2016
- Dangerous Goods (Storage and Handling) Regulations 2012
- EPA Victoria Publication 347.1, *Bunding,* October 2015
- *Manual handling (code of practice) No. 25 2000*
- Occupational Health and Safety Regulations 2017
- Plumbing Regulations 2008
- Safe Drinking Water Regulations 2015
- state environment protection policies.

These documents may be updated during the life of the code of practice, therefore the latest version should be used.

### 4.1.2 Functionality of the fluoridation plant

The fluoridation plant must be designed to meet the following requirements:

(a) The design of the fluoridation plant must provide plant operational staff with all that is required to monitor and control the fluoridation process reliably, accurately and in a timely manner.

(b) The fluoride concentration in the water supplied for drinking must comply with the requirements set out in section 4.2.2 of this code of practice.

(c) The plant must be fully automated and operated by a treatment plant-based control system, that is, a programmable logic controller.

(d) The plant must ensure dependable automatic operation with reliable stopping and starting of the system during plant shutdown and startup.

(e) The plant must have alarms, including after-hour alarms to the duty operator and automatic shutdowns.

(f) The plant must implement the dose monitoring independent check requirements described in section 4.7.6 of this code of practice.

(g) Bulk storage tanks must be equipped with online level sensors and displays consistent with safety regulations and Australian Standards. Local displays must be provided and readable in low-light conditions to allow the safe delivery of chemicals. Level switches must be provided and interlocked with the chemical delivery general power outlet and

include visual and audible warning signals. Other fluoride chemical tanks and vessels used in the fluoridation plant must be fitted with appropriate level indicators and controls to prevent overflows.

(h) Fluoride dosing must be flow-paced based on the measured water treatment plant flow into which the fluoride is being dosed. This will typically be achieved using a suitably placed flow meter and variable speed dosing pumps.

(i) The maximum dosing capacity of the fluoridation chemical feeding equipment must be limited by design to a maximum value that is as close as practicable to the operating target dose rate at the maximum water flow rate. This maximum value must not exceed 110 per cent of the operating target dose rate at the maximum plant capacity. For metering pumps that have a manual stroke adjustment, the stroke adjustment must be locked in position and its maximum operating position clearly marked to ensure that the component of the dosing that can be changed by manual adjustment does not result in exceeding 110% of the operating target dose. For digital dosing pumps the stroke rate must be limited by an electronic lock on the microprocessor.

(j) An online fluoride analyser, linked to an appropriate alarm monitoring system and automatic shutdown, must be installed downstream of the injection point. The sample point supplying the analyser must be located so that the measurement reflects the real-time dosing performance of the fluoridation plant, enables critical control actions to be implemented by the control system to prevent overdosing and prevent off-specification fluoridated water from entering the water supply. The following is required to achieve this:

- The sampling point must be located so that adequate mixing has taken place before the sampling point.
- The time taken for the sample water to travel from the sampling point to the instrument should be kept to the minimum practical time (should be less than 60 seconds). This may require the instrument to be located close to the sampling point or other hydraulic transport system design.
- The sampling point must meet the following criteria applicable to the drinking water delivery system:
  - be located before the first draw off for a consumer
  - where a clear (or treated) water storage is included, be located upstream of the clear (or treated) water storage or, where treated drinking water is supplied directly into a transfer main, be located to ensure a representative sample of fluoridated water is obtained
  - if downstream of a clear (or treated) water storage, be located so that the measurement reflects the real-time dosing performance of the fluoridation plant.
- The water agency must consider the risks associated with loss of water to the fluoride analyser. This should include a flow switch on the sample line that generates an alarm if sample water is lost or too low.
- A second analyser that monitors the drinking water supplied to customers (downstream of a clear water storage) should be operational.

(k) The water agency must ensure that upon failure of the control system, treated water exceeding the emergency process limit does not enter the drinking water supply. Refer to Table 2, section 4.3.1 for further details.

(l) Dosing pumps must be in a duty/standby arrangement to provide reliability and resilience of fluoride dosing in response to maintenance and equipment failure.

### 4.1.3 Other design considerations

#### 4.1.3.1 Water service off-takes

No drinking water service within the plant or to consumers must be taken directly off the water line to which fluoride is dosed until after the online fluoride analyser.

#### 4.1.3.2 Anti-siphon and backflow protection

The dosing system must be fitted with back pressure, anti-siphon and pressure-relief valves.

Any water supply used for dissolving the fluoride chemical or as carry water must have a backflow prevention device fitted upstream of where the fluoride chemical is dissolved or diluted (such as mixing tanks) or injected (such as dosing pumps). This can be achieved through an air gap. The device must comply with the current Australian standards. A shut-off valve (interlocked with the control system) in the dosing line at the fluoride injection point should be installed.

#### 4.1.3.3 Control equipment

It must be made physically impossible for any component of the fluoride dosing or control equipment to be manually plugged into standard electrical power outlets (such as an electrical extension lead) for continuous operation.

Any manual mode (or 'test') switch for the fluoridation chemical feeding equipment must not enable permanent selection (such as using non-spring-loaded switches) and must return to the 'off' position when released to prevent unattended manual operation. Refer to section 4.7.5 for further detail on controls and alarms.

All key components of the fluoridation plant must be interlocked in the control system to ensure total fluoridation plant shutdown on the failure of any individual equipment item and to ensure that the plant cannot operate unless the water treatment plant flow in the pipe containing the injection point is detected. These components include, but are not limited to, stop/start/pacing signals, feeders, dosing pumps, solution transfer pumps, solution tank levels, solution tank weight, dilution water pumps and an online monitoring system.

The potential for overdosing must be assessed in the plant design and, where appropriate, interlocks and alarms designed into the dosing system.

#### 4.1.3.4 Varying background fluoride concentrations

In some instances the background fluoride concentration in water entering a plant may vary significantly; for example, a plant may treat raw water and, at times, water previously fluoridated. If this is the case, the water agency must consider incorporating additional controls to accommodate varying background fluoride concentrations. For example, an online fluoride analyser on the inlet to the water treatment plant.

#### 4.1.3.5 Variation in water demand

Many water treatment plants experience variation in drinking water demand because of seasonal or significant operational changes. A water agency must consider controls to limit the maximum amount of fluoride chemical used per day during periods of low demand. This may include adopting a setpoint for the day tank based on expected daily demand.

## 4.2 Chemical

### 4.2.1 Chemical selection and approval

Fluoridation is generally achieved by adding a slurry of sodium fluorosilicate, a solution of fluorosilicic acid or a saturated solution of sodium fluoride as a metered dose for a given rate of water flow (NHMRC 2016). Only fluoride chemicals approved in the ADWG are permitted to be used to fluoridate a water supply. These fluoride chemicals are listed in Table 1.

**Table 1: Fluoride chemicals**

| Common name | Fluoride chemical | Formula | CAS no.* | Alternative name |
|---|---|---|---|---|
| Fluorosilicic acid | Dihydrogen hexafluorosilicate | $H_2SiF_6$ | 16961-83-4 | Hydrofluorosilicic acid, Hexafluorosilicic acid |
| Sodium fluoride | Sodium fluoride | NaF | 7681-49-4 | Sodium monofluoride |
| Sodium fluorosilicate | Disodium hexafluorosilicate | $Na_2SiF_6$ | 16893-85-9 | Sodium silicofluoride |

* CAS numbers are as per the Australian Inventory of Chemical Substances (AICS) on <www.nicnas.gov.au>. Note that there are other CAS numbers in use for these chemicals.

A water agency is responsible for selecting the most suitable fluoride chemical for the drinking water supply. The selection process (such as a risk assessment) should occur during the feasibility study. Details of the fluoride chemical selection must be included in the plans and specification submission to the department for assessment and approval. The selection process must consider material availability and accessibility, whether a quality management system is in place to ensure chemical purity, site constraints and how it will comply with the Safe Drinking Water Regulations. The risk assessment must also consider any potential risks from associated material used in the addition of fluoride such as soluble bags or other packaging material. Refer to section 4.2.5 Chemical quality assurance for further details.

A water agency's specification for purchasing fluoride chemicals must ensure consistency in physical characteristics and fluoride concentration, as well as the chemical specification.

The amount of chemical needed and the dosing pump feed rate required depends on the daily plant production, fluoride dose concentration, chemical purity and the available fluoride ions.

### 4.2.2 Fluoride concentration in water

The purpose of water fluoridation is to adjust the natural fluoride content of drinking water to an optimum concentration to provide a dental health benefit. The NHMRC supports Australian states and territories fluoridating their drinking water supplies within the range of 0.6–1.1 mg/L. This range is aimed at reducing tooth decay, while avoiding any occurrence of dental fluorosis of aesthetic concern (NHMRC 2017).

Water fluoridation plants in Victoria are designed and required to operate within this range. The department will advise the water agency of the appropriate operating target and operating range (± 0.1 mg/L of the operating target) for a specific water supply following the feasibility study.

The water agency should maintain a historical record of the fluoride concentration in the raw water to ensure an appropriate allowance for the natural fluoride concentration is considered when determining the dosing concentration. The fluoride concentration in the raw water should be analysed at an appropriate frequency for the expected variability.

In accordance with s. 5(3) of the Act, a water agency must not add fluoride to an extent that results in an average optimum concentration in excess of one part fluoride per million parts of water (1.0 mg/L) over any 12-month period in any water sampling locality. Note: accuracy of fluoride dosing concentrations and calculations is required to one decimal place.

### 4.2.3 Chemical delivery

The delivery of chemicals must be in accordance with occupational health and safety and environment protection requirements to ensure the safety of staff, the community and the environment. It is common for fluoride chemical to be delivered by tanker or bulk container for fluorosilicic acid, and in 5 kg bags, 25 kg bags, 1 tonne bulki-bags or canisters for powdered/granulated agents.

The site and plant must allow for the safe and secure delivery and storage of chemicals in accordance with the legislative requirements for transporting and handling chemicals.

For fluorosilicic acid, the delivery area and sump must comply with EPA Victoria's *Bunding (Publication 347.1),* chemical delivery and safety regulations and relevant Australian Standards. For fluorosilicic acid deliveries the delivery truck must be fully standing within the delivery bund during chemical transfer.

Dry fluoride chemicals must be delivered to and stored in hardstand areas for easy clean up after a spill. A delivery bund is not required for dry fluoride chemicals; however, the water agency must ensure that the chemicals can be unloaded in a safe and environmentally responsible manner. This includes ensuring that spills of the dry chemical can be cleaned up and disposed of safely.

### 4.2.4 Chemical handling and storage

The handling and storage of chemicals must be in accordance with occupational health and safety and environment protection requirements to ensure the safety of staff, the community, the environment and the drinking water supply.

A water agency must ensure sufficient chemical is available and accessible to ensure continuity of water fluoridation. A water agency should document its storage assessment (considering availability of the fluoride chemical, transport, procurement strategies and variability in water supply demand).

Design of the bulk chemical storage must consider:

- material selection (fit for purpose)
- safety in design for access, operation and maintenance, ensuring compliance with relevant codes, guidelines and regulations
- that chemicals are stored separately where required as per the Occupational Health and Safety Act and Dangerous Goods Act
- the chemical storage bund requirements for fluorosilicic acid as per EPA's *Bunding (Publication 347.1),* with guidance from AS3780, meeting the Dangerous Goods (Storage and Handling) Regulations
- that dry fluoride chemicals require handling equipment suited to the form and unit size of the delivered chemical (where manual handling is necessary, this must be in accordance with the Occupational Health and Safety Regulations)
- spill removal and clean-up procedures that minimise airborne dust particles
- ventilation and dust particle extraction as appropriate for the selected chemical
- measures to prevent corrosion (such as sealing all connections, water traps)
- weather protection
- controls and instrumentation including alarms, and visual display of tank contents
- access authorisation.

### 4.2.5 Chemical quality assurance

A water agency must implement a chemical quality assurance system to ensure chemical purity, the safe delivery and storage of fluoride chemical. The chemical quality assurance system must be implemented to manage all the factors associated with the specification, contract management, supply, purity, storage, use and handling of fluoride chemical that could adversely affect the health and safety of staff, contractors and consumers.

Requirements relating to chemical quality in r. 8(1)(e) of the Safe Drinking Water Regulations and components which make up an effective quality assurance system for drinking water

treatment chemicals detailed in Chapter 8 of the ADWG must be considered within the risk management plan.

Specifically, a water agency must implement procedures and management systems for:

- ensuring the purity of fluoride chemicals added to the drinking water does not adversely affect the quality of that water or pose a risk to human health
- controlling any residue or chemical by-products imparted to drinking water as a result of adding chemicals to water supplied for drinking water purposes
- supervising deliveries (by competent staff) for the entire duration of the operation and ensuring that the correct chemical has been delivered by checking the documentation.

The water agency must require regular chemical analysis by suppliers in supply contracts. The contractual requirement for chemical delivery must be supported by batch-testing data provided by the supplier from an independent NATA accredited laboratory, and random testing carried out by the water agency. Chemicals must not be accepted for delivery unless a batch Certificate of Analysis has been obtained and checked against the contract specification by the water agency.

## 4.3 Design control limits

The design of the fluoridation plant must:

- use a fluoride dose concentration as determined and approved by the department and be controlled to the limits specified in Table 2, section 4.3.1 of this code of practice.
- at no time allow the fluoride concentration in the drinking water supply to exceed the health guideline value of 1.5 mg/L (NHMRC 2016).

Real-time fluoride monitoring, linked to an appropriate alarm monitoring system and automatic shutdown, is required for all dosing installations and must be available at all times. The fluoridation plant control limits in Table 2, section 4.3.1, apply specifically to the instruments used for real-time fluoride monitoring, namely instruments used for calculating instantaneous water flow and fluoride dose rates, and analysers to monitor the fluoride concentration.

### 4.3.1 Analysers and process control

A water agency must carefully consider the sampling point, sampling line pipe sizes and flow rates, the physical location of the online analyser to the process stream and other interactions with water treatment plant functions to ensure delays in sample water flow to the instrument and process control (SCADA and PLC) are kept to a minimum.

Any instrument signal delays, masking, averaging or data smoothing algorithms associated with the process limits in Table 2 (to account for instantaneous spikes) must be kept to a minimum and be practical, justified and specified in the plans and specifications. A water agency must demonstrate that shutdown time delays do not allow water above the upper action process limit to reach the first customer. For example, a delay time of no more than 60 seconds to account for short-term instrument spikes is acceptable for the following:

- Any analyser or instrument signal verification/ proving time delay
- Pre-clear (treated) water storage analyser
- Post-clear (treated) storage analyser (if installed)
- Direct dosing into transfer main.

**Table 2: Fluoridation plant control limits and alarms**

| Parameter | Total fluoride concentration ( mg/L) | Response to process limits |
|---|---|---|
| Operating target | As specified by the department | – |
| Operating range | Operating target ± 0.1 mg/L | Dosing correction |
| Lower action process limit | 0.6* | Local alarm. Dosing correction. No shutdown required |
| Upper action process limit | 1.2** | Local alarm. Fluoridation plant shutdown. (Online monitoring system must be interlocked with the dosing system.)<br>Generate external alarm for operational response |
| Emergency process limit | 1.5*** | Local alarm. Fluoridation plant shutdown. (Online monitoring system must be interlocked with the dosing system.) Water agency to notify the department as per requirements detailed in Table 3, section 7.2.<br>Generate external alarm for operational response. |

* NHMRC 2007, *A systematic review of the efficacy and safety of fluoridation*

** Based on a slightly lower dose than the maximum level of fluoride permitted (ADWG) to ensure the ADWG level is never exceeded.

*** ADWG Physical and chemical characteristics Fact Sheets – Fluoride

## 4.4 Fluoridation building/room

A water agency should consider the risks associated with the chemical when designing the fluoridation building/room. For powdered plants, room design should consider dust particle management. For fluorosilicic acid plants, separate rooms or areas for electrical equipment and the fluoridation plant should be considered. This is to minimise equipment deterioration due to corrosion and the need for staff to enter the fluoridation plant room or specific areas where fluoridation equipment is installed.

If the water agency chooses to use a separate room or area for the fluoridation plant, the following design features should be considered:

- separate entry doors and viewing portals
- viewing windows in walls between chemical storage and dosing equipment and electrical/process control areas designed to prevent air and fume passage
- use of a suitable material for the viewing window (past experience has shown glass and some plastics become etched, frosted or clouded from fluorosilicic fumes; periodic replacement of windows should be considered)
- management of fumes from storage areas and sealing of doors/conduits/drains and other wall penetrations
- a clear view of the dosing equipment from the window in the room with the electrical controls
- room design to prevent dust accumulation if using powders (smooth ceilings and walls)
- where a system uses a tank containing fluorosilicic acid, it must be vented to the outside atmosphere and all connections sealed to prevent corrosion of the equipment in the room, etching, frosting or clouding of any windows and damage to any electrical panels.

For fluoridation plant equipment that is located external to any buildings, protection from weather and appropriate safety measures must be incorporated.

### 4.4.1 Plant security

A water agency must control access to the fluoridation plant by providing a security locking system to prevent unauthorised access and to minimise the risk of anyone being injured. Requirements under relevant regulations and standards apply, including appropriate signage to indicate:

- the presence of the fluoride chemical
- any electrical, chemical or occupational health and safety hazard
- any required personal protective clothing or equipment
- that only authorised entry is permitted
- the location of essential safety equipment and information.

## 4.5 Equipment

All equipment used for adding fluoride to a drinking water supply is required to operate in a safe, reliable and precise manner. All material used must be compatible with the fluoride chemical used. A material compatibility list for each fluoride chemical listed in Table 1 of this code of practice is available in Appendix A of the *Water fluoridation principles and practices* (American Water Works Association 2016).

A water agency must ensure the equipment and associated controls have safety measures against chemical overdosing and underdosing through human or operational malfunctions and that the equipment is safe to operate and maintain.

A water agency should consider the need for equipment to safeguard against downtime causing fluoride outages. A water agency should complete a critical spares analysis of the fluoridation plant that includes the mode of failures, consequence of failures or unavailable spare parts, the lead-time for spare parts from suppliers and the supply of critical spares with the original installation phase. Access to critical spares must be timely to reduce downtime. If a water agency has multiple fluoridation plants it is beneficial to standardise the systems so that spare parts can be shared.

## 4.6 Mixing and dosing

### 4.6.1 Mixers

Fluoride solutions must be homogeneous, no matter which method is used to prepare them. Mechanical mixers, if required, are preferred for preparing a dilute solution.

### 4.6.2 Softeners

A softener should be used if the hardness of the water used for sodium fluoride dissolution is greater than 75 mg/L (as $CaCO_3$) to reduce the loss of fluoride ion by precipitation of calcium or magnesium fluoride. Equipment suppliers may have specific criteria for water softening.

### 4.6.3 Dosing pumps

Dosing pumps must be able to accurately deliver the required flow rate and be sized or capped so that they operate at their maximum output at the maximum flow of the water treatment plant. A method for verifying dose rates must be available and maintained to ensure its reliability. This is typically achieved by using a manual drawdown test cylinder.

Any risk of gravity flow or siphoning of the fluoride chemical through the dosing pump must be prevented. Pressure relief and a loading valve on the delivery side of the pump must be provided.

The transfer pump and dosing pumps must be located above the maximum spillage level of the storage tank if they are located within the bunded area.

### 4.6.4 Dry feeder systems

Dry feeder systems must be able to accurately deliver the required volume or weight of fluoride chemical for the quantity of water being treated and must be sized for the maximum flow of the treatment plant. A method for verifying dose rates must be available and maintained to ensure its reliability.

### 4.6.5 Injection point

The location and detail of the chemical injection point must:

- provide homogenous mixing (minimum coefficient of variance of 0.95 is recommended) of the chemical in the treated water (where necessary, mixing devices may be used)
- reduce the loss of fluoride by precipitation with other chemicals (such as those containing calcium, aluminium, magnesium and phosphates) or treatment processes (such as coagulation, filtration and pH correction) (refer to *Water fluoridation principles and practices,* American Water Works Association, 2016)
- prevent the possibility of siphoning and overdosing
- include a sampling point and associated analytical and control equipment for automatic shutdowns
- be located upstream of buffer storage (clear water or treated water tank) of treated water
- not allow any bypass or secondary pipework (or channel) into which the fluoride chemical will not be dosed under normal operating situations and intended for delivery to customers as drinking water (except for firefighting purposes)
- in the case of multiple injection points, each point must be designed according to the requirements of section 4.6 so it functions independently of the other injection points
- consider the impact of any recycle flow streams (for example, recycling of filter backwash to the head of the plant) to avoid 'double dosing'.

## 4.7 Process control and instrumentation

For process control, the following instrumentation must be provided:

a) online fluoride analyser
b) flow meter (for calculation of flow and volume) on the process stream (treated water) into which fluoride is being dosed
c) level or pressure indicators on the bulk tank, saturator/mixing tank and day tank (with an accuracy of ± 1 per cent over the full range of the instrument)
d) control system and interlocks to automatically shut down the fluoridation plant when unsafe events are identified, alarm systems to notify of dosing abnormalities during operation including unsupervised and after-hours periods.

### 4.7.1 Online fluoride analyser

A water agency must measure the total amount of fluoride in the drinking water supplied using an online fluoride analyser. Interferences to the measurement are typically not an issue if the water has:

- consistently low aluminium and iron levels (consistently below the aesthetic guideline values in ADWG: 0.2 mg/L for aluminium and 0.3 mg/L for iron)
- a relatively stable pH that is between 6.5 and 8.5.

Instrument accuracy and interference should be verified when selecting appropriate products, and inclusion of buffering functions should be assessed on a site-specific basis.

Should a water agency experience interferences in the measurement, the ion selective method should be considered as described in the current edition of *Standard methods for the examination of water and wastewater* 4500-F-C (American Public Health Association, 2012) or seek an alternative method that has been proven to be just as accurate.

A water agency should carry out method and instrument validation to determine a limit of detection and resolution of their measuring instrument. Accuracy to at least +/- 0.10 mg/L should be achieved by a well-maintained instrument in a production environment.

Measuring techniques that cannot be calibrated against a primary standard are not accepted as definitive evidence of accurate dose control.

### 4.7.2 Benchtop fluoride analyser

Irrespective of the online measurement method, the benchtop fluoride analyser must be an ion selective electrode employing the standard method referenced above. A water agency must calibrate the benchtop fluoride analyser at appropriate intervals, as recommended by the manufacturer, using traceable primary standards. A quality control verification sample must be collected and analysed monthly to validate the accuracy of the benchtop fluoride analyser. The sample must be collected from the fluoridated drinking water and tested by a NATA accredited laboratory. The water agency must compare the NATA result with the benchtop fluoride analyser and have a procedure to rectify discrepancies between samples.

Using a benchtop analyser, a water agency must analyse the fluoridated drinking water downstream of the online analyser at least once a week and compare the results to ensure the accuracy of the online analyser. Where discrepancies have been identified, corrective actions must be undertaken immediately, which may include recalibrating the online instrument and other system checks.

### 4.7.3 Flow meter

A flow meter must be provided to measure and integrate the water treatment plant flow and to pace the fluoride dosing equipment, where the plant design calls for such, over the full water flow rate range approved by the department. The metered flow must be representative of the flow into which the fluoride is dosed.

The use of flow meters is recommended with an accuracy of ± 1 per cent over the complete range of flow but must not exceed ± 3 per cent.

Where a sodium fluoride saturator is used, a flow meter must also be placed in the service water line to monitor and record the dilution water volumes.

### 4.7.4 Day tank

A day tank acts as a physical barrier that minimises the risk of large quantities of chemicals from the bulk storage tank (or if using powders, from the saturator or mixing tank) being added into the water supply in error. The relevant independent checks (refer to section 4.7.6) must be applied and arrangements for the transfer of the fluoride chemical from the bulk tank, saturator or mixing tank to the day tank must meet the following basic principles:

a) The workable volume of the day tank must be no more than 24 hours of storage volume at maximum flow and target dose rate. The workable volume is defined as the volume between the tank outlet and the overflow. A splash zone of the lesser of 100 mm height or 10 per cent of daily use height can also be excluded from the workable volume. This splash zone takes into account the fact that filling to the overflow would mean that some chemical may splash out the overflow and go to waste.
b) The amount that can be transferred into the day tank each day cannot be more than the maximum volume required to be dosed into drinking water in the same 24-hour period based on the fluoride concentration required and the volume of drinking water delivered in the same period. Note: some facilities will include a day tank that can service 24-hour operation, in which case only one day tank fill per day is permitted. Some facilities include smaller volume day tanks that will require multiple fills for 24 hours of operation. The maximum number of day tank fills requires control to prevent fluoride overdosing and must be scalable to the water demand set by plant operations.
c) Transfer must only occur by controlled pumping. Gravity transfer must be prevented using appropriate design, such as an anti-siphon loop.
d) All equipment, pumps and day storage should be located within a bunded area, and chemical spillage must be captured in a safe manner.

### 4.7.5 Control and alarms

The fluoridation plant must alarm and respond to the fluoride process limits as specified in Table 2, section 4.3.1 of this code of practice.

All dosing systems must be configured so as to 'fail safe', that is, failure of a critical component stops dosing and triggers an alarm. Fluoride concentration alarms from the instrument must be transmitted to the duty operator.

Alarms generated during unattended periods must inform water agency staff capable of an immediate response.

Where dosing is stopped during automatic operation that is outside of the normal operating parameters of the plant, either manually or by shutdown alarms, dosing must not restart automatically or remotely without manual on-site intervention.

Where automatic shutdown systems can be manually overridden, any override events must be logged and the override facility configured so that the operator is alerted to the override, for example by a local or telemetry alarm. The manual override period must be kept to a minimum, with an appropriate operating procedure in place. The time interval between manual override operation and the alarm must not exceed 30 minutes (Drinking Water Inspectorate 2016). This aims to prevent equipment remaining in manual operation.

The operation of shutdown systems must be fully tested at least annually and the results recorded. The testing process must form part of the risk management plan. This can be done physically through increasing the fluoride concentration at the analyser by placing the probe in a concentrated solution or simulated through temporarily modifying the control system values by decreasing the upper action process limit and the emergency process limit. It is important to ensure any testing follows a predetermined plan and that the system is set back to normal operation after the test.

### 4.7.6 Dose monitoring

To minimise overdosing risks, a dose monitoring independent check is required, which measures the actual fluoride chemical used in comparison to a calculated theoretical use. One of the following two independent checks must be implemented. The independent check selected should be informed by a risk assessment.

**Independent check: Day tank balance**

This independent check involves:

- measuring the amount of fluoride used from the day tank via an online volume or mass device
- calculating the average daily fluoride concentration in delivered drinking water based on the amount of fluoride used from the day tank and total volume of drinking water passing the injection point
- calculating the average daily fluoride concentration in delivered drinking water measured by the online fluoride analyser
- comparing the two average daily fluoride concentrations to ensure both results are within the specified fluoride operating target ± 0.1 mg/L.

Discrepancies between the two calculated daily average fluoride concentrations, or where one or both daily average fluoride concentrations exceed the operating target ± 0.1 mg/L, should trigger an alarm.

The day tank must be fitted with a load cell or a level sensor. Both level sensors and load cells can be used together to provide a higher degree of assurance.

- Level sensors measure and display the liquid level in the tank and generate alarms when the deviation allowance has been exceeded. The accuracy of the sensors must be within ± 1 per cent over the full range of the operational capability.
- Load cells measure and display the mass in the tank and generate alarms when the deviation allowance has been exceeded. The accuracy of the load cells must be within ± 1 per cent of the range being measured. Load cells are preferred

for measuring mass changes in the day tank because they are more reliable than level sensors.

Daily changes in the volume/mass of fluoride chemical consumed in the process must be recorded online and used as an additional check.

The minimum requirements for independent check day tank balance are:

- The total mass or volume of fluoride chemical dosed to drinking water from the day tank must be recorded each 24-hour period.
- Where multiple day tank fills are included in the plant operation, cumulative mass or volume over the 24-hour period must be calculated and recorded.
- The total volume of drinking water passing the injection point must be recorded in the same 24-hour period.
- Adjustments to calculations for volume/density/temperature must be included and accurate for the specific batch of fluoride chemical and prevailing conditions over the same 24-hour period.
- Calculation of fluoride concentration in the drinking water must use the recorded values of mass and/or volume and be recorded for the same 24-hour period and be expressed in mg/L of fluoride.
- The online fluoride instrument readings must be recorded and averaged over the same 24-hour period.
- Comparison of the mass-based fluoride concentration with the instrument recorded average must be completed.
- Where deviation in the daily amount of fluoride chemical used or the average fluoride concentration is greater than the operating target ± 0.1 mg/L, an alarm must be generated for immediate attention.

**Independent check: Use of a fluoride-measuring flow meter on the fluoride dosing line before the injection point**

This independent check involves:

- measuring the fluoride added to the drinking water via a flow meter installed in the chemical dosing line
- calculating the average daily fluoride concentration in delivered drinking water based on the total amount of fluoride measured on the fluoride flowmeter and total volume of drinking water passing the injection point
- calculating the average daily fluoride concentration in delivered drinking water measured by the online fluoride analyser
- comparing the two average daily fluoride concentrations to ensure both results are within the specified fluoride operating target ± 0.1 mg/L.

Significant discrepancies between the two calculated daily average fluoride concentrations, or where one or both daily average fluoride concentrations exceed the operating target ± 0.1 mg/L, should trigger an alarm.

The chemical dosing line before the injection point must be fitted with a flow meter. This flow meter must be linked to an appropriate alarm monitoring system and an automatic shutdown of the fluoridation plant. The flow meter must not be used as part of a feedback control to alter the dose rate. The flow meter's purpose is for alarming only and deviations from the expected dose flow should alert the operator so they can determine the appropriate action.

The flow meter must measure the rate of flow, and the SCADA must record the rate and total volume of flow. An electromagnetic flow meter should be used to achieve an accuracy of ± 1 per cent and to minimise flow meter blockages.

The minimum requirements for determining deviation from expected dose are:

- The chemical flow meter must record the instantaneous flow and cumulative flow over a 24-hour period.
- The instantaneous flow must be compared with the control system flow setpoint at a suitable interval.
- The suitable interval for comparing recorded flowrate and setpoint flowrate is the lesser of the control system setpoint change interval or five minutes. The flowrate readings should be averaged over the same period.
- The total volume of fluoride chemical dosed to drinking water measured by the chemical flow meter must be recorded each 24-hour period.
- The total volume of drinking water passing the injection point must be recorded in the same 24-hour period.
- Adjustments to calculations for volume/density/temperature must be included and be accurate for the specific batch of fluoride chemical and prevailing conditions over the same 24-hour period.
- Calculation of fluoride concentration in the drinking water must use the recorded values of volume measured by the chemical flow meter and be recorded for the same 24-hour period and be expressed in mg/L of fluoride.
- The online fluoride instrument readings must be recorded and averaged over the same 24-hour period.
- Comparison of the delivered volume-based fluoride concentration with the online fluoride instrument recorded average must be completed.
- Where deviation in the daily amount of fluoride chemical used or the average fluoride concentration is greater than the operating target ± 0.1 mg/L, an alarm must be generated for immediate attention.

All online instruments used for the above independent checks must be calibrated regularly, in accordance with the manufacturer's recommendations.

# 5 Operation and maintenance

All plant and equipment used for adding fluoride to a drinking water supply must operate in a safe, reliable and precise manner. A water agency must also ensure that plant and equipment are maintained.

## 5.1 Operational and verification monitoring

### 5.1.1 Monitoring of fluoride concentration in the raw water

The fluoride concentration in the raw water should be analysed at an appropriate frequency for the expected variability. The sample must be analysed at a NATA accredited laboratory. Any detected variation must be considered when setting the fluoridation plant operation and control mechanisms. Additional on-site analyses may be used for operational monitoring of raw water fluoride concentration and may influence the frequency of accredited analyses.

### 5.1.2 Continuous monitoring of fluoride concentration at fluoridation plant

Continuous fluoride monitoring, linked to an appropriate alarm monitoring system and an automatic plant shutdown, is required for all fluoridation plants. The performance of the online fluoride analyser must be checked against a benchtop reference unit at least weekly (refer to section 4.7.2). The frequency of this check is determined by a risk assessment. These measurements should be compared with plant production volume and the quantity of fluoride dosed.

### 5.1.3 Monitoring in the distribution system

A water agency must arrange to take water samples as follows:

- If a fluoridation plant (or plants) supplies fewer than five water sampling localities, the water agency must take a sample each week in each water sampling locality supplied from those plants.

  OR
- If a fluoridation plant (or plants) supplies five or more water sampling localities, the water agency must take a sample each month in each water sampling locality supplied from those plants, so that a sample is collected from the distribution system at least once per week.

Notes:

- If a water sampling locality receives a blended supply of fluoridated water from two or more fluoridation plants at the same time, only one sample per locality is required.
- If a fluoridation plant (or plants) supplying a water sampling locality is offline for an extended period, monitoring in the distribution system must continue so that any abnormality or incorrect dosing of fluoride can be identified.
- The monitoring of fluoride in the distribution system must be integrated in the water agency's risk management plan and with any downstream water supplier receiving fluoridated water from the water agency.

## 5.2 Plant quality assurance

The plant quality assurance system must ensure the fluoridation plant is adequately monitored and maintained so that any discrepancy, equipment reliability issue or unacceptable variability in the final fluoride concentration is readily identified and effectively rectified.

A water agency must include in its plans and specifications submitted to the department the details of the quality assurance and quality control framework that will be implemented to verify the accuracy of the results, the corrective actions and the process by which operators will be informed if the fluoridation plant is either underdosing or overdosing.

The quality control framework must comprise activities (checks) designed to ensure:

- data integrity (consistency and accuracy)
- use of standardised procedures for sampling, analysis and data interpretation
- identification of errors or omissions, and estimation of uncertainties
- calibration of equipment
- credible results that relate to the data and analysis.

The water agency must ensure the operation manual is a controlled document with defined procedures and processes for making amendments.

## 5.3 Maintenance and calibration

The water agency must carry out regular plant inspections and record the results, including actions from these inspections. Plant inspections will help ensure effective process control, determine whether equipment is operating normally and identify the need for maintenance. These inspections could be done remotely using virtual technology but must be done in conjunction with regular visits; a weekly plant inspection is considered a minimum.

All equipment and instruments considered vital for the process control must be maintained and calibrated regularly according to a maintenance schedule and a calibration schedule documented in the operation manual.

The performance of dosing pumps should be verified at least monthly by measuring the volume of solution pumped during a measured time interval.

Fluoride feeders should be regularly cleaned, lubricated, inspected and recalibrated.

The risk of spills and leaks in the dosing lines must be considered (Refer to section 3.4.1). For fluorosilicic acid plants, design should include secondary confinement or to replace the dosing lines every 12–24 months.

A water agency must keep evidence of maintenance and calibration records.

## 5.4 Operational personnel

A water agency must ensure that operational personnel are appropriately skilled and trained in managing and operating the fluoridation plant. Operational personnel must have a sound knowledge base from which to make effective operational decisions, and they must be aware of how their decisions can affect the safety and efficacy of the fluoridation plant.

A water agency is responsible for developing and implementing standard operating procedures for carrying out routine operational duties within the fluoridation plant. It must ensure the operation of the fluoridation plant is supervised and operated by competent personnel. Specific operational skills and competencies required for the safe and effective operation of the fluoridation plant and equipment must be incorporated into the water agency's drinking water risk management plan, as per the requirement of r.(8)(f) of the Safe Drinking Water Regulations.

A water agency must ensure it has a sufficient number of trained people available to ensure the fluoridation plant operates at all times.

# 6 Documentation

## 6.1 Documentation for departmental approval

Under the Act, before adding fluoride to any public water supply, a water agency is required to submit plans and specifications to the department for the proposed plant.

In the case of a fluoridation plant modification or upgrade (Refer to 2.4.1), the department must be consulted in advance and, if required by the department, the water agency must submit documentation for approval to fluoridate the water supply.

A water agency must submit the following documentation to the department for assessment and approval:

- The drinking water supply and water sampling localities proposed to be supplied.
- Plans and specifications, including:
  - general description of the plant and process, including an outline of the overall treatment process, description of the fluoridation plant and its design capacity, expected minimum and maximum flows in normal operations and the expected growth of flows with time
  - a location map, a site plan, and a 'general arrangement' showing the fluoridation plant in the context of the overall water treatment plant
  - evidence of the chemical selection process, natural fluoride content and the fluoride dose concentration
  - fluoride design control limits, maximum pumping rate, feed rate and dose calculations
  - functionality of the fluoridation plant, including details of intended process control, process and instrumentation (including process and instrumentation design), control philosophy for the proposed plant and integration into the overall treatment process
  - risk assessments, including the fluoride chemical selection process, chemical quality assurance processes, supply and delivery risks, storage risks and the prevention or control of dosing risks associated with human error, plant malfunction and plant performance
  - specification limits developed for contaminants of the selected fluoride chemical
  - plans showing the spatial relationship (including levels) between the storage and metering facility and the injection point, the relationship between the injection point for fluoride and for any other chemicals added 'post treatment', and the pipeline layout from the injection point downstream to the next component in the plant such as the clear water storage
  - measurement of fluoride, the monitoring program and chemical quality assurance.
- An assessment of the proposed design against the requirements of the code of practice, providing justification for any deviations from the requirements of the code of practice and demonstrating an equivalent or greater level of safety.
- Project plan including timelines.
- Commissioning plan addressing water quality risks and change management risks from the new or replaced fluoride dosing system.
- Responses to recommendations from the technical appraisal.
- Additional information requested by the department.

## 6.2 Documentation after departmental approval

Upon completion of plant construction and commissioning, documentation relating to approved fluoridation plants must be incorporated in the water agency's quality management system. Staff must be aware of the location of these documents and be familiar with their content once the plant has been commissioned.

A water agency must maintain the following documentation:

- An operation manual including as-constructed drawings and functional description. The operation manual should be a controlled document and must contain adequate provisions and details to assist the operational staff in the operation and maintenance of the plant.
- An emergency management plan. This must be integrated into the drinking water risk management plan under the SDWA and in accordance with r. 8(1)(c) of the Safe Drinking Water Regulations. This includes details of arrangements and procedures to manage incidents and emergencies, including fluoride overdosing, spills entering the environment and operator exposure. It must address:
  - procedures for shutting down the plant in the event of overdosing
  - actions required to identify and rectify the problem
  - actions to advise and protect the public of a significant overdosing event
  - reporting protocols including a clear chain of communication and designated responsibility.
- Maintenance and calibration schedules for major equipment items.
- Commissioning records verifying that the fluoridation plant installation is in accordance with the plans and specifications and its operation is safe and reliable.

## 6.3 Record keeping

The water agency must keep records verifying that the fluoridation plant is managed and operated in accordance with the code of practice. The manner in which this information is recorded and stored (such as log sheets and SCADA) should be determined by the water agency in a manner consistent with the objectives of the code of practice and the Act.

Records include:

- regular chemical analysis of the fluoride chemical delivered
- regular analysis of the fluoride concentration in raw water (frequency determined by the variability in the source water)
- plant and equipment calibration and maintenance
- routine testing of critical alarms and corrective actions and results of the system shutdown tests
- surveillance monitoring and audit records
- staff training records.

The water agency must also record the following parameters at the minimum frequencies indicated:

- continuously
  - water flow
  - online fluoride concentration
  - fluoride chemical/solution flow (if implemented)
- daily
  - the volume of water treated
  - the quantity (mass or volume) of fluoride chemical added to the water
  - the weight and/or level of the day tank before refilling and following refilling
  - the amount of fluoride stored
  - average fluoride concentration over the day on the basis of the online fluoride analyser records
  - average fluoride concentration over the day on the basis of the loss of mass and/or volume in the day tank

  - average fluoride concentration over the day on the basis of the volume measured by chemical flow meter (if implemented)
  - a reconciliation of the measured fluoride concentration (based on online analyser records) with the calculated fluoride concentration (based on day tank weight or loss of volume or measured volume from the chemical flow meter)
- weekly
  - the results of fluoride analysis of water samples taken from fluoridated water (online versus benchtop fluoride analyser)
  - the results from weekly sampling in each water sampling locality/water supply receiving fluoridated water
  - average weekly fluoride concentration using total weekly figures of water treated and fluoride used
- monthly
  - the fluoride concentration from quality control verification sample.

# 7 Reporting and auditing

## 7.1 Annual reporting

The SDWA requires water suppliers and water storage managers to give the department a report each financial year covering issues relating to the quality of drinking water and management of the water supply. Regarding fluoride, the water agency is required to include information pertaining to water fluoridation for every fluoridated water supply. The reporting requirements for fluoride is included in the water quality annual report guidance note and apply to all drinking water supplies in Victoria. The reporting requirements include:

- the annual average, minimum and maximum fluoride concentrations at each water sampling locality, water supply and fluoridation plant
- a summary of incidents and emergencies reported during the year
- a summary of the fluoridation process and chemicals used at each fluoridation plant (including fluoridation plants operated by an upstream water storage manager).

## 7.2 Notification requirements

The department's Water Unit must be notified of emergency and exceptional situations as described in Table 3.

All events requiring notification must be investigated by the water agency and a report provided to the department in a timely manner.

## 7.3 Auditing

Under the SDWA, risk management plans are externally audited. Sites with fluoridation plants may be selected for auditing purposes. The water agency's water fluoridation activities must be integrated into the water agency's risk management plan.

**Table 3: Emergency and exceptional notifications**

| Emergency and exceptional situation | Method of notifications |
|---|---|
| Fluoride concentration in drinking water supplied, or to be supplied, exceeds or may exceed 1.5 mg/L. | Immediate verbal reporting followed by written reporting within 24 hours as per s. 22 of SDWA reporting requirements. |
| Fluoride concentration in drinking water measured at the fluoridation plant exceeds 1.5 mg/L, however, does not enter the drinking water supply. | An email detailing the issue to be sent to <water@dhhs.vic.gov.au> within 24 hours of the issue occurring. |
| Fluoride concentration in drinking water measured at the fluoridation plant is less than 0.6 mg/L (the lower action process limit) for a continuous period of > 72 hours. | An email detailing the issue to be sent to <water@dhhs.vic.gov.au> within 24 hours of the issue occurring. |
| The rolling annual average fluoride concentration of drinking water supplied or to be supplied exceeds or is expected to exceed 1.0 mg/L in any 12-month period. | An email detailing the issue to be sent to <water@dhhs.vic.gov.au> within 10 days of the issue being identified. |
| The rolling annual average fluoride concentration of drinking water supplied or to be supplied is outside the department's specified operating range in any 12-month period. | An email detailing the issue to be sent to <water@dhhs.vic.gov.au> within 10 days of the issue being identified. |

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# Further information

**Department of Health and Human Services**

**<https://www2.health.vic.gov.au/public-health/water/water-fluoridation>**

**1800 651 723**

**water@dhhs.vic.gov.au**