Water Fluoridation

Code of Practice

Revised September 2010

Water Quality Unit
Environmental Health Branch

Water Fluoridation Code of Practice

Water Fluoridation Act 2008
Water Fluoridation Regulation 2008

September 2010

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i) Foreword

Water fluoridation involves the adjustment of the level of fluoride in public water supplies to achieve optimal levels for the prevention of dental caries. Queensland Health recognises that this important public health measure must be conducted safely and effectively to ensure appropriate health benefits for the community.

The Water Fluoridation Code of Practice (the Code) defines the operational criteria needed to meet the requirements of the *Water Fluoridation Regulation 2008* as well as the relevant workplace health and safety, and environmental legislation. The Code identifies criteria to ensure that fluoride dosing facilities are established and operated in a safe manner and applies to all new and existing fluoride dosing facilities in Queensland. The Code has been endorsed by the following organisations:

- Queensland Health
- Department of Environment and Resource Management
- Department of Infrastructure and Planning
- Department of Employment, and Industrial Relations
- Queensland Water Commission
- Queensland Water Directorate
- Local Government Association of Queensland.

Queensland Health recognises and greatly values the contribution of local governments and water boards to improving the health of the community.

The Code was first published in January 2000 following extensive consultation with major stakeholders. Since then all local governments with fluoride dosing facilities have taken steps to ensure that they comply with the Code. These local governments are to be congratulated for their commitment to ensuring this important public health measure is available to their communities.

Sophie Dwyer
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September 2010

ii) Introduction

Fluoridation of drinking water is the most effective means of tackling tooth decay, particularly in areas with high levels of dental caries. Water fluoridation at optimal levels remains the most significant dental public health program in Australia and provides the most cost-effective and socially equitable means of achieving community-wide exposure to the preventive effects of fluoride. Water fluoridation provides the means to reach the entire community regardless of age, socio-economic status, education or individual motivation. Water fluoridation is a very effective public health measure that results in true cost savings as it saves more money than it costs to implement and operate.

Fluoride occurs naturally in varying concentrations in almost all public water supplies. The optimum level of fluoride in the public water supply is the level associated with the maximum reduction of tooth decay in the population balanced against the potential for dental fluorosis. Water fluoridation involves the adjustment of fluoride in public water supplies to achieve the optimum level of fluoride. This important public health measure must be conducted safely and effectively to ensure appropriate health benefits for the community.

Australian and overseas surveys show repeatedly that children living in communities receiving optimally fluoridated water have less tooth decay than children living in communities without a fluoridated water supply. Victorian surveys show six-year-old children in fluoridated areas have 45 percent less decay in baby teeth compared with those living in non-fluoridated areas and 12-year-olds have 38 % less decay[1]. Appropriately designed studies within Queensland showed that children aged 5-12 living in Townsville, a community with optimally fluoridated water, had less tooth surfaces with caries than children living in Brisbane, which did not have a fluoridated water supply[2]. This difference in caries rate per tooth surface corresponds to 45 % fewer surfaces being affected with caries in Townsville than in Brisbane[2]. Studies in Britain show 3 year olds in the fluoridated communities in Yorkshire had 59% less tooth decay, measured as decayed, missing or filled teeth per child, than those in the non-fluoridated Yorkshire communities[3].

The majority of the Australian population now live in an area where fluoride levels have been adjusted to achieve an optimally fluoridated water supply. It is estimated that over 350 million people are currently receiving optimally fluoridated water worldwide[4] including communities in the United States, the United Kingdom, Ireland, Israel, New Zealand, Canada, Malaysia, Singapore and Hong Kong.

Water fluoridation is supported by Queensland Health and has been endorsed as a safe and effective public health measure by more than 150 science and health organisations, including the National Health and Medical Research Council (NHMRC), Australian Dental Association, International Dental Federation (FDI), the International Association for Dental Research (IADR), and the World Health Organisation (WHO).

iii) Aim

The aim of the Code is to help relevant Public Potable Water Suppliers meet the various regulatory requirements and to help them achieve best practice in the design, installation and operation of fluoride dosing facilities in Queensland, benchmarked against Australian and international standards. Where appropriate, the Code has adopted the requirements contained in the NSW Health's *Code of Practice for the Fluoridation of Public Water Supplies,* with the aim of achieving consistency across jurisdictions. The Code is intended to complement, and should be read in conjunction with, the following key legislation:

Water Fluoridation Act 2008
Water Fluoridation Regulation 2008
Workplace Health and Safety Act 1995
Dangerous Goods Safety Management Act 2001
Environmental Protection Act 1994

iv) Legislative framework

The Water Fluoridation Act refers to a "relevant public potable water supply." This is a water supply supplying drinking water to a population of 1000 people or more. All public potable water suppliers supplying a relevant public potable water supply must add fluoride to that supply, unless they apply for and receive an exemption. The number of members of the public being supplied potable water by a relevant public potable water supply will be determined by Queensland Health using the most recent Census of Population and Housing data published by the Australian Bureau of Statistics.

Under Part 3 section 8 of the Act, the Health Minister may grant an exemption from the requirement to fluoridate where:

- The water supply contains natural average fluoride concentrations within or above the prescribed fluoride concentrations in the Water Fluoridation Regulation
- The water supply, due to the natural water chemistry, cannot maintain fluoride levels in the water at the concentrations prescribed in the Water Fluoridation Regulation or
- The addition of fluoride to the water is unlikely to result in substantial ongoing health benefit to the community and the numbers of members of the public that consume water from the water supply is less than 1000.

A water supplier who is not required to add fluoride to their water supply (e.g. A supplier supplying water to less than 1000 people) may add fluoride to a public potable water supply at their discretion. Such a water supplier will then be subject to the same requirements under the Water Fluoridation Act and Regulation as a water supplier for a relevant public potable water supply.

The Water Fluoridation Act requires that, 30 days prior to the commencement of adding fluoride to a public potable water supply, all water suppliers must give a fluoridation notice, in the approved form, to the Chief Executive of Queensland Health and publish the fluoridation notice at least once in a newspaper circulating in the area of the state serviced by the water supply. A fluoridation notice is a notice stating that the water supplier intends to add fluoride to the public potable water supply from a stated date.

v) Implementation of Water Fluoridation in individual treatment plants

Section 4 and Schedule 1 of the Water Fluoridation Regulation provides information on the prescribed periods by which the addition of fluoride must commence. Copies of the Water Fluoridation Regulation can be found online at:

http://www.legislation.qld.gov.au/LEGISLTN/CURRENT/W/WatrFluorR08.pdf

If there are any queries regarding this list, Queensland Health should be contacted by email at fluoride@health.qld.gov.au. Alternatively you can contact Queensland Health's Water Quality Unit at:

PO Box 2368
Fortitude Valley BC 4006
Telephone: (07) 3328 9310
Fax: (07) 3328 9354

vi) Terminology

In this document this Water Fluoridation Code of Practice is referred to as the Code.

Throughout this document the use of "must" implies that there is a legislative requirement for the procedure or equipment. The word "should" implies that the procedure or equipment is consistent with the best practice approach detailed in the Code. Queensland Health recommends that all performance criteria and minimum standards detailed in the Code be achieved at all times.

In this document the term *water suppliers* means "a public potable water supplier for a relevant public potable water supply" as well as "public potable water suppliers who opt to add fluoride at their discretion'. In most instances, the water supplier is responsible for the operation of the fluoride dosing facility and the management of the reticulation system. However, in some instances the fluoride dosing facility and reticulation system will be operated by different entities. To provide for this situation, the Code uses the terms:

- *fluoride dosing facility operator* for the entity that operates the fluoride dosing facility that adds fluoride to the water supply; and
- *reticulation system manager* for the entity that is responsible for reticulating the fluoridated water.

vii) Structure of the Code of Practice

The Code has been designed to provide performance solutions to meet the statutory requirements of the Water Fluoridation Act and Regulation and ensure the safe operation of fluoride dosing facilities.

The Code covers a number of subject areas. Within each area there is a table with performance criteria and minimum standards. The performance criteria reflect the fundamental intent of the Code and should remain the focus of water suppliers at all times. Minimum standards are the minimum requirements for achieving the performance criteria. In some instances guidance notes are available to provide further explanation and give acceptable solutions to meet the performance criteria and minimum standards.

The performance criteria and minimum standards are presented in table form with the performance criteria in column 1 and the minimum standards in column 2. Relevant guidance notes including acceptable solutions (where relevant) are provided immediately following the table.

viii) Fluoride chemicals

The fluoride chemicals prescribed under Section 5 of the Water Fluoridation Regulation are listed in Table 1, together with their alternative names. The National Health and Medical Research Council (NHMRC) Australian Drinking Water Guidelines, 2004[5] states that these chemicals are suitable for use in drinking water.

Table 1: Fluoride chemicals used in treatment of drinking water

Fluoride compound	***Formula***	***CAS No.***	***Alternative names***
Sodium fluorosilicate	Na_2SiF_6	39413-34-8	Sodium silicofluoride, Disodium hexafluorosilicate
Fluorosilicic acid	H_2SiF_6	16961-83-4	Hexafluorosilicic acid, Dihydrogen hexafluorosilicate
Sodium fluoride	NaF	7681-49-4	Sodium monofluoride

ix) Risk management

Risk management is a holistic management process aimed at managing those risks which could adversely impact upon an organisation's objectives. For water suppliers, risks that jeopardise workers' health and safety, as well as those that may jeopardise the provision of safe and optimally fluoridated water, are likely to rank highly. It is therefore highly recommended that water suppliers develop appropriate risk management systems for both workplace health and safety and water fluoridation risks and incorporate this documentation into an overall risk management system.

In accordance with the requirements of the *Water Supply (Safety and Reliability) Act 2008,* all drinking water service providers will be required to operate under an approved Drinking Water Quality Management Plan (DWQMP) by July 2013. These management plans are essentially risk management systems and all drinking water providers operating a fluoride dosing facility will need to address the risks associated with their fluoride dosing facility in their DWQMP. The *Water Supply (Safety and Reliability) Act 2008* is administered by the Department of Environment and Resource Management (DERM) through the Office of the Water Supply Regulator (OWSR). DERM's requirements for DWQMPs can be accessed via the DERM web site at: www.derm.qld.gov.au.

Various risk management frameworks have been developed by a number of proponents, however, risk management usually consists of the following steps in some form:

- establishing the context
- identifying risks
- assessing risks
- evaluating risks in light of context
- identifying and implementing appropriate control measures
- monitoring
- record keeping
- communication with stakeholders and regular review

Risk management frameworks that drinking water providers may be familiar with, and would be appropriate for adoption in the context of managing fluoridation risks, include:

- HAZard and OPerability analysis (HAZOP)
- Hazard Analysis and Critical Control Point (HACCP) principles
- The 12 risk management principles (also known as 'the 12 elements') discussed in the Australian Drinking Water Guidelines 2004
- The risk management methodology detailed in Australian Standard 4360 – Risk Management or ISO 31000 – Risk Management and Principles

Site-specific risk assessments for both workplace health and safety issues as well as fluoride dosing issues should actively involve the design team, the fluoride dosing facility operator and (if applicable) the reticulation system manager. Involving a cross section of staff will help ensure the resulting risk management system is relevant and understood by those staff involved in water fluoridation activities.

Where risks are identified, appropriate control measures should be identified, implemented and monitored. Control measures should be based on the hierarchy of controls. That is, wherever possible hazards should be eliminated. If elimination is not possible, hazards should be controlled using engineered control methods.

The outcome of the risk assessment and a description of control measures should be documented in a risk management plan. It is likely that certain supporting documents will need to be developed, such as Standard Operating Procedures (SOPs), to help ensure risks that could affect the continuous and safe dosing of fluoride are eliminated or at least minimised.

The risk management systems should be reviewed on a regular basis. Any changes to the water treatment plant or the fluoride dosing facility that may impact on the original risk assessment should trigger a review of the risk management plan.

Water suppliers may wish to seek the assistance of a suitably qualified consultant to assist in the development of appropriate risk management systems.

Managing Dosing Risks

Under the *Water Fluoridation Regulation 2008* water suppliers are required to fluoridate at a prescribed concentration when averaged over a quarter. Further to this, the *Public Health Regulation 2005* prescribes a maximum fluoride concentration of 1.5mg/L, where fluoride is added to the water supply. A detailed risk assessment should therefore be carried out to assess any risks which may prevent fluoride dosing to occur continuously at the prescribed concentration.

As mentioned previously, it is important to employ a cross-section of the organisation's employees involved with water fluoridation, in some way, so that as many of the potential risks are identified as possible and so that appropriate and practical control measures can be developed.

The risk assessment should be site-specific and encompass, at a minimum, those risks associated with equipment, dosing, chemical supply, staffing, recording, reporting, and analyses. Some examples of risks that need to be addressed include those that are related to:

- Incorrect operation of flow meters and/or flow switches;
- Incorrect understanding of the control philosophy of the fluoride dosing system among operational staff;
- Inadequate incident management planning and incorrect responses to 'out of specification' operations;
- Inadequate record keeping and analysis of results;
- Inadequate communication protocols for issues that affect the operation of the fluoride dosing facility; and
- Offtakes before storage reservoirs.

This fluoride dosing risk assessment process should form part of an overall risk management plan and any risk assessment documents should be retained by the water supplier.

Managing Workplace Health and Safety Risks

Water suppliers also have certain responsibilities under the *Workplace Health and Safety Act 1995* to ensure a safe working environment for their employees. Many workplace health and safety risks can be eliminated or reduced simply through appropriate workplace design. Therefore, it is important that in the preliminary design stage for each fluoride dosing facility, that a risk assessment is carried out to identify and eliminate, or help manage, any workplace health and safety risks.

The risk assessment should be site-specific and encompass the design of the entire plant including facilities, hardware, systems, equipment, products, tooling, materials, energy controls, layout and configuration. Again, the risk assessment process should form part of an overall risk management plan and any risk assessment documents should be retained by the water supplier.

Safety in design principles should be followed in the design of the fluoride dosing facility. The Queensland Plant Code of Practice, 2005 provides general information on safety in design at the Workplace Health and Safety website at:

www.deir.qld.gov.au/workplace/law/codes/plant/index.htm

Workplace Health and Safety Queensland can be contacted at:

Phone: 1300 369 915

Internet: http://www.deir.qld.gov.au/workplace/aboutus/contactus/whsenquiry.htm

1. Design criteria for all fluoride dosing facilities

There are a variety of different fluoride delivery systems available for use in fluoride dosing facilities. Design criteria in this section apply to all fluoride dosing facilities.

1.1. Design criteria for all fluoride dosing facilities

Performance criteria	Minimum standard
P 1.1.1 • The water suppiler must ensure the fluoride dosing facility is designed to ensure operator safety and safe fluoride addition.	**MS 1.1.1.A** • The fluoride dosing facility operator must ensure that the legislative requirements of the Water Fluoridation Act and Water Fluoridation Regulation are met.
	MS 1.1.1.B • A risk assessment should be completed before the fluoride dosing facility is designed to ensure that safety considerations have been addressed. The risk assessment should address risks related to operator safety and the safe addition of fluoride to the water.
	MS 1.1.1.C • All structures and installations, including bunding, must be designed and built to comply with all relevant legislation.
	MS 1.1.1.D • The fluoridation room should be purpose designed for the type of fluoride dosing system it will house. • The fluoridation room should be designed to allow easy cleaning and removal of spilt fluoridation chemical. • A hose and stop cock should be provided in the fluoridation room.
	MS 1.1.1.E • The fluoride dosing facility must be designed in such a way as to be conducive to easy operation, safe work practices and easy maintenance
	MS 1.1.1.F • A laboratory where fluoride analyses can be performed should be located in close proximity to the fluoride dosing facility and should contain appropriate resources to ensure accurate fluoride analysis.

Guidance notes for MS 1.1.1. B

- The risk assessment process, discussed in part ix of the Code should be initiated in the plant design stage. Safety in design should incorporate hazard identification, risk assessment and risk management methods early in the design process to eliminate or minimize the risk of injury or overdosing throughout the life of the fluoride dosing facility.
- Under Workplace Health and Safety legislation, risks arising from a plant at workplaces must be controlled in accordance with the Queensland Plant Code of Practice 2005. Plant includes (a) machinery, equipment, appliance, pressure vessel, implement and tool; (b) personal protective equipment; and (c) a component of plant and a fitting, connection, accessory or adjunct to plant. The Queensland Plant Code of Practice 2005 provides practical advice on ways to manage risks related to the use of a plant, including its safe design, manufacture and installation. It outlines the obligations of persons involved with a plant and provides information on risks and their control. A plant should be designed in accordance with acceptable engineering principles and relevant standards. A risk assessment should be conducted to identify risks and implement controls to minimise risk.

Guidance notes for MS 1.1.1. D

- The floor of the fluoridation room should be made of concrete.

Guidance notes for MS 1.1.1. E

- Careful thought needs to be given to the physical layout of equipment within the fluoridation room so that the operator safety can be assured. For example, trip hazards and items that people may walk into or hit their heads on should be avoided.
- The installation of all equipment, valves, controls and access points should facilitate easy access for all expected operational and maintenance requirements (e.g. relative locations, mounting height and general access).

Guidance notes for MS 1.1.1. F

- If a laboratory is not already available, it should be sited in an area separate from but in close proximity to the fluoridation room. It should contain appropriate fittings (eg: power, water supply and equipment) to enable the required analyses to be carried out.

1.2. Design criteria for fluoride dosing facilities using dry chemical

Design criteria in this section apply only to fluoride dosing facilities that use dry chemical for the fluoridation of water.

Performance criteria	Minimum standards
P 1.2.1. • The water supplier must ensure that a fluoride dosing facility using dry fluoride chemical is designed to provide a safe working environment and facilitate safe working practices for operators and safe fluoride addition.	**MS 1.2.1. A** • An appropriate dust management system should be included in the plant design to prevent escape of powder into the fluoridation room and maintain acceptable air quality. • The bag loader for filling a storage hopper should have a dust extraction fan, vented to an appropriate location outside of the fluoridation room.
	MS 1.2.1. B • The design of the fluoridation room should prevent any potential for the build up of powder, from air deposition, over time. • The fluoridation room ceiling should be designed to prevent dust accumulation on roof beams and other surfaces. • The internal walls and ceilings of the fluoridation room should have smooth surfaces to prevent dust accumulation and simplify cleaning.
	MS 1.2.1. C • Dry fluoridating agents should not be allowed to escape from the fluoridation room to the external atmosphere. • Doors and walls of the fluoridation room should be flush with no gaps.
	MS 1.2.1. D • The design of the plant should minimise the need for manual handling. Where manual handling is necessary, the design should minimise the number of lifts required, the amount of bending, and the distance and height through which bags are lifted.
	MS 1.2.1 E • Fluoridation equipment must be kept separate from other water treatment plant equipment in a separate building or room (the 'fluoridation room'). • Control panels, such as electrical control panels for the fluoride dosing facility should be located outside of the fluoridation room.

	MS 1.2.1. F • The capacity of the storage/feed hopper should be sufficient to ensure continuity of fluoridation but should not exceed seven days supply. • If, due to operational and/or workplace health and safety considerations the capacity of the storage/feed hopper exceeds seven days supply additional control measures should be incorporated to ensure the risk of overdosing is not increased.

Guidance notes for MS 1.2.1. A
The design of the dust management systems should take into account the total process from unloading the bags into storage hoppers, powder transport from the hoppers to the feeders and from the feeders into the dosing solution. Depending on the size of the hopper and fluoridation room, the use of two ventilation systems may need to be considered.

Guidance notes for MS 1.2.1. B
A suitable smooth surface for internal walls and ceilings would include gloss paint. Windows should have no ledges.

Guidance notes for MS 1.2.1. C
The use of doors with rubber seals and airtight windows should be considered. The storage and handling of sodium fluorosilicate and sodium fluoride must comply with requirements under the *Dangerous Goods Safety Management Regulation 2001.* Australian Standard 4452 applies to the storage and handling class 6.1 (toxic) dangerous goods (such as sodium fluorosilicate and sodium fluoride). Consequently, it is highly recommended that this standard be consulted early in the design phase. Systems such as dust exhausts blowing down into external water tanks can be used to capture fluoride dust.

Guidance notes for MS 1.2.1. D
The design should consider the use of hand operated pallet forklifts, the matching of the height of the fluoride loading floor with the tray of the delivery truck, use of self raising pallet systems to maintain the same 'lifting' level as bags are taken off a pallet for loading into the storage hopper – this minimises the need to bend further as the pallet empties.

Guidance notes for MS 1.2.1 E
Electrical control panels should be located outside the fluoridation room for dry chemical fluoride dosing facilities to minimise deterioration due to corrosion and to minimise the need for entry into the room for operational and maintenance staff.

The control panels should be in a separate room adjacent to the room containing the fluoridation equipment. In these instances, the room containing the control panels should have a separate entry door with no interconnecting door or other means by which air can pass between the two rooms. There should be a window in the common wall between the fluoridation room and the control panel room to allow operators to have a clear view of the dosing equipment when operating the control panel.

If it is not practical to separate the fluoride dosing facility from the control panels, the risks of corrosion can be managed with effective house keeping, dust extraction and dust control measures outlined further in the Code.

The separation of fluoride dosing facility from the control panels is still strongly recommended for fluorosilicic acid plants.

Guidance Note for MS 1.2.1 F
It is recommended that the capacity of the storage/feed hopper not exceed seven days supply due to the associated risk of overdosing.

Should the capacity of the storage/feed hopper exceed seven days supply due to operational and/or workplace health and safety issues, additional control measures should be incorporated into the design and operation of the fluoride dosing facility to negate the increased risk of overdosing. Such control measures may include, but not be limited to, the use of online weight-loss monitors and/or online fluoride analysers. Appropriate corrective actions for these additional control measures should also be developed before operation begins.

1.3. Design criteria for fluoride dosing facilities using fluorosilicic acid

Design criteria in this section apply only to fluoride dosing facilities that use fluorosilicic acid for the fluoridation of water.

Performance criteria	Minimum standards
P 1.3.1. • The water supplier must ensure that a fluoride dosing facility using fluorosilicic acid is designed to provide a safe working environment and facilitate safe working practices for operators and the safe fluoride addition.	**MS 1.3.1. A** • Corrosive fumes associated with fluorosilicic acid should be removed from the fluoridation room via mechanical ventilation and venting of fume sources, such as internal storage tanks, to an appropriate outside location. Acid fumes should be maintained at a level below occupational exposure standards.
	MS 1.3.1. B • Storage and handling systems such as carboys, drums, day tanks, indoor bulk storage tanks and graduated calibration tubes should be sealed and vented back to the bulk storage tank or directly to the outside of the fluoridation room.
	MS 1.3.1. C • All tanks containing fluorosilicic acid should be in a bunded area. This includes the day tank and the bulk storage tank. The bunded area should have sufficient capacity to comply with the relevant Australian Standard.
	MS 1.3.1. D • Fluorosilicic acid equipment must be kept separate from other water treatment plant equipment in a separate building or room (the 'fluoridation room'). • Control panels, such as electrical control panels for the fluorosilicic acid should be located outside of the fluoridation room.

Guidance notes for MS 1.3.1. A

- Fluorosilicic acid is corrosive and will give off acidic fumes. These fumes will affect the air quality and increase corrosion rates of equipment in the fluoridation room. Fumes from internal storage tanks should be minimised through sealing of the tank and extending vents outside the building. Water seals can be used on the tank overflow outlet if the bunded area is internal to the room. An exhaust fan should be installed to remove the fumes from the fluoridation room. The location of the fan and room vents should be chosen to maximise cross flow ventilation of the room. If exhaust fans are used, they should be acid-fume resistant, designed for continuous operation and vented to open air away from doors, windows and air inlets and any area that may be accessed outside the fluoridation room.

Guidance notes for MS 1.3.1. B & C

- Storage and handling of fluorosilicic acid must comply with requirements under the *Dangerous Goods Safety Management Regulation 2001.* This includes making provision for spill containment systems for leaks and spills from the storage and handling systems. Bunded areas can be used to achieve this as long as they can contain sufficient volume such that no acid can escape into the environment. Australian Standard 3780 states that for class 8 (corrosive) dangerous goods, the bunding capacity must be at least 100 % of the combined capacity of the containers (up to a total 3000L) plus a recommended 10% of the combined storage capacity under the standard. Other requirements apply to the design and construction of the bunding and as a consequence AS 3780 should be consulted early in the design phase.

Guidance notes for MS 1.3.1 D

- Electrical control panels should be located outside the fluoridation room for fluorosilicic acid plants to minimise deterioration due to corrosion and to minimise the need for entry into the room for operational and maintenance staff.
- The Control panels should be in a separate room adjacent to the room containing the fluoridation equipment. In these instances, the room containing the control panels should have a separate entry door with no interconnecting door or other means by which air can pass between the two rooms. There should be a window in the common wall between the fluoridation room and the control panel room to allow operators to have a clear view of the dosing equipment when operating the control panel.

2. Operational controls for all fluoride dosing systems

Operational controls should be incorporated into the design of the fluoride dosing facility to ensure it can consistently achieve the prescribed concentration. The operational controls in this section apply to all fluoride dosing facility dosing systems regardless of the type of the fluoridation agent used.

2.1. Operational controls for all fluoride dosing systems

Performance criteria	Minimum standards
P 2.1.1 • The water supplier must ensure that the fluoride dosing facility is designed to consistently achieve the prescribed fluoride concentration in accordance with the requirements of the Water Fluoridation Regulation.	**MS 2.1.1. A** • The design of the plant must incorporate at least two water flow-measuring devices, one of which must be a flow meter.
	MS 2.1.1. B • All key components of the fluoride dosing system must be interlocked to ensure dosing system shutdown on the failure of any equipment in the fluoride dosing system and to ensure that the dosing system is paced to the flow of the water and as such cannot operate unless water is flowing. • All key components should be alarmed to alert the operator of a failure in the system. The alarm system should incorporate the appropriate technology to alert an operator if the plant is unattended.
	MS 2.1.1. C • Feeding or dosing systems should be able to accurately deliver the required volume or weight of fluoridation chemical for the quantity of water being treated. • Feeding or dosing systems should be sized appropriately to enable the delivery of the required volume or weight of fluoridation chemical to meet the prescribed fluoride concentration when the treatment plant is running at maximum flow rate.
	MS 2.1.1. D • It should be made physically impossible for any component of the fluoridation feeding or control equipment to be manually plugged into standard electrical outlets for continuous operation. • Automatic fluoride dosing equipment should be used and should be operated in automatic mode to prevent unattended manual operation. Equipment should be designed such that it is impossible for it to be switched to manual mode.

Guidance notes for MS 2.1.1. A

- The fluoride dosing system must be designed to consistently achieve the prescribed fluoride concentration for the relevant local government area detailed in Section 6 of the Water Fluoridation Regulation.
- Two separate physical indications of water flow through the plant should be hard wired in series, either directly or via PLC (programmable logic controller) coding, in the control loop for starting and stopping the fluoride dosing facility. One indicator of water flow must be a flow meter that measures flow into which the fluoride is being dosed. The failure of either one of the devices should stop the fluoridation dosing system from operating. That is, they must be interlocked. Flow-measuring devices should be appropriately located to enable the fluoride dosing equipment to be paced to water flow over the full range of flow rates for the water treatment plant.
- The physical indicators of water flow through the plant can be via two flow meters or by a combination of a flow meter with a flow-sensing device such as a flow switch. Reliance on a single primary flow-sensing device can significantly increase the risk of overdosing, as a fault or failure could lead to the fluoride dosing facility continuing to dose after the water flow has actually stopped. Care should be taken in selecting the most appropriate devices for this purpose.
- Flow-measuring devices should measure both the rate of flow and total volume of flow. This is critical to the accuracy and reliability of the entire process. Where possible the use of electromagnetic flow meters is recommended as they can achieve an accuracy of ± 1-2%.
- For a gravity flow supply, the first flow signal could originate from a flow meter (upstream location) and the second signal could come from a secondary flow-based measuring device or control device installed on the downstream side of the dosing point. The flow indication or flow measuring device should be positioned to provide a true representation of flow through the plant.
- For pumped supplies, the fluoride-dosing pump should be electrically interlocked with the pump supplying water.
- Online monitoring of fluoride concentration in the fluoridated water may also be used as part of the fail-safe system. The online monitoring system can be interlocked with the dosing system to shut it down when the concentration of fluoride exceeds a maximum set point. Further guidance on maximum set points is given in MS 5.3.1. and Guidance notes for MS 5.3.1.

Guidance notes for MS 2.1.1. B

- The risk assessment, as discussed in Part ix of the Code, should include consideration of all possible causes of overdosing and where feasible appropriate electrical or mechanical interlocks and alarms should be designed into the system. This will minimise the risk of fluoride overdosing and facilitate timely intervention by operational staff where required. The assessment should be documented, stored, and made available upon request by an authorised person under the Water Fluoridation Act.
- The key components of a fluoride dosing system would include stop/start/pacing signals, feeders, dosing pumps, solution transfer pumps, solution tank levels, mixers and dilution water pumps. The failure of any of these key components should result in alarms being generated and operational staff responding.

Guidance notes for MS 2.1.1. C

- Fluoride dosing systems, including pumps, should be sized appropriately so that the dosing pump, running at full capacity, delivers as close as practicable to the desired fluoride dose when the plant is running at the maximum flow rate. The size of the fluoride dosing system should be such that fluoride chemical can not be delivered into treated

water at concentrations that lead to an exceedance of 1.5 mg/L of fluoride in the reticulation system.

- Electronically controlled pumps should be locked with a code to ensure the operational staff cannot inadvertently set the pump to a rate that may result in an overdose.

Guidance notes for MS 2.1.1. D

- Dosing pumps or electrical controls at small water treatment plants are sometimes wired with standard single or three phase power plugs to facilitate removal for maintenance by non-electrical staff. This is not recommended for fluoride dosing facilities.

Performance criteria	Minimum standards
P 2.1.2. • The water supplier should ensure that the fluoride dosing facility is designed to prevent backflow of fluoridating agent into the water supply.	**MS 2.1.2.** • The water supply for making up each batch of fluoridating solution should have a backflow prevention device, such as an air gap, fitted upstream of the point where the fluoridating agent is diluted (e.g. mixing tanks) or injected (e.g. dosing pumps). The device should comply with the relevant Australian Standards.

Guidance notes for MS 2.1.2.

It is important that fluoridating agent is not syphoned backwards into the solution water system should a failure of the solution water system occur. This possibility could cause problems to other equipment, create a health hazard, or result in an environmental release.

Performance criteria	Minimum standards
P 2.1.3. • The water supplier should ensure that the fluoride dosing point will allow adequate mixing of fluoride chemicals with water being fluoridated.	**MS 2.1.3.** • The fluoride dosing point should be located where adequate mixing with water being fluoridated water can occur. • The fluoride dosing point should be located so that other water treatment chemicals and processes do not interfere with adequate mixing.

Guidance notes for MS 2.1.3.

- The dosing point should occur after any coagulation, filtration and pH adjustment to avoid substantial losses that can occur if fluoride reacts with other water treatment chemicals such as aluminium, calcium or magnesium. This can cause the fluoride to form a precipitate and thereby cease to be in solution, reducing its effectiveness.
- A storage (e.g. service reservoir) or mixing process designed to achieve adequate mixing should be provided between the fluoride dosing point and any sampling point. Without sufficient mixing the accuracy of results from sampling and analysis cannot be assured.
- Where there is no storage reservoir between the dosing point and water service offtakes, it is strongly recommended that additional control measures be implemented such as installing an online analyser and conducting extra quality control activities. In addition, it is strongly recommended that the emergency response plan contains details on how to ensure that residents serviced before a storage reservoir are not exposed to elevated

levels of fluoride in the event of an overdosing incident.

Performance criteria	Minimum standards
P 2.1.4. • The water supplier should ensure that the design of the fluoride dosing facility will enable operational staff to appropriately measure and control the fluoridation process accurately and in a timely manner.	**MS 2.1.4.** • The plant design should provide the ability to immediately measure the fluoride dose rate. • The plant design should provide the ability to immediately measure water flow and chemical usage. • Plant design should allow operators to be able to perform a gross check that the estimated concentration of fluoride in water is being achieved to within 5% of the prescribed fluoride concentration. • Fluoride plant inspections and dosing calculations should be performed daily.

Guidance notes for MS 2.1.4.

- It is important to provide plant operators with the ability to accurately monitor the fluoride dosing facility and equipment performance. Local indicators that should be considered include water flow, fluoridating agent feed rate, pressure and level indicators, storage levels, equipment status, alarms, ammeters and hours run.

2.2. Operational controls for dry fluoride feed systems

The operational controls in this section apply to fluoride dosing facilities with dry feed systems.

Performance criteria	Minimum standards
P 2.2.1. • The water supplier should ensure that the design of a dry fluoride feed system will minimise the risk of fluoride overdosing.	**MS 2.2.1. A** • Dry fluoride feed systems should include: o a powder unloading system o a storage/feed hopper o a volumetric or gravimetric dry feeder o a dissolving tank with mechanical stirrer o a weight loss system to monitor the weight of fluoridating agent used o a potable dilution water source and o a solution transfer pump (if not gravity fed).
	MS 2.2.1. B • The system should include a water softener where the total hardness of the water used for dissolving sodium fluoride chemical exceeds 75 mg/L as calcium carbonate. This requirement applies only to the water used to make up the fluoride solutions in the mixing tanks and does not apply to the main water supply being treated.

2.3. Operational controls for fluoride batch solution dosing systems

The operational controls in this section apply to fluoride dosing facilities with batch solution dosing systems.

Performance criteria	Minimum standards
P 2.3.1. • The water supplier should ensure that the design of a fluoride solution feed system will minimise the risk of fluoride overdosing.	**MS 2.3.1. A** • Fluoride batch solution feed systems should include: o two batching tanks with mechanical mixers o a dilution water meter o a potable or filtered dilution water source o a method for calibrating dosage rates o a metering pump with pressure relief and o a loading valve on the delivery side of the pump.
	MS 2.3.1. B • The capacity of the tank should be sufficient to ensure continuity of fluoridation but should not exceed seven days supply
	MS 2.3.1. C • Any water supply used for dissolving the fluoridating agent should have a fixed flow rate in order to maintain correct dissolving time in solution.

Guidance notes for MS 2.3.1. A

- The two batching tanks containing the dissolved fluoride chemical should be located in a bunded area.
- Suitable methods for calibrating dose rates include a graduated calibration tube or calibrated dipsticks.

Guidance notes for MS 2.3.1. C

- A positive displacement pump should be used for dosing batch solutions into fluoridated water.

2.4. Operational controls for fluoride saturator systems

The operational controls in this section apply to fluoride dosing facilities with a fluoride saturator system.

Performance criteria	Minimum standards
P 2.4.1. • The water supplier should ensure that the design of a fluoride saturator solution dosing system will minimise the risk of fluoride overdosing.	**MS 2.4.1. A** • A downflow saturator should always contain at least 150 mm of chemical above the top of the media but should not be filled to the top of the tank where it may impede the flow of water into the tank. • An upflow saturator should never be filled so high that undissolved chemical can be drawn into the suction line.
	MS 2.4.1. B • The saturator tank should be designed so that it is possible to visually check the level of undissolved fluoridating agent in the saturator tank.
	MS 2.4.1. C • Fluoride saturator systems should include: o a saturator tank with powder support media o a powder unloader system o a dilution water meter o a potable or filtered dilution water source o a method for calibrating dose rates and o a metering pump with pressure relief and a loading valve on the delivery side of the pump.
	MS 2.4.2. D • The system should include a water softener where the total hardness of the water used for dissolving sodium fluoride chemical exceeds 75 mg/L as calcium carbonate. This requirement applies only to the water used to make up the fluoride solutions in the mixing tanks and does not apply to the main water supply being treated.

2.5. Operational controls for fluorosilicic acid dosing systems

The operational controls in this section apply only to fluoride dosing facilities dosing with fluorosilicic acid.

Performance criteria	Minimum standards
P 2.5.1. • The water supplier should ensure that the design of a fluorosilicic acid dosing system will minimise the risk of fluoride overdosing.	**MS 2.5.1. A** • No more than 24 hours supply of fluorosilicic acid should be connected at any time to the suction side of the chemical feed pump. All bulk storage tanks with more than a 7-day supply should have a day tank. A day tank can contain up to 24 hours supply of acid and the fluoride transfer from the bulk tank to the day tank should be controlled and not occur more than once in any 24 hour period.
	MS 2.5.1. B • All fluorosilicic acid day tanks should be equipped with online weight measurement.
	MS 2.5.1. C • Fluorosilicic acid dosing systems should include: o a day tank o a weighing platform for the acid container o a method for calibrating dose rates o a metering pump with pressure relief and a loading valve on the delivery side of the pump, and o a potable or filtered water source.
	MS 2.5.1. D • Practical controls should be incorporated into the acid dosing system to prevent overdosing by rapid release of the day tank's contents into the water being fluoridated. Methods may include anti-siphon pump controls.

Guidance Note for MS 2.5.1 A

- Fluoride transfer from the bulk tank to the day tank should be initiated manually and stopped automatically and only occur once in a 24 hour period. Manual initiation can include initiation via a SCADA system. Day tanks should be equipped with online weight management to ensure overdosing does not occur. There should be a motorised valve in the line between the bulk tank and the day tank. Another safeguard is to have an anti-siphon and a motorized valve installed in the metering pump discharge line.

Guidance notes for MS 2.5.1. C

- Suitable methods for calibrating dose rates include a graduated calibration tube or calibrated dipsticks.
- A load cell can be provided for online measurement and the accuracy of load cell measurements should be within ± 1% for the range being measured.

3. Water supply system and fluoride dosing facility upgrade

This section applies to any fluoride dosing facility undergoing a system upgrade that will affect the decisions and outcomes of the original risk assessment for the fluoride dosing facility. It does not apply to new fluoride dosing facilities.

Performance criteria	Minimum standards
P 3.1.1. • The water supplier should ensure that initial design risk control measures for controlling risks will not be degraded through subsequent modifications of the fluoride dosing facility and/or the water supply system.	**MS 3.1.1.** • The fluoride dosing facility must comply with the provisions of the Water Fluoridation Act and Regulation and should also comply with the provisions of the Code following any water supply system capacity upgrade or major fluoride dosing facility upgrade. • A new risk assessment should be undertaken if any alteration or modification is made to the fluoride dosing facility. Control measures should be adjusted or implemented accordingly to control any risks arising from the alterations or modifications. • Any alterations or amendments that result in changes to the operation and/or incident response procedures should be communicated to all staff involved in the operation and management of the fluoride dosing facility.

Guidance notes for MS 3.1.1.

- Plant upgrades or water supply system capacity upgrade must not negatively impact on the fluoridation control measures. All changes to the fluoride dosing facility should be recorded in a plant register or via a maintenance management system.
- Modifications to the plant should not increase any workplace health and safety risks to the workers or visitors to the plant.

4. Fluoridation chemicals

This section applies to all fluoride dosing facilities. It provides information on the quality and storage of fluoridation agents

4.1. Quality of fluoridation chemicals

Performance criteria	Minimum standards
P 4.1.1. • The water supplier must ensure that any impurities in the fluoridation chemical used to fluoridate the water supply would not adversely affect public health.	**MS 4.1.1.** • The water supplier must not add fluoride to the water supply if the concentration of impurities is such that it is likely to adversely affect public health • The water supplier must, on the receipt of each batch of fluoridation chemical, obtain a copy of the batch analysis certificate from the manufacturer, importer or supplier. • If a batch analysis certificate is unable to be obtained, the water supplier must arrange for a sample of the fluoridation chemical to be analysed, at a laboratory accredited by NATA for the analysis, to determine the level of any impurities. • The water supplier should develop and use a suitable chemical specification standard. This standard should be used to assess the quality of fluoridation chemical being purchased. The specifications for fluoridation chemicals detailed in Appendix 1 (Tables 1 and 2) should be treated as a minimum standard. • The water supplier should periodically submit samples of fluoride chemical for the full range of parameters listed in Table 3 to further ensure appropriate chemical quality. • The water supplier should ensure that the physical characteristics of the fluoridation chemical or variations in fluoridation chemical strength do not lead to excess variability in the prescribed fluoride concentration in the treated water and should not cause excessive workplace health and safety hazards.

Guidance notes for MS 4.1.1.

- Metals are the main impurities of health significance found in fluoride chemicals, particularly fluorosilicic acid.
- The presence of moisture in powdered chemicals can lead to unreliable feeder operation.
- The level of insoluble matter can increase turbidity levels in the final water.
- Water suppliers should include the requirement for regular full chemical analysis by suppliers in supply contracts. It is also good practice to periodically obtain an independent chemical analysis of shipments of fluoride chemical. Samples may be sent to Queensland Health Forensic and Scientific Services or to a laboratory with NATA accreditation for the analysis required.
- Relevant chemical specifications in relation to contaminant concentrations can be found in

Appendix 1.

- Further information on the approximate purity and fluoride content of fluoridation chemicals is shown in Appendix 1, Table 4.
- Further guidance on contaminants in drinking water chemicals is available in Chapter 8 of the Australian Drinking Water Guidelines, 2004.

4.2. Storage of fluoridation chemicals

Performance criteria	Minimum standards
P 4.2.1. • The water supplier should ensure a continuous supply of fluoride chemical is available at the fluoride dosing facility.	**MS 4.2.1.** • Sufficient fluoride chemical should be available or kept in storage to ensure continuity of water fluoridation.

Guidance notes for MS 4.2.1.

- The risk associated with ensuring a continuous supply of fluoridation chemical is influenced by a number of issues including the quantities involved, transport distance, procurement strategy, general availability of the chemical and access to the treatment facility. For some plants, seasonal conditions (eg: potential for flooding, cyclones) may require the plant to store a few months' supply of chemical on site.

Performance criteria	Minimum standards
P 4.2.2. • The water supplier should ensure that fluoride chemicals are appropriately stored to minimise deterioration.	**MS 4.2.2.** • Fluoridation chemicals must be stored under weatherproof conditions, for example, in a dry environment elevated from the ground • Fluoride chemicals must be stored separate from other water treatment plant chemicals in a separate building or room.

Guidance notes for MS 4.2.2.

- When bags of powdered fluoridating agent become damp or wet they can be very difficult to use in the fluoridation equipment, often leading to increased maintenance and variable fluoride concentrations in the fluoridated water. In more extreme circumstances, the fluoride chemical can become unusable and would need to be disposed. In some situations the use of dehumidifiers or air conditioning can minimise such problems.
- Powdered fluoridating agents should always be stored in an elevated location. A raised platform is one option for both storage and chemical loading to dry feeders or solution tanks.
- Chemical storage areas should be bunded in accordance with the relevant Australian Standard (AS4452 for Sodium fluorosilicate and Sodium Fluoride; AS3870 for Fluorosilicic Acid).
- These Australian Standards should be consulted early in the design phase to ensure compliance with the relevant provisions of the *Dangerous Goods Safety Management Act 2001.*

5. Fluoride dosing facility operation

This section applies to all fluoride dosing facilities. It provides operating targets for fluoride dosing facilities to ensure they comply with the Water Fluoridation Regulation. It also provides information on the measurement of fluoride in water, quality assurance, maintenance, calibration and operator competency.

5.1. Operational considerations

This section of the Code needs to be read in conjunction with the Water Fluoridation Regulation.

Performance criteria	Minimum standards
P 5.1.1. • The water supplier should ensure that the fluoride dosing facility is operated in a manner that ensures the fluoridated water meets the requirements for the prescribed fluoride concentration for the applicable local government area.	**MS 5.1.1.** • The fluoride dosing facility operator must ensure the average measured fluoride concentration over a quarter meets the prescribed fluoride concentration, as per Section 6 and Schedule 2 of the Water Fluoridation Regulation. • The fluoridation dosing facility operator should ensure the fluoridated water complies with the prescribed concentration (±0.1mg/L) at least 95% of the time. • Standard Operating Procedures (SOPs) should be produced and followed for all routine operational duties at the fluoride dosing facility. • If fluoride dosing equipment has not been in operation for a continuous 2 week period, the water supplier must notify the Chief Executive using the approved form, within 1 day of the end of the 2 week period. • If the concentration of fluoride in the fluoridated water exceeds 1.5 mg/L, the water supplier must immediately take corrective actions and notify the Office of the Water Supply Regulator within the Department of Environment and Resource Management.

Guidance notes for MS 5.1.1.

- The fluoride dosing facility operator must take into account the naturally occurring fluoride present in the water supply when adding fluoride to water to maintain the prescribed fluoride concentration in the fluoridated water.
- Some water supplies have fluctuating naturally occurring fluoride concentrations in their raw water, which may present a risk of fluoride overdosing if not assessed accurately. Raw water sampling may be necessary during the initial operating period of the fluoride dosing facility to gain a better understanding of the presence and concentration of any naturally occurring fluoride. It is the responsibility of each water supplier to assess this risk as part of the risk assessment process discussed in part ix of the Code. Online monitors may be needed to consistently monitor the raw water fluoride concentration where fluctuations in naturally occurring fluoride concentrations could affect the ability of the water supplier to maintain the prescribed fluoride concentrations in fluoridated water
- Fluoride dosing facility shutdowns that result in unfluoridated water being delivered to customers should not occur for greater than two weeks per year. If the fluoride dosing facility is non-operational for a continuous period of two weeks the water supplier must

complete and submit a 'Notice of Period of Non-Operation' to the Chief Executive of Queensland Health. A copy of this form can be found in Appendix 5.

- In some instances, the fluoride dosing facility operator and the reticulation system manager may be different entities resulting in the reticulation system manager having no direct control over the fluoride concentration in the water. The fluoride dosing facility operator should have an agreement with the reticulation system manager outlining the procedures to be followed if water cannot be supplied at the prescribed fluoride concentration. This agreement should include a communication process outlining how the reticulation system manager is informed of any disruption to the addition of fluoride to the water or any exceedence of 1.5mg/L. Clearly articulating and establishing these communication procedures is an essential part of Emergency Response Planning (see Part 5.3) and is also important for effectively communicating other water fluoridation issues in a timely manner. Wherever possible, these communication procedures should be integrated into existing reporting arrangements
- If the reticulation system manager is not satisfied that the fluoride dosing facility operator is able to supply fluoridated water at the prescribed fluoride concentration the reticulation system manager may need to contact the Chief Executive of Queensland Health.
- The water supplier should develop SOPs for all routine operational duties within the fluoride dosing facility. The water supplier should provide training to all staff on how to carry out these procedures so there is consistency between operators. All operators should be competent in carrying out these SOPs. The use of SOPs is a clear outcome of integrating quality management principles into routine duties. The use of pictures in SOPs can be quite useful and effective. The SOPs should cover routine daily inspections, management of fluoridating agent (e.g. topping up of day tanks, hoppers, saturators, ordering new stocks), process control decisions, dose corrections, and record keeping.
- The maximum allowable fluoride standard in the *Public Health Regulation 2005* is 1.5 mg/L. Under the provisions of the *Water Supply (Safety and Reliability) Act 2008,* the Office of the Water Supply Regulator (OWSR) requires monitoring and reporting against standards contained in the Public Health Regulation. Exceedances of the fluoride standard must be reported to the OWSR immediately. The OWSR will then notify Queensland Health of the exceedance.

5.2. Measurement (analysis) of fluoride in treated water

This section applies to all fluoride dosing facilities. It provides information on where samples should be taken and how fluoride samples should be analysed.

Performance criteria	Minimum standards
P 5.2.1. • The water supplier must ensure that representative samples of fluoridated water are collected and analysed in accordance with the Water Fluoridation Regulation.	**MS 5.2.1.** • The fluoride dosing facility operator must obtain *at least* 1 sample each day of fluoridated water from a point where the fluoridated water would have a consistent concentration of fluoride. The sampling point location should be far enough downstream from the fluoride dosing point to ensure the fluoride is well mixed, but prior to any customer connection and reservoir or tank. • The reticulation system manager should obtain at least 2 samples each week from well-separated locations in the reticulation system.

Guidance notes for MS 5.2.1.

- Daily sampling serves two purposes. Firstly, it must be used to determine if customers are receiving optimally fluoridated water as required under the Regulation. Secondly, it should be used to determine if the fluoride dosing facility is operating correctly.
- Where fluoride is dosed into a single main, it is often the case that one sampling point can be used for both purposes.
- In such cases it is important to ensure that the sample point is far enough downstream so that the fluoride is well mixed with the treated water but not too far downstream, or after a service reservoir.
- Complex supply networks will require at least two sampling points.
- Where long sample lines are used it is good practice to carry out regular checks to ensure the sample line is not affecting the sample water quality (e.g. compare results taken from each end of the sample line).
- Any daily sampling point must be at a point where the fluoride is well mixed with the treated water to ensure the results are representative.

Performance criteria	Minimum standards

P 5.2.2.
• The water supplier should ensure that the fluoride concentration in water is analysed by trained staff using an accurate and precise method.
	MS 5.2.2.
	• The water supplier must use a method of analysis that has been prescribed under Water Fluoridation Regulation. Prescribed analysis methods include the following:
	  ◦ ion-selective electrode (ISE) method
	  ◦ SPADNS method (see Glossary)
	  ◦ ion chromatography method.
	• Water supplies using an online fluoride analyser must analyse at least one sample each day using a prescribe analysis.

	• The method should conform to the latest edition of Standard Methods for the Examination of Water and Wastewater[6]. • Staff should be appropriately trained in the method used to analyse fluoride. Staff should be trained in following any SOPs associated with fluoride analysis. • The analysis procedure should ensure that the fluoride calibration standard(s), quality control samples and the routine fluoride samples are at the same temperature before proceeding with the analysis.

Guidance notes for MS 5.2.2.

- The ISE and SPADNS methods are included in the Standard Methods for the Examination of Water and Wastewater[6]. The ion chromatography method is not included and is generally only used at specialised analytical laboratories.
- Appropriate spare equipment/parts should be available on site. Only plastic should be used for fluoride samples as the use of glassware (such as bottles, beakers) may lead to lower results due to fluoride interacting with the glass.
- The ISE method is preferred as it is reliable, easy to perform and less affected by interfering substances.
- It is essential that measurements be carried out as described with the use of appropriate, calibrated equipment and reagents of appropriate quality. Failure to do so may lead to inaccurate results and unnecessary concern.
- The minimum requirements for equipment and reagents to carry out ISE analyses are:
  - An ion selective meter that can be used for fluoride and temperature probes, and that can display millivolts (and preferably fluoride concentration) and degrees Celsius, as required.
  - Fluoride electrodes (either a combined electrode, or separate measuring and reference electrodes)
  - Temperature probe (for measuring temperature of sample being tested)
  - A magnetic stirrer with insulated top, moveable arm stand with probe holder for fluoride and temperature probes, and teflon coated stirrer bars
  - Laboratory plastic ware (beakers, measuring cylinders and sample/storage bottles)
  - Timer and thermometer
  - Reagents (total ionic strength adjuster (TISAB), and electrode filling solution) of appropriate quality
- The meter attached to the fluoride ion selective electrode should be checked regularly for sensitivity (follow manufacturers instructions).
- Electrode filling solutions, if used, should be of suitable quality.
- Calibration standards should include at least 4 points between 0.1 and 2 mg/L (e.g. 0.1, 0.5, 1.0, 1.5, 2.0)
- It is good practice to carry out regular checks on fluoride standards and chemical reagents bought or made by a water supplier. Simple checks help to give confidence in the fluoride results. Checks may include keeping track of the following for fluoride analysis reagents and fluoride standards:
  - batch numbers
  - age and expiry date

- comparison of results when changing from one batch to another
- quality assurance documentation from the manufacturers.

- Where online analysers are used, at least 1 sample each day must be analysed using a prescribed analysis. The result from the prescribed analysis can also be used to confirm the accuracy of the online results.
- The online fluoride analyser should correct for temperature and pH and should include buffering if interferences cause errors in the measurement of the fluoride ion of 0.05 mg/L or greater. Interferences are caused when fluoride forms complexes with several other cations (such as aluminium and iron). The extent to which complexes are formed depends on solution pH, fluoride concentration and concentration of complexing species.
- Calibration records should be kept. Information from instrument calibration such as slope can identify changes in performance, such as sensitivity changes, in fluoride meters and electrodes. Calibration records will identify when instrumentation needs servicing or replacing.
- It is important to follow manufacturer's instructions with regard to calibration of equipment for the method used for fluoride analysis. Instructions should indicate any interference likely to affect the fluoride reading.
- An SOP should be established for calibration of analysis equipment and for the fluoride analysis.
- SOPs should include sampling procedures and analytical procedures and should specify any areas that may be problematic (eg. adding reagents, timing of methodology or interfering substances).

Performance criteria	Minimum standards
P 5.2.3. • The water supplier should ensure that the appropriate resources for determining fluoride concentration in the fluoridated are provided at all times.	**MS 5.2.3.** • A laboratory, or an appropriate permanent bench area, should be provided in an area separate from the fluoridation room, but in close proximity to it, to allow routine fluoride concentration analyses to be performed. • There should be adequate power, water supplies and equipment to enable the analyses to be carried out.

Guidance notes for MS 5.2.3.

- Analytical equipment should be permanently set up. Bench space should be adequate for analysis and sufficient storage available for consumables (such as glassware, chemicals and spare parts). The area should not be exposed directly to sun or high temperature. Air conditioning is preferred. A small fridge for storing samples and reagents at a constant low temperature should be provided.

5.3. Emergency response planning

Fluoride dosing facility operators and reticulation system managers should have an emergency response plan developed to manage incidents and emergencies, including fluoride overdosing events. Where the fluoride dosing facility and the reticulation system are managed separately, communication procedures should be included in the contingency plan.

Performance criteria	Minimum standards

P 5.3.1.
• The water supplier should develop and implement emergency response plans to manage incidents and emergencies, including fluoride overdosing.
	MS 5.3.1.
	• Emergency response planning should be developed and documented as part of the risk management plan discussed in Part ix of the Code.
	• An overdosing event can be defined as when the fluoride concentration in treated water or the reticulation system is over 1.5 mg/L.
	• If fluoridated water leaving the fluoride dosing facility has a fluoride concentration greater than 0.3 mg/L above the prescribed fluoride concentration the fluoride dosing facility should be shut down immediately, the treatment plant supervisor should be notified and the cause of the elevated concentration should be investigated and rectified before recommencing dosing.
	• Emergency response planning should include:
	  • Procedures for shutting down fluoridation equipment in the event of overdosing.
	  • Actions required to identify and rectify problems.
	  • Actions required to advise and protect the health of the public in the event of an overdosing event.
	  • Reporting protocols including a clear chain of command and designated responsibility.

Guidance notes for MS 5.3.1.

- Ideally, the risk assessment conducted during the planning of the fluoride dosing facility should have identified all possible causes of overdosing and appropriate control measures will have been developed and implemented to deal with each one. These controls should be integrated with existing risk management documentation or the Drinking Water Quality Management Plan, when it is developed.
- The detection of fluoride concentrations in excess of 0.3mg/L higher than the prescribed concentration indicates significant dosing inaccuracy and that safe water fluoridation cannot be ensured. In such instances it is appropriate that the fluoride dosing facility be shut down immediately until such time as the cause of the dosing inaccuracies have been determined and rectified. Automated shutdown by way of interlocking with an online analyser may also be appropriate.
- Shutting the fluoride dosing facility down in such circumstances will help ensure that the limit of 1.5mg/L is never exceeded.
- The standard for fluoride is 1.5mg/L. If this value is exceeded, the incident must be

reported immediately to the Office of the Water Supply Regulator and appropriate corrective actions taken.

- The Office of the Water Supply Regulator will in turn notify Queensland Health who will then begin an investigation into the incident.
- **Appendix 3 details actions which may be appropriate in the event of an overdosing incident.**

5.4. Quality assurance and quality control samples

This section provides information on quality assurance and quality control samples. Terms such as daily quality control sample and monthly quality control samples are defined in the glossary of the Code. This section applies to all fluoride dosing facilities.

Performance criteria	Minimum standards
P 5.4.1. • The water supplier should ensure that quality assurance processes are in place to ensure the accuracy, precision and reliability of fluoride concentration measurements in water.	**MS 5.4.1.** • A daily quality control sample should be analysed by the fluoride dosing facility operator along with the mandatory daily samples of fluoridated water. This sample should be analysed using the same prescribed analysis as the routine samples. • A weekly quality control sample should be analysed by the reticulation system manager along with the analysis of the recommended weekly samples of fluoridated water. This sample should be analysed using the same prescribed analysis as the routine samples. • On 1 day each month the fluoride dosing facility operator must split a daily sample into 2 parts and analyse 1 part using a prescribed analysis. The other part must be forwarded to a laboratory that is NATA accredited for fluoride analysis, and the results of analysis obtained by the water supplier.

Guidance Notes for MS 5.4.1.

- The daily quality control sample is a sample of known fluoride concentration that should be analysed alongside every daily routine fluoride sample using the same prescribed analysis. This daily quality control sample provides a means to ensure that any analysis performed by the fluoride dosing facility operator is providing accurate results. This daily quality control sample should be prepared separately from the calibration standards (see Section 5.5 of the Code) as it is used to check on the accuracy and precision of the analysis performed.
- It is recommended that the results of quality control analyses be plotted over time to ascertain any trends that may be forming (eg. fluoride concentration of QC sample may be gradually dropping over time and corrective action may be required).
- If there is a greater than 0.2 mg/L difference in fluoride concentration between the locally and externally analysed monthly control samples, then the reason for the discrepancy should be investigated.
- The daily quality control sample can be prepared in the treatment plant laboratory from analytical grade chemicals or can be purchased from an external provider.
- The obtaining and analysis of a quality control sample each month is required under the Water Fluoridation Regulation to provide confirmation of the accuracy of the analytical procedures employed at the treatment plant. Queensland Health Forensic and Scientific Services is NATA accredited for fluoride analysis.

5.5. Maintenance and calibration

This section provides information on the maintenance of the fluoride dosing facility equipment and the calibration of equipment used to measure the concentration of fluoride in water. This section applies to all fluoride dosing facilities and reticulation systems.

Performance criteria	Minimum standards
P 5.5.1. • The water supplier should ensure that any analytical equipment used by the water supplier to is calibrated on a programmed basis.	**MS 5.5.1.** • All operational staff involved in fluoride analysis should follow an SOP when calibrating equipment and analysing fluoride samples. • All operational staff should be trained and competent in following any SOPs for calibration of instruments and analytical methods. • Standards used for calibration should be the same temperature as the fluoride sample being analysed.

Guidance notes for MS 5.5.1.

- It is essential that calibration standards are kept at the same temperature as the fluoridated water sample. This can be achieved by either keeping the calibration standards at room temperature and waiting for the fluoridated water sample to come to room temperature before analysis or keeping the calibration standards in a water bath using a continuously running fluoridated water sample, in which case the analysis can be done immediately. The potential impact of this issue is greatest where the diurnal temperature range is large and the laboratory area is not air-conditioned.

Performance criteria	Minimum standards
P 5.5.2. • The water supplier should ensure that equipment in the fluoride dosing facility is properly maintained.	**MS 5.5.2.** • Frequent inspections should be conducted to assess the condition of equipment in the fluoride dosing facility. • The fluoride dosing facility and associated equipment should be adequately maintained to achieve reliable operation. • All staff at a fluoride dosing facility should be trained and competent in following SOPs for equipment maintenance and servicing.

5.6 Operator qualifications and training

This section provides information on the competency requirements for fluoride dosing facility operators.

Performance criteria	Minimum Standard
P 5.6.1. • The water supplier must ensure that the fluoride dosing facility operators have the necessary skills and knowledge to operate a fluoride dosing facility in a manner that ensures their safety, the safety of others, the protection of public health, and the environment.	**MS 5.6.1.** • Operators of the fluoride dosing facility must have the relevant skills and knowledge to competently operate a fluoride dosing facility. • A sufficient number of competent people must be available to operate the fluoride dosing facility. A minimum of two plant operators should be qualified. • Only competent operators, or operators in training in the presence of a competent operator, should operate the fluoride dosing facility and equipment.

Guidance notes for MS 5.6.1.

- The necessary skills and knowledge can be obtained through the nationally recognised unit of competency *NWP276 – Monitor, operate and report on fluoridation systems,* or an equivalent competency. The unit of competency (NWP276) should be from the Water Industry Advisory Committee *Water Training Package NWP07* or equivalent.
- The number of qualified people required will depend on the particular staffing arrangements used by a water supplier (e.g. single operator or team based). As a minimum, two competent operators should be available to ensure periods of sickness, annual leave, weekends and other issues such as training and meetings will not result in the unavailability of a competent operator for the fluoride dosing facility. It is also recommended that the fluoride dosing facility operator's supervisor (or other appropriate manager) obtain the necessary skills and knowledge in order to provide a detailed awareness of the legislative requirements of the Water Fluoridation Act and Regulation within the management structure of the water supplier (as well as providing operational support in an emergency).
- Operating staff with prior experience operating a fluoride dosing facility in Australia or overseas may seek recognition of prior learning from any training provider registered to deliver the unit of competency in Queensland . Recognition of prior learning may include a short skills assessment.

6. Records and reporting requirements

6.1. Record keeping requirements

It is the responsibility of all fluoride dosing facility operators to keep the mandatory records described in this section. This information should be recorded electronically or in hard copy for auditing purposes.

Performance criteria	Minimum standards

P 6.1.1.
• The water supplier must keep records that demonstrate compliance with the recording requirements of the Water Fluoridation Regulation.
	MS 6.1.1.
	• The fluoride dosing facility operator must record, on the approved form, the daily:
	  • Volume of fluoridated water
	  • Amount of fluoride chemical added
	  • Calculated fluoride concentration of treated water
	  • Measured fluoride concentration in the treated water from a point where the fluoride has a consistent concentration (see MS 5.2.1)
	• The fluoride dosing facility operator should record the measured concentration of the daily quality control sample (see MS 5.4.1. and the glossary)
	• The fluoride dosing facility operator must record the fluoride concentration in the monthly quality control sample analysed at the treatment plant as detailed in MS 5.4.1.
	• The fluoride dosing facility operator must record the fluoride concentration in the monthly quality control sample analysed at a laboratory which is NATA accredited for the prescribed analysis as detailed in MS 5.4.1.
	• The results of the measured daily fluoride concentration and the monthly quality control sample must be kept for a minimum of 5 years.
	• Where online fluoride analysers are used, the fluoride dosing facility operator should record the average fluoride concentration over the day.
	• Records should also be kept of the following
	  • Results from the chemical analysis of fluoride chemicals
	  • Results from analysis of fluoride concentration in raw water
	  • Maintenance and calibration records of plant and equipment.
	• All other fluoride results from NATA registered laboratories should be recorded maintained and available for auditing.

Performance criteria	Minimum standards
P 6.1.2. • Reticulation system managers should keep records that demonstrate that the prescribed fluoride concentration is maintained in the reticulation system	**MS 6.1.2.** • The reticulation system manager should record weekly: • Measured fluoride concentration from samples taken from two or more well-separated locations in the reticulation system as discussed in MS 5.2.1

Guidance Notes for MS 6.1.1.

- The volume of fluoridated water should be recorded in litres (L) or a multiple thereof (e.g. kL, ML). The weight of fluoride chemical added to water should be recorded in kilograms (kg) or a multiple thereof. The calculated and measured fluoride concentrations should be recorded in milligrams per litre (mg/L).
- The daily calculations need to be based on a set 24 hour period, however, this period need not be from 12am to 12am. For example, a fluoride dosing facility operator may perform the daily calculation based on the amount of water produced and fluoride used in the 24 hours from 10am to 10am.
- Whilst the chosen 24 hour period is up to the operator, the determined 24 hour period must not be changed as this could give rise to inaccurate results. The chosen 24 hour period and the rationale for its choosing should be documented.

Guidance notes for MS 6.1.2.

- Monitoring of the reticulation system is not mandatory at present. However, the need for mandatory monitoring and reporting for the reticulation system will be reconsidered in the future.
- In the interim, Queensland Health highly recommends that where fluoridated water is reticulated to customers, that monitoring of fluoride levels in the reticulation system is conducted to ensure prescribed fluoride levels are being maintained throughout the system.

6.2. Reporting requirements

This section provides information on reporting for both the fluoride dosing facility manager and reticulation system manager.

Performance criteria	Minimum standards

P 6.2.1.
• The water supplier must submit quarterly reports that demonstrate compliance with the reporting requirements of the Water Fluoridation Regulation.
	MS 6.2.1.
	• The fluoride dosing facility operator must provide Fluoridated Water Quarterly Reports in the approved form (Form 3). The completed form must be submitted to the Chief Executive of Queensland Health within 30 business days of the completed quarter.
	• The quarterly report must contain the following information:
	  • Quarterly average measured fluoride concentration in the treated water.
	  • Maximum and minimum measured fluoride concentration in the treated water.
	  • The number of samples taken for the reporting period.
	  • The number of times the fluoride concentration has exceeded 1.5mg/L.

Performance criteria	Minimum standards

P 6.2.2.
• Where the reticulation system manager opts to take and analyse fluoridated water samples, reports should be submitted to the Chief Executive of Queensland Health.
	MS 6.2.2.
	• The reticulation system manager should provide quarterly reports to the Chief Executive of Queensland Health with the following information:
	  • Quarterly average measured fluoride concentration in samples taken from two or more well-separated locations in the reticulation system;
	  • Maximum and minimum fluoride concentration in samples taken from two or more well-separated locations in the reticulation system; and
	  • The number of times fluoride concentrations exceeded 1.5mg/L.

Guidance notes for MS 6.2.1. & 6.2.2.

- In order to reduce the administrative burden on water suppliers, the Office of the Water Supply Regulator (OWSR) has agreed to receive Fluoridated Water Quarterly Reports from water suppliers as part of the mandatory water quality reporting requirements under Section 630 of the Water Supply (Safety & Reliability) Act. OWSR will then pass these reports on to Queensland Health. This process will satisfy the reporting requirements of the Water Fluoridation Regulation. The Fluoridated Water Quarterly Report (Form 3) can be found in Appendix 5.

6.3. Auditing

Queensland Health may audit the operation of fluoride dosing facilities periodically.

Performance criteria	Minimum standards
P 6.3.1. • The water supplier should ensure appropriate records documenting the fluoride dosing facility performance are maintained and accessible.	**MS 6.3.1** • Records documenting plant operation relating to regulatory requirements must be available to persons authorised under the Water Fluoridation Act. • Water suppliers must keep analytical records for a minimum of 5 years.

Guidance notes for MS 6.3.1

- Care needs to be taken to ensure electronic records are reliably backed up and paper records are kept in an appropriate environment that will minimise deterioration. In applying quality management principles, it is important that records are traceable to the date they were created and the person or people who generated the records.

7. Workplace health and safety

This section applies to all fluoride dosing facilities. All activities relating to fluoride dosing facilities must be undertaken with utmost regard for the health and safety of workers. Factors to consider include (but are not limited to) plant, exposure to hazards, ergonomics and manual handling.

Performance criteria	Minimum standards
P 7.1.1 • The water supplier should provide a safe working environment and ensure safe working practices for plant operators, other staff and visitors.	**MS 7.1.1.** • Safety obligations must be met under the *Workplace Health and Safety Act 1995* (WHS Act) and the *Dangerous Goods Safety Management Act 2001* (DGSM Act). • Pipes, conduits and ducts should be identified as referenced in Australian Standard AS1345 - Identification of the contents of pipes, conduits and ducts. • Material Safety Data Sheets (MSDS) should be available on-site for all fluoridation chemicals • Appropriate personal protective equipment (PPE) should be available for operator protection.

Guidance notes for MS 7.1.1

- Water suppliers need to regularly review the safety requirements of the WHS Act and DGSM Act and associated Regulations to ensure compliance.
- Compounds used for the fluoridation of water supplies are in the National Occupational Health and Safety Commission's "List of Designated Hazardous Substances" in the *Workplace Health and Safety Regulation 2008* - Part 16 (Hazardous Substances). This means that an employer must do a risk assessment on their workers and themselves to assess the risk from the use and handling of fluoridation chemicals in the workplace.
- If the employer believes there is a risk to workers health then a health surveillance program must be undertaken by a doctor who is an "approved" or a "designated doctor" for fluoride compounds.
- Specialist occupational physicians are designated doctors for all hazardous substances. Other practitioners need to make application to the Director of Workplace Health and Safety to obtain the necessary information material on each substance to enable them to undertake this role.
- The biological monitoring of fluoride exposed workers involves the collection and analysis of before-shift and end-of-shift urine samples.
- A risk assessment, as described in section ix of the Code, should include all safety aspects of the design, commissioning, operation, testing, maintenance, repair and decommissioning of a fluoride dosing facility. The risk assessment process should involve a range of stakeholders such as plant operators, managers and technical experts. Hazards and control mechanisms should be identified in the risk assessment and incorporated into the design. Control measures should be implemented. Based on the hierarchy of controls, hazards should be eliminated wherever possible, followed by use of engineering controls. The use of personal protective equipment should not be relied upon as a sole control measure and will often be used in conjunction with other controls.
- An MSDS is essential for providing information on fluoridation chemicals such as effects from exposure and details on safe storage and handling and how to manage leaks and

spills. MSDSs must be available to workers.

- Depending on the activity being performed, PPE for fluoride dosing facilities may include:
  - elbow length impervious rubber or plastic gloves, long sleeve shirt, trousers, full length impervious rubber or plastic apron for protection of skin
  - impervious rubber or plastic boots
  - a full face mask with type P3 respiratory filters (as per AS/NZS 1715) for plants using dry fluoridating agents
  - a full face respirator fitted with an acid gas filter for fluorosilicic acid plants where there is a risk of exposure to acid fume
  - a full face shield or splash proof safety goggles for plants using fluorosilicic acid.
- The atmosphere of any areas where fluoridating agents are stored or used should be safe for workers. For dry fluoridating agents the fluoride dust concentration should not exceed the recommended exposure limit specified by Workplace Health and Safety legislation. The current recommended exposure limit for fluorides is 2.5 mg/m^3. For fluorosilicic acid plants exhaust fans should be used to ventilate the fluoride dosing facility room. This will not only benefit the air quality for staff but should also reduce corrosion rates due to the acidic fumes. Air sampling and analysis should be performed if there is any concern regarding air quality in fluorosilicic acid plants.
- If a worker is exhibiting a symptom that could be related to fluoride exposure they should consult a medical practitioner. Symptoms of acute fluoride poisoning include increasing stiffness in the back, nausea, vomiting, abdominal pain, diarrhoea, fatigue and drowsiness.
- Emergency eyewash and showers and adequate routine washing facilities should be available where ever fluoridating agents are stored and handled.
- Appropriate spills cleanup materials and equipment should be provided and located appropriately.
- Dry clean up, if managed safely, may be more effective for fluoride chemical spills than the hosing of granulated chemical into a sump. The collection, treatment or disposal of the resulting contaminated water may be more difficult to manage than dry chemical waste.
- Further information on workplace health and safety requirements can be found at the Workplace Health and Safety Queensland web site: http://www.deir.qld.gov.au/workplace/index.htm
- The obligations applicable under the DGSM Act are determined by the quantity of dangerous goods at the facility. Every facility holding dangerous goods has obligations under the DGSM Act.
- The quantities of fluoride chemicals and other dangerous goods stored or handed at the facility may invoke specific requirements under the DGSM Act including site classification, safety signage and warning placards. For guidance on warning placards refer to Appendix 2.
- All dangerous goods facilities are required to have a Safety Management System developed, implemented and maintained for the facility. Larger facilities may be required to establish emergency plans and procedures for a hazardous materials emergency along with a manifest for emergency services of their location and quantities of dangerous goods.
- A number of documents including codes of practice, guidelines and Australian Standards are available to assist with complying with the legislative requirements for operator safety including:
  - *Plant Code of Practice* (DEIR 2005)
  - *Code of Practice for Electrical Work* (DEIR 2002)
  - *Hazardous Substances Code of Practice* (DEIR 2003)
  - *Manual Tasks Code of Practice* (DEIR 2000)
  - *Risk Management Code of Practice* (DEIR 2007)
  - *Safe Storage and Handling of Dangerous Goods: Guidelines for Industry* (Department of Emergency Services, 2002)
  - *AS3780 The storage and handling of corrosive substances* (relevant to

hydrofluorosilicic acid)

- *AS4452 The storage and handling of toxic substances* (relevant to powdered fluoridation chemicals)
- *Australian Dangerous Goods Code*
- *AS1319 Safety signs for the occupational environment*
- *ISO 31000 Risk Management – Principles and guidelines (supersedes AS/NZS 4360 Risk Management)*
- *AS/NZS 4801 Occupational health and safety management systems- Specification with guidance for use*.
- *AS/NZS 1715 Selection, use and maintenance of respiratory protective devices*.

8. Environmental safety

Fluoride dosing facilities must consider environmental protection laws and take all reasonable and practicable steps to prevent environmental harm from occurring. The Department of Environment and Resource Management should be contacted on 1300 130 372 for further advice.

Performance criteria	Minimum standards

P 8.1.1.
• The water supplier must ensure the fluoride dosing facility and its operation does not result in environment harm
	MS 8.1.1.
	• The water supplier must comply with the *Environmental Protection Act 1994* (EP Act) and associated regulations, policies and approvals.
	• The plant risk assessment discussed in Part ix should consider the potential for environmental impacts associated with fluoridation chemical unloading and spill containment.
	• Any spills of fluoridating agent should be carefully managed:
	  • Dry sweeping of dry fluoride chemical should not occur. Removal by vacuum cleaner is permissible; however the cleaner should be fitted with a HEPA filter.
	  • Appropriate spill kits should be located in key areas of the facility to enable safe and effective management of minor spills and leaks.
	  • Safety procedures detailed in the MSDS should be followed when a large spill of fluoridating agent occurs.
	• The fluoride dosing facility operator should prepare, document and implement an SOP for the disposal of fluoridating agent containers or contaminated fluoridating agent. Wherever possible, fluoridating agent containers should be returned to the manufacturer for disposal.
	• The fluoride dosing facility operator should prepare, document and implement an SOP for an emergency response to a spill of fluoridating agent.

Guidance notes for 8.1.1.

- The operator has a general environmental duty under the EP Act not to carry out any activity that causes or is likely to cause environmental harm unless the person takes all reasonable and practicable measures to prevent or minimise the harm. If clarification of EP Act requirements is necessary then the Department of Environment and Resource Management should be consulted.
- The water supplier should prepare, document and implement an SOP that manages the disposal of fluoride waste. The disposal SOP should outline disposal plans for contaminated fluoridating agent and fluoridating agent containers. The options for disposal of fluoridating agent may include returning them to the supplier, disposal through a waste

disposal contractor or disposal in the local waste landfill (if permitted by the operator of the landfill). Concentrated fluoride powder is poisonous to wildlife and disposal options should be considered carefully.

- The water supplier should prepare, document and implement an SOP that manages spills of fluoridating agent. This SOP should also deal with small and large emergency spills and include procedure and emergency contact numbers.

9. Plant security

Performance criteria	Minimum standards

P 9.1.1
• The water supplier should ensure visitors to the fluoride dosing facility are supervised and given an appropriate safety induction.
	MS 9.1.1.
	• The fluoride dosing facility operator should ensure that visits by any personnel to the fluoridation room are authorised and a qualified operator accompanies visiting personnel.
	• Maintenance staff must not be permitted to be in charge of or operate the fluoride dosing facility unless they have the appropriate skills and knowledge as detailed in Section 5.6 of this Code.
	• Once visitors have entered the fluoridation room, the presence of the competent operator may not be required, provided that the competent operator is satisfied that:
	  • The visitors have been adequately instructed and will not be in contact with the fluoridating agent or any part of the fluoridation equipment; or
	  • The visitors have been given appropriate instruction and provided with the appropriate personal protective equipment if contact with fluoridating agent is likely when maintaining specific items of the fluoridating equipment.

Guidance notes for MS 9.1.1.

- Entry to the fluoride dosing facility by untrained persons (staff and public) needs to be controlled both for the protection of the fluoridation equipment and for personal safety. Maintenance workers need to be supervised to prevent impacts on the fluoridation process. The fluoride dosing facility manager and competent operators are responsible for ensuring maintenance staff do not put themselves, the fluoridation process, or the environment at risk. Best practice could involve the use of a work permit system that includes a systematic risk assessment of the potential impact on the fluoridation process from the work being done.
- The operator and the maintenance staff should assess the risks together and agree on any special controls required while the work is being carried out (e.g. work carried out while water flow is off, maintenance staff will not switch dosing equipment on or off for testing without the knowledge of the operator). The degree of control required will depend on the knowledge and training of the maintenance staff.

Performance criteria	Minimum standards
P 9.1.2. • The water supplier should ensure that the design of the fluoride dosing facility building minimises the risk of accidental or wilful damage.	**MS 9.1.2.** • The building housing the fluoride dosing facility should be a solid lockable construction. • The building housing the fluoride dosing facility should be kept locked when unattended to prevent unauthorised entry.

Guidance notes for MS 9.1.2.

- The fluoride dosing facility (plant room/building, fluoridating agent storage areas, dosing lines etc) should be of sufficiently solid construction to minimise the risk of damage to equipment due to vandalism. The plant design should minimise the risk of accidental damage to equipment such as dosing lines, valves etc. where feasible.

10. Glossary

Australian Standards (AS/NZS)
Standards are published documents setting out specifications and procedures designed to ensure products, services and systems are safe, reliable and consistently perform the way they were intended to. They establish a common language which defines quality and safety criteria. Where standards are referred to in the Code it is recommended that, due to the fact that Australian Standards are regularly updated, the most recent version of the standard be consulted unless otherwise prescribed under legislation.

Calculated fluoride concentration
The calculated fluoride concentration (CFC) is the theoretical concentration of fluoride ions in the water after addition of the fluoridating agent. It is calculated in mg/L using the following:

a. the amount (kg) of fluoride chemical added to water calculated using the loss of volume from a tank (day tank or otherwise) or loss of weight from a tank (day tank or otherwise),
b. % of fluoride ion in the fluoride chemical (NaF = 45.3%; H_2SiF_6 = 79.2%; Na_2SiF = 60.7%)
c. Purity of the fluoride chemical (% purity). This information can be obtained from the batch analysis certificate. Approximate % purity for each fluoride chemical is in Appendix 1, Table 4.
d. volume of water treated in ML
e. fluoride concentration in the raw water before treatment (F in raw water in mg/L)

Equation
Using a to e above the equation is as follows:

$$\text{CFC mg/L} = \frac{(a \times b \times c)}{(d \times 100 \times 100)} + e$$

or written in full, the equation is as follows:

$$\text{CFC mg/L} = \frac{(\text{Amount of chemical added (kg)} \times \% \text{ of fluoride ion} \times \% \text{ purity})}{(\text{Volume of water treated ML}) (100\%) (100\%)} + \text{F in raw water (mg/L)}$$

The calculated fluoride concentration should equal the measured fluoride concentration. It will also be a 24 hour average fluoride dose rate.

Chief executive
Chief Executive means the Director-General of Queensland Health.

Daily quality control sample
The daily quality control sample is a sample of known fluoride concentration that is analysed alongside the routine treated water sample in the treatment plant laboratory. This sample is of known concentration and is intended to alert the operator to any problems with the analytical method procedure and/or problems with analytical equipment.

Dangerous goods
Dangerous goods are defined under the Australian Dangerous Goods Code and are classified on the basis of immediate physical or chemical effects, such as fire, explosion, corrosion and poisoning, affecting people, property or the environment.

Externally analysed fluoride concentration
A fluoride sample analysed at a laboratory, not at the fluoride dosing facility site. This laboratory must be NATA accredited for fluoride analysis.

Fluoridating agent
A fluoridating agent is a substance that is added to drinking water to achieve fluoridation. Fluoridating agents include the dry (or powder) fluoridating agents sodium fluorosilicate (Na_2SiF_6) and sodium fluoride (NaF) as well as fluorosilicic acid (H_2SiF_6).

Fluoridation
Fluoridation is the addition of fluoride to drinking water for the purpose of oral health benefit. Fluoridation involves the controlled addition of a fluoridating agent to a public water supply to increase the fluoride to a level that effectively prevents tooth decay.

Fluoride dosing facility
The building and equipment involved in the fluoridation of drinking water, including chemical storage areas, dosing and control equipment, safety equipment and any other fixtures used for, or associated with, the purpose of fluoridation.

Fluoride concentration
Fluoride concentration means fluoride ion concentration. Where fluoride concentration is mentioned in the Water Fluoridation Regulation of this Code of Practice, it refers to the concentration of the fluoride ion.

Guidance notes
Guidance notes include explanatory notes for the minimum standard requirements. They may include suggestions for meeting the minimum standard or may just provide additional information. Also included in the guidance notes is information on meeting the requirements of other legislation, such as the Dangerous Goods Regulation and the Workplace Health and Safety Regulation. The guidance notes are not mandatory.

Hazardous substances
Hazardous substances are classified on the basis of health effects (whether they are immediate or long-term). Materials are classified as hazardous substances if they meet the classification rules in Safe Work Australia's, 'Approved criteria for classifying hazardous substances [NOHSC1008 (2004)] 3rd Edition (Approved Criteria)' and/or if their name appears in the 'Hazardous Substances Information System above the cut-off concentrations. For further information, see:
http://www.safeworkaustralia.gov.au/swa/HealthSafety/HazardousSubstances/

Interlocked
An interlocked fluoride dosing system is interconnected in such a way that the failure of any one part of the fluoride dosing system results in the shutdown of the entire fluoride dosing process and cannot be automatically restarted. An interlocked system must also ensure that the automatic fluoride dosing equipment cannot operate unless it receives confirmation of water flow through the fluoride dosing facility via a water flow measuring device.

Ion chromatography
The fluoride ion can be analysed by ion chromatography. This method can be automated and is generally used in larger laboratories that handle large numbers of samples. It is not a bench top system found in most water treatment plants. Ion chromatography is a process that allows the separation of ions and polar molecules based on the charge of the molecules. A sample is injected and is separated by a strongly anionic exchange column. The fluoride ion is negatively charged and therefore can be separated out by ion chromatography.

Ion-selective electrode method
Fluoride ion in a water sample can be detected by an electrode sensitive to the fluoride ion. This method can be adapted to field or online instrumentation as well as a laboratory instrument. It is generally the method of choice for most treatment plant laboratories.

Local government area
Local government areas are listed in Schedule 2 of the *Water Fluoridation Regulation 2008*.

Locally analysed fluoride concentration
Fluoride sample analysed at the on-site laboratory.

Measured fluoride concentration
The concentration of fluoride measured using one of the prescribed analyses in the *Water Fluoridation Regulation 2008*.

Minimum standard
Minimum standards are the minimum requirements considered necessary to achieve the performance criteria. Performance criteria relate to legislative requirements under the *Water Fluoridation Act 2008* and *Water Fluoridation Regulation 2008* where the word 'must' is used. See section vi – Terminology.

Monthly quality control sample
The monthly quality control sample is a sample that is taken from the fluoridated treated water or the reticulation system and split into two portions. One portion is analysed at the on-site laboratory using the fluoride method routinely used at the treatment plant and the other portion is sent away to a laboratory that is NATA accredited for fluoride analysis.

Office of the Water Supply Regulator
The Office of the Water Supply Regulator, within the Department of Environment and Resource Management, regulates drinking water service providers and is responsible for administering the *Water Supply (Safety and Reliability) Act 2008.*

PLC
Programmable Logic Controller

Prescribed fluoride analysis
The *Water Fluoridation Regulation 2008* lists three prescribed fluoride analyses. These analyses or methods include ion selective electrode, SPADNS and ion chromatography.

Prescribed fluoride concentration
The prescribed fluoride concentration is specified in Section 8 of the Water Fluoridation Regulation as follows: local government zone 1 – 0.6 mg/L, local government zone 2 – 0.7 mg/L and local government zone 3 – 0.8 mg/L.

Quarter
Quarter in the *Water Fluoridation Regulation 2008* means each of the following:
a. 1 January to 31 March of each year
b. 1 April to 30 June of each year
c. 1 July to 30 September of each year
d. 1 October to 31 December of each year

Quarterly average measured fluoride concentration
This is a single value that is calculated by adding up all the measured fluoride concentrations for samples taken during the quarter and divided this number by the number of samples. For example, for a 5-day period, 5 samples are taken and fluoride is measured. The results are 0.7, 0.6, 0.7, 0.8 and 0.7 mg/L. The average measured fluoride concentration in this example is 0.7 mg/L {(0.7 + 0.6 + 0.7 + 0.8 + 0.7) ÷ 5}.

SCADA
Supervisory Control and Data Acquisition. A SCADA system is a control system that receives signals from components in the water treatment system. An operator can usually monitor any aspect of the treatment system such as levels of chemical tanks and water reservoirs or operation of pumps. SCADA systems generally alert an operator when a component in the system fails. The operator can generally access the SCADA system via a computer to see why an alarm was generated.

SPADNS method
The SPADNS (Sodium 2-(parasulfophenylazo)1,8-dihydroxy-3,6-naphthalene disulfonate) method is a colorimetric method for determining fluoride concentration in water. Fluoride ions react with the zirconium-SPADNS dye lake resulting in a loss of colour. The residual colour of the dye is then measured at 570 nm in a spectrophotometer. The concentration of the fluoride ion is inversely proportional to the

intensity of the colour. This method is suitable for fluoride ion analysis in water treatment plant laboratories.

Water Fluoridation Act
Water Fluoridation Act means the *Queensland Water Fluoridation Act 2008*.

Water Fluoridation Regulation
Water Fluoridation Regulation means the Queensland *Water Fluoridation Regulation 2008*.

11. Appendices

Appendix 1 – Guidance on fluoride chemical quality

Water Suppliers are required to ensure that fluoride chemicals used in water fluoridation are of an appropriate quality to ensure public health is not jeopardised and to minimise workplace health and safety risks and operational issues which could contribute to periods of non-operation.

For the purpose of determining impurity specifications for fluoride chemicals, it is appropriate to think of fluoride as a water treatment chemical and adopt the methodology for water treatment chemicals detailed in ADWG (Part 8.8). In essence this methodology requires that when a certain water treatment chemical is dosed into the water, the concentration of any impurities in the treated water, as a result of that dosing, should not exceed 1/10th of the relevant ADWG guideline value.

According to 'NSF/ANSI Standard 60: Drinking Water Chemicals – Health Effects' (NSF 60), the main impurities of concern for fluoride chemicals are arsenic, cadmium, copper and lead. Accordingly, Maximum Impurity Content (MICs) specifications have been derived for these impurities below (Table 1), based on the ADWG methodology and the relevant guideline values. Operators should compare the results detailed in the accompanying 'batch analysis certificate' or 'certificate of analysis' with the specifications detailed below to determine if the fluoride chemical is adequately free of impurities.

Table 1

Impurity	Maximum Impurity Content (MIC)*		
	Sodium Fluorosilicate (mg/kg)	**Sodium Fluoride** (mg/kg)	**Fluorosilicic Acid** (mg/L)
Arsenic	420	320	130
Cadmium	120	90	37
Copper	121,300	90,500	37,200
Lead	610	450	186

*A conservative fluoride dosing concentration of 1mg/L has been adopted in deriving these specifications.

Further to these MICs, batches of fluoride chemical should also comply with the following specifications in Table 2.

Table 2

Fluoride chemical	Minimum Purity (%)	Moisture %w/w	Insoluble Matter %w/w	Maximum free acid content (%)	Heavy metals, expressed as Pb, % by weight
Sodium Fluorosilicate	98	0.5	0.5	N/A	0.05
Sodium Fluoride	97	0.5	0.6	N/A	0.04
Fluorosilicic Acid	20-30	N/A	N/A	1 (expressed as HF)	0.02

According to NSF 60, other impurities that have been detected in less than 1% of fluoride chemicals include antimony, barium, beryllium, chromium, mercury, selenium and thallium. Based on the ADWG guideline values for these impurities, a complete list of MICs for fluoride chemicals has been derived:

Table 3

Impurity	Sodium Fluorosilicate	Sodium Fluoride	Fluorosilicic Acid
	MIC mg/kg	MIC mg/kg	MIC mg/L
Antimony	180	140	56
Arsenic	420	320	130
Barium	42,400	31,700	13,020
Beryllium*	3640	2714	1116
Cadmium	120	90	37
Chromium	3,030	2,260	930
Copper	121,300	90,500	37,200
Lead	610	450	186
Mercury	61	45	19
Nickel	1,210	900	372
Selenium	610	450	186

*Based on draft 2010 ADWG guideline value.

Water suppliers should periodically submit quality assurance samples to laboratories with NATA accreditation for the analysis of these parameters to further ensure fluoride chemical quality.

Workplace Health and Safety and Operational Concerns

In addition to addressing public health concerns, it is also important to ensure that the fluoride chemical used is of suitable physical quality such that it is not likely to create additional workplace health and safety issues and/or operational issues that could lead to unnecessary periods of non-operation.

Therefore, powdered fluoride chemicals should be free flowing and free of lumps or debris that could interfere with efficient feeding, dosing or other handling equipment.

Industry standards such as the relevant American Waterworks Association (AWWA) standards provide useful guidance in these respects. It is therefore highly recommended that water suppliers obtain a copy of the relevant standard for their reference.

Chemical	Relevant Standard
Sodium Fluoride	ANSI/AWWA B701-06
Sodium Fluorosilicate	ANSI/AWWA B702-06
Fluorosilicic Acid	ANSI/AWWA B703-06

General physico-chemical information on fluoride chemicals is provided below, for reference:

Table 4

Fluoride chemical	Sodium Fluoride	Fluorosilicic Acid	Sodium Fluorosilicate
Form	Powder or crystal	Liquid	Powder

Molecular weight	42.0	144.1	188.1
Commercial purity %	95 – 98	22 – 30	98 – 99
Fluoride ion % w/w in 100% pure material	45.3	79.2	60.7
Fluoride ion % w/w commercial grade (% purity)	43.4 (at 96%)	23.8 (30%)	59.8 (98.5%)
Solubility in water % (g/100ml) at 25 ºC	4.05	Infinite	0.76
pH of saturated solution	7.6	1.2 (1% solution)	3.5
Approximate amount of chemical (kg) to dose 1mg/L into 1 ML	2.33	4.20 (for 23.8%)	1.68
Class of Dangerous Goods	Class 6.1 - Toxic	Class 8 - Corrosive	Class 6.1 - Toxic

Appendix 2 – Warning placards

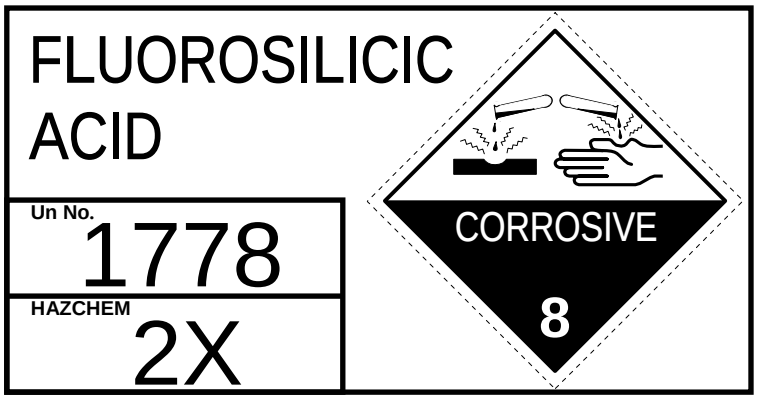
Placards provide visual warning of the hazards associated with dangerous goods present at the premises and are a requirement under the *Dangerous Goods Safety Management Regulation 2001.* The form and dimensions of the placards are specified in Schedule 3 of the *DGSM Regulation 2001*. Dangerous Goods Locations must display an Outer Warning Placard at all entrances to the facility as shown below.

HAZCHEM

In addition to the outer warning placard for the facility, placards are required at each individual chemical storage areas.

Placards for dangerous goods in tanks

Placards for the storage of dangerous goods in tanks are essentially the same as the full size Emergency Information Panels (EIP) required by the Australian Code for the transport of dangerous goods (ADG Code) for bulk transport but without the bottom row showing emergency contact details as shown below.



Example of a placard for a storage tank for Fluorosilicic acid.

The example above displays the form identifying the Proper Shipping Name, the dangerous goods class, the UN number and the Hazchem code. This information is obtained from the ADG Code. The placard for the bulk storage of dangerous goods must be located on, or adjacent to, each tank or vessel.

Placards for dangerous goods in packages

Storage and handling areas for packages containing fluoridation chemicals must be placarded with the class label ('diamond') if the quantity in the area exceeds the quantity specified below:

- For fluorosilicic acid in packages such as drums where aggregate amount exceeds 250L, the following class label is required:

- For Sodium fluoride or Sodium fluorosilicate in packages such as 25 kg bags where the aggregate amount exceeds 1000 kg, the following class label is required:

A placard is also required in the area where fluoridating chemicals are stored. The placard must be displayed at the main point of entry to the building where the store is located, and either, at every point of entry to the storage room or enclosure, or adjacent to the fluoridating chemicals.

For further information refer to Dangerous Goods Safety Management Regulation 2001, Sections 50-55.

Appendix 3 – Actions in event of overdosing

If Fluoride Concentration in Treated Water is:	Perform the following Actions:
> 1.5 mg/L	1. Resample. 2. If the fluoride concentration is still over 1.5 mg/L, manually shut down fluoride dosing facility immediately, if not already done so. 3. Immediately notify your supervisor 4. Immediately notify the Office of the Water Supply Regulator. 5. Immediately implement your Emergency Response Plan. This Plan should include, at a minimum, the following actions: i. Allowing the water treatment plant to run without the fluoride dosing facility to dilute the water in the treated water reservoir. (unless there are connections to the main before a service reservoir in which case immediately notify affected residents and provide alternative drinking water supplies) ii. Sampling within the reticulation system to determine the extent of the overdosing event. iii. Working with Queensland Health, where Queensland Health assumes the lead agency role, to ensure public health is not jeopardised. iv. Completing and submitting a 'Form A' to the Office of the Water Supply Regulator within 24 hours of becoming aware of the overdosing. A copy of 'Form A' is available at: http://www.nrw.qld.gov.au/water/regulation/pdfs/dw_incident_form.pdf v. Determining the reason for the overdose, and implementing the corrective actions required to ensure overdosing doesn't happen again. 6. Once the problem has been rectified, restart the fluoride plant. 7. Closely monitor treated water. 8. If no further problems arise, complete and submit a 'Form B' to the Office of the Water Supply Regulator. A copy of 'Form B' is available at: http://www.nrw.qld.gov.au/water/regulation/pdfs/dw_incident_form.pdf 9. The overdosing incident must be recorded on the relevant fluoridated water quarterly report – "Number of samples exceeding 1.5 mg fluoride/L" (See Appendix 5 – Form 3). 10. Details of the incident should be included in drinking water quality quarterly reporting to the Office of the Water Supply Regulator.

Appendix 4 – Calculations for fluoride dosing facilities

1. Calculation of fluoride ion content (%) in the powdered chemical

The fluoride ion content (F), expressed as a percent (%), equals the % of fluoride ion in the fluoridating chemical multiplied by the purity (expressed as a fraction, "K") of the fluoridation chemical. K, the purity fraction is derived by dividing the % purity by 100. For example, if the purity of NaF in a particular batch is stated as 97%, then K = 0.97.

The fluoride ion content in any of the permissible fluoridating agents (see below) can be calculated by using the theoretical percent fluoride ion concentration in fluoridation chemicals at 100% purity and multiplying them by K (equation 1a). The symbol for the % fluoride ion in the fluoridating chemicals at 100 % purity is shown here as "P".

Equation 1a:

F ion content (NaF) = P x K

The following P values apply:

- P for NaF = 45.3%
- P for H_2SiF_6 = 79.2% - Please see Note below
- P for Na_2SiF_6 = 60.7%

For example, consider the case where a batch analysis certificate for sodium fluoride (NaF) indicated that the purity is 98%. Therefore K = 0.98. The fluoride ion concentration as a percent in the purchased batch of sodium fluoride calculates as follows:

F ion content (in NaF) % = P x K

= 45.3 x 0.98

= **44.4%**

That is, 100g of sodium fluoride from the batch mentioned above contains 44.4g of fluoride ion.

Note: Fluorosilicic acid (H_2SiF_6)

Fluorosilicic acid (H_2SiF_6) is not normally produced as a 100% pure product. This acid is usually produced as a faintly blue coloured aqueous liquid with purity ranging from 20% to 30% W/W (weight/weight basis) i.e. 100grams of the product in the vat contains between 20 and 30grams of pure H_2SiF_6. The principal Australian manufacturers usually produce this product as a 20%W/W solution. 100grams of the 20% acid product contains 20grams of pure H_2SiF_6 so that the concentration of fluoride ion in the 20% purchased acid (expressed as a percent) is 15.84% (i.e. P = 79.2 and K = 0.2)**.** The specific gravity (SG) of 20% H_2SiF_6 is about 1.1748 at 17.5°C.

Table 4, Appendix 1 in the row titled Fluoride ion % w/w commercial grade (% purity) has calculated the F product content % using expected F ion percentages found in commercial grade chemical. If the figures in Table 4, Appendix 1, row 5 are used for the F ion content % in the calculations below, then the purity on the batch analysis certificate for the chemical should be checked against the purity in brackets in Table 3, row 5 to ensue the % purity is similar.

2. Calculation of the strength (S%) of fluoridating agent in solution

The strength of fluoridating agent in a solution can be expressed as a percent (%) and is given the symbol here of "S". S is determined by dividing the mass of fluoride chemical (e.g. NaF) used to make the solution by the amount of water used to dilute the fluoridation chemical in a solution tank. Equation 2a is used to calculate the solution strength of the fluoridating agent and takes into consideration the purity of the chemical. Equation 2a applies if the mass of fluoridating agent (symbol here is "M") is expressed in grams (g) and the volume of water (symbol "V") used to dissolve the fluoridating agent is expressed in litres (L).

Equation 2a:

$$\textbf{Solution strength (S\%)} = \frac{\textbf{(M x K) x 100}}{\textbf{(V x 1000)}}$$

e.g. 20kg of 98% pure sodium fluoride is dissolved in a holding tank with 980L of water (therefore V = 980). 20kg is equal to 20,000g (therefore M = 20,000) and K is equal to 0.98.

$$\text{NaF solution strength (S\%)} = \frac{(20000 \times 0.98) \times 100}{980 \times 1000} = \textbf{2.0\% NaF solution}$$

It is important to note that S% represents the percentage of pure fluoride chemical in solution since the purity has been taken into consideration. The fluoridating agent solution strength (S%) is used in the equations below.

3. Calculation of the fluoride ion concentration (F) in a solution in units of mg/L

The concentration of fluoride ion in solution (symbol given here is "C_s") is expressed in milligrams per litre (mg/L) and can be calculated from S% (see section 2 above) by multiplying S by 100P (equation 3a).

Equation 3a:

$$\textbf{C}_\textbf{s}\textbf{ (F in solution in mg/L)} = \textbf{S x 100 x P}$$

Using the example above: 20kg of sodium fluoride (98% purity) is dissolved into a solution tank with 980 L of water, S(%) = 2 and P for NaF is 45.3 (see Section 1 above for meaning of P)

Therefore:

$$C_s = 2 \times 100 \times 45.3 = \textbf{9060mg/L (as fluoride ion } \textbf{F}^-\textbf{)}$$

Alternatively, equation 3b can be used to calculate C_s for fluoridating agents in the holding tank.

Equation 3b:

$$\textbf{C}_\textbf{s} = \frac{\textbf{(M x K) x 10 x P}}{\textbf{V}}$$

Consider the following example: 6kg of Na_2SiF_6 (M = 6,000g) was dissolved in 990L of water (V = 990). The certificate of analysis indicated that the product was 99% pure (K = 0.99). The P value for sodium hexafluorosilicate (Na_2SiF_6) is 60.7 (see above). Therefore, the fluoride ion concentration in solution calculates as follows:

C_s = $\frac{(M \times K) \times 10 \times P}{V}$

= $\frac{(6{,}000 \times 0.99) \times 10 \times 60.7}{990}$

= 3642mg/L (as fluoride ion F^-)

Equation 3a may also be used to calculate the fluoride concentration in a holding tank containing fluorosilicic acid. For example, a purchased vat of fluorosilicic acid was supplied with an analysis certificate stating that the concentration of the pure acid (H_2SiF_6) was 20%W/W. 50kg of this product (corresponding to a volume of 42.5L volume since the SG of 20% fluorosilicic acid is 1.1748) was added to 957.5L of water. The final volume in the holding tank will therefore be 957.5L + 42.5L = 1000L. The mass (M) of pure H_2SiF_6 in the 1000L holding tank is 10kg (i.e. 50kg x 20/100 = 10). Therefore, S = 1% because 10kg contained in 1000L = 1%). C_s can be calculated as follows from equation 3a with P = 79.2,

C_s (F in solution in mg/L) = S x 100 x P

= 1 X 100 X 79.2 = **7920mg/L (as fluoride ion F^-)**

The same result (C_s = 7920mg/L) is obtained with equation 3b if M = 50,000g, K = 0.20, P = 79.2 and V = 1000L.

4. Calculate the mass of fluoride chemical needed to make a specific fluoride solution strength %

Equation 2a can be used to calculate the mass of fluoride chemical needed to be added to make a specific percent concentration of the pure chemical in solution. Rearranging equation 2a, the mass of fluoride agent (M) in grams (g) can be calculated as follows from equation 4a:

Equation 4a:

M = $\frac{\mathbf{S \times V \times 1000}}{\mathbf{100 \times K}}$

For example, a 4% solution (therefore S = 4) of sodium fluoride (NaF) is required in a tank containing 200L of water (V = 200). According to the certificate of analysis, the purity of the NaF is 97% (K = 0.97). How much of the NaF chemical (i.e. mass M) is required to be added to make this 4% solution?

M = $\frac{4 \times 200 \times 1000}{100 \times 0.97}$ = **8247g (i.e. 8.247kg)**

That is, 8.247kg of the fluoridating chemical NaF needs to be added to the holding tank containing 200L of water to make a pure 4% solution of NaF.

5. Calculate the fluoride concentration from the chemical usage.

Dry Feed Systems:

If the quantity of chemical being used (i.e. grams of chemical used over a defined period) is known and the volume (symbol "V_t") of water treated is known, the theoretical fluoride concentration (in mg/L) in the final treated water can be calculated using equation 5a provided the concentration of fluoride in the raw water (symbol "C_{rw}" in mg/L) is also known:

Equation 5a:

$$\textbf{F mg/L (treated water)} = \frac{\textbf{(M x K x P x 1000)}}{\textbf{(}V_t \textbf{ x 100)}} + C_{rw}$$

For example, a dry feeder uses 2kg of NaF (M = 2000g) in one day to treat 1ML (V_t = 1,000,000L) of water. The purity of the NaF is 98% (K = 0.98) and the P value for NaF is 45.3%. The natural fluoride concentration C_{rw} in the raw water was found to be 0.1mg/L. What is the calculated fluoride concentration in the final treated water?

$$\text{F mg/L (treated water)} = \frac{\text{(M x K x P x 1000)}}{(V_t \text{ x } 100)} + C_{rw}$$

$$= \frac{\text{(2000 x 0.98 x 45.3 x 1000)}}{\text{(1,000,000 x 100)}} + 0.1$$

$$= 0.888 + 0.1$$

$$= \textbf{0.988mg/L (as fluoride ion } F^-\textbf{)}$$

Solution Feed Systems:

In a solution feed system where powdered NaF or Na_2SiF_6 or bulk fluorosilicic acid has been dissolved in a holding tank, the fluoride chemical is added to the plant clean water stream from the holding tank at a steady rate. Let "V_b" be the volume of solution that was used from the holding tank and let "V_t" be the volume of water that was dosed i.e. treated water produced in that period. Equation 5b can then be used to calculate the fluoride concentration in the treated water.

*Equation 5*b:

$$\textbf{F (mg/L treated water)} = \frac{\textbf{(S x 100 x P x } V_b\textbf{)}}{V_t} + C_{rw}$$

Consider the example shown in Section 2 where 980L of a 2% NaF solution was prepared (therefore S = 2 and P = 45.3). During a particular day, 1.5ML of water was dosed (i.e. V_t = 1,500,000L) and at the start of the day, the NaF holding tank was at a capacity of 980L; at the end of the run, the volume of NaF solution remaining in the tank was measured to be 845L. Therefore, V_b = 980 – 845 = 135L. The natural fluoride content in the water (C_{rw}) was found to be 0.08mg/L.

F (mg/L treated water) = $\frac{(S \times 100 \times P \times V_b)}{V_t} + C_{rw}$

= $\frac{(2 \times 100 \times 45.3 \times 135)}{1{,}500{,}000} + 0.08$

= 0.815 + 0.08

= 0.895mg/L (as fluoride ion F^-)

6. Calculate the fluoride concentration in treated water using flow rates.

Dry Feed Systems:

In a dry feed system, powdered fluoride chemical (NaF or Na_2SiF_6) is steadily added at a known rate in kilograms per hour (kg/h) to the water supply which is flowing at a known flow rate in litres per second (L/s). Let the delivery rate of the dry feed fluoride system be "R_g" kg/h and let the flow rate of the water being dosed in the plant be "R_p" L/s. Let C_{rw} be the concentration of fluoride ion in the raw water being treated so that equation 6a can be used to calculate the concentration of fluoride in the treated water:

Equation 6a:

F (mg/L treated water) = $\frac{(R_g \times P \times K \times 1000 \times 1000)}{(R_p \times 3600 \times 100)} + C_{rw}$

For example, a fluoride dosing facility is using sodium hexafluorosilicate (Na_2SiF_6) dry powder (i.e. P = 60.7) to fluoridate their water supply. The analysis certificate indicated that the product was 99% pure (i.e. K = 0.99). The powder is added to the plant water stream at a delivery rate of 0.05kg/h (R_g = 0.05) and the plant clean water is flowing at a rate of 15L/s (R_p = 15). The clean plant water has a fluoride ion concentration (C_{rw}) of 0.15mg/L so that the concentration of fluoride in the treated water is calculated as follows:

F (mg/L treated water) = $\frac{(R_g \times P \times K \times 1000 \times 1000)}{(R_p \times 3600 \times 100)} + C_{rw}$

= $\frac{(0.05 \times 60.7 \times 0.99 \times 1000 \times 1000)}{(15 \times 3600 \times 100)} + 0.15$

= 0.556 + 0.15

= **0.706mg/L (as fluoride ion F^-)**

Solution Feed Systems:

Equation 6b may be used to calculate the concentration of fluoride ion in the final treated water where a solution feed system is being used to dose the water supply using the flow

rate of the fluoride dosing pump and the flow rate of the water supply being dosed. Let the flow rate of the dosing pump be given the symbol "R_d" mL/min (millilitres per minute) and let the flow rate of the water being dosed in the plant be "R_p" L/s (litres per second). If C_s is the concentration of fluoride ion in the holding tank (see equation 3a or 3b for calculation of C_s) and C_{rw} is the concentration of fluoride ion in the clean plant water being treated, then the concentration of fluoride in the treated water can be calculated as follows:

Equation 6b:

$$\textbf{F (mg/L treated water)} = \frac{(R_d \times C_s)}{(R_p \times 1000 \times 60)} + C_{rw}$$

As an example, a fluoride dosing facility is pumping a solution of sodium fluoride from a holding tank at a rate of 50 mL/min (R_d = 50). The strength of the NaF solution is 2% so that the concentration of fluoride ion in the holding tank (C_s) is 9060mg/L (see equations 2a and 3a to calculate C_s). Thus C_s = 9060. The water to be fluoridated in the plant is flowing at a rate of 10 L/sec (R_p = 10). The concentration of fluoride in the clean plant water was 0.1mg/L (C_{rw} = 0.1) so that the concentration of fluoride in the treated water is calculated as follows:

$$\text{F (mg/L treated water)} = \frac{(R_d \times C_s)}{(R_p \times 1000 \times 60)} + C_{rw}$$

$$= \frac{(50 \times 9060)}{(10 \times 60 \times 1000)} + 0.1$$

$$= 0.755 + 0.1$$

$$= \textbf{0.855 mg/L (as fluoride ion } \mathbf{F^-}\textbf{)}$$

The fluoridating agent used in another plant is fluorosilicic acid. A day working solution of this acid was prepared by mixing 50kg (equivalent to 42.5L – see Section 3) of the 20% product acid from the vat with 957.5L of water in a holding tank. The concentration of fluoride in this solution, expressed in mg/L, was calculated to be 7920mg/L (see Section 3 above) so that C_s = 7920. At this particular plant, the acid in the holding tank was added at a rate of 45mL/min (R_d = 45) and the plant clean water flow rate was 9L/s (R_p = 9). The concentration of fluoride in the clean plant water was measured to be 0.05mg/L (C_{rw} = 0.05). Applying equation 6b, the fluoride content in the final dosed water calculates to be 0.71mg/L i.e.

$$\text{F (mg/L treated water)} = \frac{(R_d \times C_s)}{(R_p \times 1000 \times 60)} + C_{rw}$$

$$= \frac{(45 \times 7920)}{(9 \times 1000 \times 60)} + 0.05$$

$$= 0.66 + 0.05$$

$$= \textbf{0.71 mg/L (as fluoride ion } \mathbf{F^-}\textbf{)}$$

Appendix 5 – Approved forms

The following forms are approved under the *Water Fluoridation Regulation 2008*.

- **Form 1 – Fluoridation notice**. This form is to be used to notify the chief executive that a water supplier intends to add fluoride to a public potable water supply from a stated date. This notice must be submitted 30 days prior to the stated date. This fluoridation notice must also be published at least once in a newspaper circulating in the area of the state serviced by the water supply.
- **Form 2 – Notice of period of non-operation.** This form is to be used to notify the chief executive if a fluoride dosing facility is continuously non-operational for a period of two weeks. This form must be submitted to the chief executive within 1 day after the end of the two week period.
- **Form 3 – Quarterly reporting form.** This form must be used when submitting the quarterly reports as required under the *Water Fluoridation Regulation 2008*. The completed form must be submitted to either Queensland Health or the Office of the Water Supply Regulator within 30 business days of the completed quarter.
- **Form 4 A, B, C & D – Recording requirements.** These forms are to be used to ensure that the recording requirements of the Water Fluoridation Regulation are met. If these forms are filled in correctly, the requirements of section 10 of the Regulation will be fulfilled. Only one form, either A, B, C or D needs to be used depending on the fluoridation system being used at the treatment plant.
    - Form A is for dry feeder systems.
    - Form B is for acid feed systems.
    - Form C is for batch solution feed systems.
    - Form D is for saturator systems.

WATER FLUORIDATION ACT 2008
SECTION 13
Form 1

FLUORIDATION NOTICE

Queensland Government
Queensland Health

1. Water Supplier Details

Name

ABN/ACN | Service Provider ID

Principal contact

Family Name | Given Name/s | Position

Street address | Post Code

Postal address (if different to above) | Post code

Phone | Fax | Mobile

Email

2. Water Supply Details

Proposed Commencement Date

Name and location of treatment plant | Local Government Area

Details of fluoridation process (type of chemical, dry or solution feed, prescribed fluoride level)

Area or communities receiving fluoridated water

Attachments – Please tick the box if you have attached the following

1. A copy of the public notice advising consumers of the intention to fluoridate must be attached ☐
2. Has additional information been attached? YES ☐ Number of additional pages attached _____

Signature of Principal Contact | Date

Submit this notice to Chief Executive Officer, Queensland Health, PO Box 2368, Fortitude Valley BC, 4006

WATER FLUORIDATION REGULATION 2008
SECTION 7(3))
Form 2

NOTICE OF PERIOD OF NON-OPERATION

Queensland Government
Queensland Health

1. Water Supplier Details

Name

ABN/ACN | Service Provider ID

Principal contact

Family Name | Given Name/s | Position

Street address | Post Code

Postal address (if different to above) | Post code

Phone | Fax | Mobile

Email

2. Details of period of non-operation

Period of non-operation

Name and location of treatment plant

Reasons for non-operation

Action taken to remedy matter

Attach additional information if necessary

Signature of Principal Contact | Date

Submit this notice to Chief Executive Officer, Queensland Health, PO Box 2368, Fortitude Valley BC, 4006

WATER FLUORIDATION REGULATION 2008
SECTION 11
Form 3

FLUORIDATED WATER QUARTERLY REPORT

Queensland Government
Queensland Health

1. Water Supplier and Supply Details

Name of Water Supplier

Name of Treatment Plant	Location of Treatment Plant

Service Provider ID

2. Contact Details

Family Name	Given Name/s	Position

Phone	Fax	Mobile

Email

Signed	Date

3. Results
Reporting Period

From……to ……Year……..

Fluoridated Water Results for the above quarter

Number of days in the quarter	
Number of fluoridated water samples analysed	
Prescribed concentration for Local Government Area	
Average measured fluoride concentration	
Maximum measured fluoride concentration	
Minimum measured fluoride concentration	
Number of samples exceeding 1.5 mg fluoride/L	

This form must be retained by the water supplier for a period of at least 5 years. Completion of the table above ensures compliance with the reporting requirements of Section 11 of the *Water Fluoridation Regulation 2008.* This form must be forwarded to either the Office of the Water Supply Regulator or the Chief Executive of Queensland Health within 30 business days of the end of the quarter.

WATER FLUORIDATION REGULATION 2008
RECORDING REQUIREMENTS (SECTION 10)

Form 4A - (Dry Feed) Daily Record Sheet for Week Ending……..

Day	Date	Time	**Column 1** Water Treated (ML) [Section 10 - 1a]	**Column 2** Amount of fluoride chemical added to water (kg)	**Column 3** Chemical Purity [a] %	**Column 4** Amount of fluoride ion added to water [b] (kg) [Section 10 - 1b]	Fluoride ion concentration in treated water (mg/L)		Additional records *	
							Calculated [c] [Section 10 - 1c]	Measured [d] [Section 10 - 1d]		
Sat										
Sun										
Mon										
Tues										
Wed										
Thurs										
Fri										
Water Supplier:					Name of treatment plant:				Operator:	
Fluoridation chemical used:					Name of supplier:				Supervisor:	

[a] Column 3 = % fluoride ion in the fluoride chemical multiplied by the % purity (See Appendix 4, Equation 1a for the calculation of % fluoride ion in fluoride chemical). % Purity should be taken from the batch analysis certificate (Further information is available in Appendix 1, Table 4 of the Water Fluoridation Code of Practice).

[b] Column 4 = (column 2) X (column 3)/100

[c] Calculated fluoride ion concentration = (Column 4 (kg)) ÷ (column 1 (ML)) + fluoride concentration in raw water.

[d] Fluoride must be measured by a prescribed analysis listed in the *Water Fluoridation Regulation 2008*, Schedule 3, Dictionary.

[ ] brackets indicate the section in the *Water Fluoridation Regulation 2008* to which this requirement relates.

* Operators may use these columns to capture additional records such as the results of reticulation sampling, verification samples, average results of online analysers, etc

WATER FLUORIDATION REGULATION 2008
RECORDING REQUIREMENTS (SECTION 10)

Form 4B - (Acid Feed) Daily Record Sheet for Week Ending……..

Day	Date	Time	**Column 1** Water Treated (ML) [Section 10 - 1a]	**Column 2** Amount of fluoride acid solution added to water [a] (kg)	**Column 3** Chemical Purity [b] %	**Column 4** Amount of fluoride ion added to water [c] (kg) [Section 10 - 1b]	Fluoride concentration in treated water (mg/L)		Additional records *	
							Calculated [d] [Section 10 - 1c]	Measured [e] [Section 10 - 1d]		
Sat										
Sun										
Mon										
Tues										
Wed										
Thurs										
Fri										
Water Supplier:					Name of treatment plant:			Operator:		
Fluoridation chemical used:					Name of supplier:			Supervisor:		

[a] Column 2 is the loss in weight in kg from the acid solution tank.

[b] Column 3 = % fluoride ion in the fluoride chemical multiplied by the % purity (See Appendix 4, (1) for information on the calculation of % fluoride ion in fluoride chemical). %Purity should be taken from the batch analysis certificate as strength and purity of acid can vary (Further information is available in Appendix 1, Table 4 of the Water Fluoridation Code of Practice).

[c] Column 4 = (Column 2) x (column 3).

[d] Calculated fluoride ion concentration = column 4 (kg) ÷ column 1 (ML) + fluoride concentration in raw water

[e] Fluoride must be measured by a prescribed analysis listed in the *Water Fluoridation Regulation 2008*, Schedule 3, Dictionary.

[ ] brackets indicate the section in the *Water Fluoridation Regulation 2008* to which this requirement relates.

* Operators may use these columns to capture additional records such as the results of reticulation sampling, verification samples, average results of online analysers, etc

WATER FLUORIDATION REGULATION 2008
RECORDING REQUIREMENTS (SECTION 10)

Form 4C - (Solution Feed) Daily Record Sheet for Week Ending……..

Day	Date	Time	**Column 1** Water Treated (ML) [Section 10 - 1a]	**Column 2** Amount of fluoride solution added to water (L)	**Column 3** Solution fluoride strength [a] (g/100ml or %)	**Column 4** Chemical Purity % [b]	**Column 5** Amount of fluoride ion added to water [c] (kg) [Section 10 - 1b]	Fluoride concentration in treated water (mg/L)		Additional records *	
								Calculated [d] [Section 10 - 1c]	Measured [e] [Section 10 - 1d]		
Sat											
Sun											
Mon											
Tues											
Wed											
Thurs											
Fri											
Water Supplier:					Name of treatment plant:				Operator:		
Fluoridation chemical used:					Name of supplier:				Supervisor:		

[a] Column 3 is determined using equation 2a) in Appendix 4 of the Water Fluoridation Code of Practice.

[b] Column 4 = % fluoride ion in the fluoride chemical multiplied by the % purity (See Appendix 4, Equation 1a for the calculation of the % fluoride ion in the fluoride chemical). Purity % should be taken from the batch analysis certificate. Further information is available in Appendix 1, Table 4 of the Water Fluoridation Code of Practice.

[c] Column 5 = (column 2) X (column 3)/100 X (column 4)/100 X 1000mL/L ÷ 1000kg/g

[d] Calculated fluoride ion concentration = (Column 5 (kg)) ÷ (column 1 (ML)) + fluoride concentration in raw water.

[e] Fluoride must be measured by a prescribed analysis listed in the *Water Fluoridation Regulation 2008*, Schedule 3, Dictionary.

[ ] brackets indicate the section in the *Water Fluoridation Regulation 2008*, to which this requirement relates.

* Operators may use these columns to capture additional records such as the results of reticulation sampling, verification samples, average results of online analysers, etc

WATER FLUORIDATION REGULATION 2008
RECORDING REQUIREMENTS (SECTION 10)

Form 4D - (Saturator Feed) Daily Record Sheet for Week Ending……..

Day	Date	Time	**Column 1** Water Treated (ML) [Section 10 - 1a]	**Column 2** Amount of fluoride solution added to water (L)	**Column 3** Solution fluoride strength [a] (g/100ml)	**Column 4** Chemical Purity % [b]	**Column 5** Amount of fluoride ion added to water [c] (kg) [Section 10 - 1b]	Fluoride concentration in treated water (mg/L)		Additional records *	
								Calculated [d] [Section 10 - 1c]	Measured [e] [Section 10 - 1d]		
Sat											
Sun											
Mon											
Tues											
Wed											
Thurs											
Fri											
Water Supplier:					Name of treatment plant:				Operator:		
Fluoridation chemical used:					Name of supplier:				Supervisor:		

[a] Solubility of NaF is 4 % and for Sodium fluorosilicate (Na_2SiF_6) is 0.76 %

[b] Column 4 = Column 3 X purity % (This information is available in Appendix 1, Table 4 of the Water Fluoridation Code of Practice). For sodium fluoride (NaF) the fluoride ion % is 43.4 (at 96% purity) and for Sodium fluorosilicate (Na_2SiF_6) the fluoride ion % is 59.8 (at 98.5% purity)). Purity % should be checked against the batch analysis certificate.

[c] Column 5 = (column 2) X (column 3)/100 X (column4)/100 X 1000ml/L ÷ 1000kg/g

[d] Calculated fluoride ion concentration = (Column 5 (kg) ÷ (column ML) + fluoride concentration in raw water

[e] Fluoride must be measured by a prescribed analysis listed in the *Water Fluoridation Regulation 2008*, Schedule 3, Dictionary.

[ ] brackets indicate the section in the *Water Fluoridation Regulation 2008*, to which this requirement relates.

* Operators may use these columns to capture additional records such as the results of reticulation sampling, verification samples, average results of online analysers, etc

12. References

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