New South Wales Code of Practice for Fluoridation of Public Water Supplies

Fluoridation of Public Water Supplies Act 1957

NSW Health
April 2018

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Document revision

Revision date	Description of changes from previous version
17 April 2018	• Amendments to Appendix 1 – Application process flowchart and Form 1 • General updates to references to legislation and guidance documents • General updates to organisation names and contact details

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1 Introduction - Water Fluoridation

Water fluoridation is the upward adjustment of fluoride in water to optimal levels to help prevent tooth decay. The optimal level of fluoridation is the level of fluoride in the community water supply that is associated with the maximum reduction of dental decay in the population and the minimal occurrence of any adverse dental effects. Fluoridation of drinking water at optimal levels remains the most significant dental public health program in Australia. Water fluoridation delivers the most effective, efficient and socially equitable means of achieving community wide exposure to the dental decay preventive effects of fluoride.

In the 1940's and 1950's Australian children had among the highest level of dental decay experience in the world with only 1 per cent of 12-year-old children free of dental decay. The level of dental decay began to decrease in the mid 1960's coinciding with the introduction of water fluoridation and the use of fluoride toothpaste. By 1993 over half of the children in Australia had no experience of dental decay. Today, only a minority of children in Australia experience dental decay. The percentage decrease in decay prevalence attributed to water fluoridation was 70 per cent, while 26 per cent was attributed to fluoride toothpaste and only 2 per cent to fluoride tablets (Spencer 1986). In adults, water fluoridation has also contributed to improving oral health and decline in edentulism (no natural teeth remaining in the mouth).

Water Fluoridation in New South Wales

In the 1950's, prior to water fluoridation, the level of dental caries amongst children in New South Wales (NSW) was one of the highest in the world with 12 year olds having a mean of 9 to 10 decayed, missing and filled teeth (DMFT). In NSW, water fluoridation was first introduced in the town of Yass in 1956, followed by Tamworth in 1963 and Sydney in 1968. By the late 1970's approximately 90 per cent of the population in NSW had access to fluoridated water. Currently approximately 94 per cent of NSW population has access to fluoridated water.

Prior to the introduction of fluoridation in Tamworth in 1963, all schoolchildren were examined. Follow up surveys were then carried out annually to 1973, in 1979, and in 1988. Baseline data on dental caries for 12 year olds was 8.4 DMFT, this decreased to 7.0 in 1967, 5.6 in 1970. By 1973 dental decay decreased by 50 % to 4.3 and in 1988 it was 0.9 (Barnard and Sivaneswaran 1990). This outcome compares favourably with the WHO goal for 12 year olds were to reach a DMFT of 1 by the year 2000. The DFMT rate for 12 year old children in NSW in 2007 was 0.8.

A special feature of water fluoridation is that it reduces the social inequalities in caries experience (Slade et al 1996). In New South Wales children living in unfluoridated areas have significantly higher dental decay rates than those living in fluoridated areas despite the availability of fluoride toothpaste (Armfield 2005).

The advantage of water fluoridation is that the entire community benefits from the preventive measure, regardless of age, socioeconomic level, educational achievement, individual motivation or the availability of a dental workforce.

As early as 1958, the World Health Organisation recognised the importance of water fluoridation and has repeatedly endorsed the fluoridation of drinking water as a desirable public health policy based on numerous scientific studies carried out throughout the world. As a result of the oral health and economic benefits it confers, water fluoridation has also been endorsed and recommended by more than 150 scientific, health and political organisations throughout the world including the National Health and Medical Research Council of Australia (NHMRC). In fact the Centers for Disease Control rates water fluoridation as amongst the Top 10 Public Health Measure of the

twentieth century alongside the eradication of poliomyelitis and smallpox. The NHMRC has recently conducted extensive reviews of recent literature on fluoride and health and concluded that water fluoridation at optimal levels remains the most effective measure for reducing dental caries (NHMRC 2017). Numerous organisations both nationally (AHMAC, 2004) and internationally (FDI *et al*., 2006) have published contemporary policies urging the universal implementation of water fluoridation. Communities that have ceased water fluoridation have a demonstrated increase in dental caries experience.

References

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FDI World Dental Federation, International Association for Dental Research and World Health Organization [FDI, IADR and WHO] (2006): *Call to action to promote dental health by using fluoride*, 17–19 November 2006. Geneva: FDI World Dental Federation and World Health Organization. Available at: http://www.who.int/oral_health/events/oral%20healthc.pdf (accessed April 13, 2009)

2. Legislative framework

Legislation providing for water fluoridation in New South Wales is described as permissive or enabling legislation. The legislation, first passed in 1957 (*Fluoridation of Public Water Supplies Act* 1957), permits the Secretary of NSW Health to define the conditions when fluoride may be added to a water supply. The Act provides for the establishment of the Fluoridation of Public Water Supplies Advisory Committee with the power to initiate and refer to the Minister proposals concerning the addition of fluoride to public water supplies. The *Fluoridation of Public Water Supplies Regulation* 2017 under the *Fluoridation of Public Water Supplies Act* 1957 deals with the procedures for keeping records of the addition of fluoride, analysing the water for fluoride content, qualifications of the operators, as well as precautions to be taken by water supply authorities to protect operators.

This Code of Practice includes generally technical material, which has not been specified in the Act or in the *Fluoridation of Public Water Supplies Regulation* 2017. The material in this Code therefore either forms part of the regulatory framework which water supply authorities that fluoridate are required to follow, or is part of an advisory guide to water utilities as to the source of other relevant material or legislation (such as that governing occupational health and safety).

The NSW Health recognises that water fluoridation, when implemented, must be effectively managed to achieve maximum oral health benefits and to minimise any risks associated with excessive exposure to fluoride. The aim of this Code is to achieve best practice in the establishment and operation of fluoridation plants in New South Wales, in order to meet the technical, occupational health and safety and environmental requirements of the relevant legislation. It applies to all new and existing plants in New South Wales and it is the responsibility of all fluoridating water utilities to ensure that they comply with this Code.

There are potential aesthetic, health and environmental risks associated with the use of fluoridation chemicals. These risks need to be effectively managed. The application of risk control measures should be applied systematically to all identified risks based on a hierarchy of control.

The *Fluoridation of Public Water Supplies Act* and the associated Regulations and this Code are the key documents for the communication and implementation of this risk control strategy. This Code of Practice is a supporting document to the *Fluoridation of Public Water Supplies Act* and associated Regulations prepared by Department of Health to assist water utilities in interpreting and complying with the Act and Regulations. This Code of Practice will be updated from time to time as considered necessary by the NSW Health in consultation with key stakeholders.

NSW Health is committed to improving the oral health of all members of the New South Wales' population and continues to strongly support water fluoridation as an important public health policy.

3 Structure of the Code of Practice document

This Code covers a number of areas. Within each area there will be statements of the *outcomes* required within those areas. These *outcomes* are the fundamental intent of the controls required in this Code, and as such, should remain the focus of water supply authorities at all times.

Under these *outcomes* will be listed various minimum standards that are considered necessary to achieve the required outcomes. All *minimum standards* must be complied with unless NSW Health has approved otherwise.

Simple compliance with these *minimum standards* however, does not relieve the fundamental requirement for a water utility to focus on achieving the stated *outcomes*. Compliance with the *minimum standards* and achievement of the stated *outcomes* are the basis on which NSW Health will assess whether a water utility meets the requirements of the Fluoridation Act and Regulations.

In some places there will be *guide notes* that are inserted to more fully explain a specific requirement. These *guide notes* may also include suggestions for improving performance or reducing risk beyond the minimum standard requirements. Compliance with the guide notes is not mandatory, however the guide notes provide further clarification, record lessons learnt from past experience, and give an indication of current best practice.

Within this document:

3.1.1 Required outcomes are printed in bold typeface.

3.1.1.1 Minimum standards are listed under an outcome in italic typeface.

Guide notes are indented under the minimum standards in plain typeface.

4 Application and approval to fluoridate

4.1 New Applications to Fluoridate a Water Supply

4.1.1 Systematic and appropriate risk control measures are in place at each fluoridation facility within NSW to minimise the potential for over and under dosing of fluoride

4.1.1.1 A water utility shall obtain approval from NSW Health prior to fluoridating any water supply.

The process for a water utility to gain an approval to fluoridate is set out in Appendix A which contains the application protocol, and form. The process includes the initial application, the detailed specification and design of the fluoridation plant, through to commissioning of the plant.

As part of the approval process, NSW Health considers any request for subsidisation of the capital cost of fluoridation plant works in accordance with its current subsidy policy.

4.1.1.2 A water utility shall not commence fluoridating until formally approved to do so by the Secretary of NSW Health and all conditions imposed by the Secretary have been complied with.

The formal Instrument of Approval from the Secretary of NSW Health will specify:

- The name of the water utility
- The public water supply to be fluoridated
- The allowable fluoride concentration operating range
- The fluoridating agent(s) that can be used
- Other conditions to be met before the commencement of fluoridation

4.1.1.3 A water utility must not commence fluoridation of a water supply prior to the consumers within that supply area being given adequate warning of the commencement date.

It is important that consumers are aware of the intention to fluoridate, both in terms of keeping the public informed, and to prevent excessive intake of fluoride by those who may currently be taking fluoride tablets.

4.2 Fluoridation Plant and Water Supply System Upgrades

4.2.1 Initial design risk control measures shall not be degraded through subsequent modifications of the fluoridation plant and/or the water supply system.

4.2.1.1 For any water supply system capacity upgrade or major fluoridation plant upgrade, NSW Health must be consulted in advance and the water utility must submit a new Form 1 Application to Fluoridate (refer to Appendix A).

Where a water utility replaces equipment items within a fluoridation plant, without changing the sizing of the equipment or negatively impacting on any existing control measures (eg. interlocks etc) then NSW Health need not be informed.

It is good practice however to maintain a record of all changes made to the fluoridation plant (eg. in a plant register, or via maintenance management systems).

4.2.2 Relevant staff of a water utility has an awareness of the key design risk control measures to prevent over and under dosing of fluoride.

4.2.2.1 The water utility shall display a current copy of the Instrument of Approval document at the plant, and provide relevant staff with easy access to a copy of this Code of Practice.

A visible "approval document" helps maintain staff awareness of key control limits on the fluoridation plant design and that NSW Health has a direct interest in its operation.

The Code of Practice provides a useful educational tool and easy reference source.

4.3 Permanent Cessation of Fluoridation of a Water Supply

4.3.1 The community receives water that is fluoridated to the optimal level so that oral health is not compromised.

4.3.1.1 A water utility shall not permanently cease fluoridating a water supply without the written approval of NSW Health

This requirement does not refer to short-term stoppages due to breakdowns or maintenance work – refer to Section 11

5 Design controls for fluoridation facilities

5.1 General Design Criteria

5.1.1 The design of the fluoridation plant shall ensure it can consistently achieve an overall accuracy of within ± 5% of the required fluoride target dose rate over the full water flow rate range approved by NSW Health. For example, to consistently achieve between 0.95 to 1.05 mg/L of fluoride in the treated water for a target of 1.00 mg/L F.

5.1.1.1 The fluoridation chemical feeding equipment shall be designed to dose fluoride within ± 5% of the target dose rate specified in the Instrument of Approval over the full water flow rate range approved by NSW Health.

5.1.1.2 Water flowmeter(s) must be provided to measure and integrate the water flow, and to pace the fluoride dosing equipment where the plant design calls for such, over the full water flow rate range approved by NSW Health.

A flow meter must be provided to measure the water flow. This is critical to the accuracy and reliability of the whole process. Where possible the use of electromagnetic flowmeters is recommended as they can achieve an accuracy of ± 1-2% of rate over a large turn down range.

5.1.2 The design of the fluoridation plant shall ensure reliable automatic operation. That is, it must reliably stop and start with the water flow being dosed.

5.1.2.1 Two discreet physical indications of water flow shall be 'hard' wired in series, either directly or via PLC (programmable logic controller) coding, in the control loop for starting and stopping of the fluoridation plant. Where practicable one indication shall be from upstream of the fluoride injection point and one shall be downstream.

Reliance on a single primary flow sensing device (eg. flow switches, flowmeter etc) can significantly increase the risk of overdosing, as a fault/failure could lead to the fluoridation plant continuing to dose after the water flow has actually stopped. The use of two devices in series should significantly reduce this risk, as it would require both devices to give false positive readings at the same time. The failure of one of the devices will stop the fluoridation plant dosing when it should, but this is a much more acceptable situation than overdosing which could create an acute health risk – refer Section 11 for short term stoppages. In selecting the most appropriate flow sensing devices care should be taken to ensure they are reliable and durable for this duty.

Use of flow sensing devices, which are remote to the fluoridation plant via telemetry, may have a higher risk of failure.

5.1.2.2 All key components of the fluoride dosing system shall be electrically interlocked to ensure total fluoride dosing system shutdown on the failure of any individual equipment item.

It is good design practice for discrepancy alarms and interlocks to be provided where possible to minimise the possibility of overdosing. A risk assessment of the possible causes of overdosing should be carried out on the plant design and, where feasible, appropriate interlocks and alarms designed into the system. This will minimise
Both, the risk of overdosing occurring, and the length of time for which the condition exists before plant staff intervention. This assessment should be documented, stored, and made available upon request.

The key components would include stop/start/pacing signals, feeders, dosing pumps, solution transfer pumps, solution tank level signals, mixers, dilution water pumps etc.

The failure of any key component should result in alarms being generated and operational staff responding.

5.1.2.3 Any solution water supply shall have a backflow prevention device fitted upstream of where the fluoridating agent is diluted (eg mixing tanks) or injected (eg dosing pumps). Where relevant the device should comply with the current Australian Standard.

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. In some situations this can be achieved simply through use of an air gap.

5.1.3 The design of the fluoridation plant shall minimise the risk of overdosing due to human error wherever possible.

5.1.3.1 The maximum physical dosing capacity of the fluoridation chemical feeding equipment shall be limited by design to a maximum value equivalent to 110% of the operating target dose rate specified in the instrument of approval at the maximum water flow rate approved by NSW Health.

5.1.3.2 It shall 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.

It is not uncommon for dosing pumps, electrical controls etc at small plants to be wired with standard single or three phase power plugs to facilitate removal for maintenance by non-electrical staff.
Unfortunately, in terms of overdosing risks, this significantly increases the reliance on the human factor as the equipment could be easily left operating continuously independent of the water flow.

5.1.3.3 Any manual mode (or 'test') switch for the fluoridation chemical

feeding equipment shall not permit permanent selection (eg spring loaded switches) and must return to the off position when released to prevent unattended manual operation.

Any manual operation via PLC/SCADA control modes shall include a "hard" coded timer (i.e. not changeable by operators or maintainers) that will turn the fluoride pumps off. The timer shall be set at a maximum of five minutes unless otherwise approved.

Manual operation of equipment needs to be carefully controlled as it is totally reliant on the human factor. For example the ability to plug a dosing pump directly into a power outlet and operate it manually creates a high risk of overdosing should the plant flow stop and the operating staff be unaware of it, or if they simply forget to turn it off.

This requirement is focused on the design of local control panels. Where PLC/SCADA (supervisory and data acquisition) systems are provided then there is a clear risk of overdosing of fluoride if the dosing pumps were to be left in any remote manual or semi-manual control mode. Although the use of a fixed timer reduces this risk, the water utility may need to consider other risk management controls in the PLC and SCADA software to minimise the risk of the plant overdosing particularly when there is no water flow. The PLC/SCADA controls should form part of the risk assessment discussed under section 5.1.2.2 above.

In addition the water utility should have an appropriate change management procedure to cover any changes to the PLC and SCADA programming.

The approach to be taken in some instances may need to be negotiated with NSW Health.

5.1.4 The design of the fluoridation plant shall provide plant operational staff with all that is required to measure and control the fluoridation process (and equipment) accurately and consistently in a timely manner.

5.1.4.1 The plant design must provide the ability to measure:
- the instantaneous water flow
- the total amount of water treated and fluoridating agent used over a 24 hour period (for sodium fluoride saturator or batching systems, this shall be calculated)

The calculation of instantaneous and average 24 hour calculated doses shall not have errors greater than ± 5%

The use of large storage tanks, inappropriately designed drop test tubes, and poor choice of integrated water flow units can significantly increase measurement errors to a point where they become meaningless for daily process control.

Not providing plant operators with the ability to accurately monitor their plant performance is counter productive and only increases risk to the water utility and consumers.

5.1.4.2 All necessary local indications shall be provided to allow the operator to assess whether the process and equipment are running satisfactorily.

Not providing plant operators with the ability to accurately monitor their plant and equipment performance is counter productive and only increases risk to the water utility. Local indicators which need to be considered would include water flow, integrators, fluoridating agent feed rate, pressure and level indicators, storage levels, equipment status, alarms, ammeters, hours run, etc.

5.1.5 The design of the fluoridation plant shall provide a safe working environment and facilitate safe working practices to protect both plant operations staff and the public (refer also to Section 6).

5.1.5.1 Where hydrofluosilicic acid is used electrical control cubicles for the fluoridation plant shall be located so as to minimise deterioration due to corrosion and to minimise the need for staff to enter the fluoridation plant room or specific areas where fluoridation equipment is installed.

This requirement is focused on minimising the need for entry into the fluoridation plant room or the plant site for operational and maintenance staff, and reducing risk to the fluoridation process due to breakdowns from increased corrosion problems (particularly plants using hydrofluosilicic acid), as well as improving general asset life of the control equipment. Where dedicated fluoridation plant rooms are provided, it is suggested that the control cubicles should be in a separate room beside the room containing the fluoridating agent dosing equipment. The two rooms would have separate entry doors, a window in the common wall but no inter-connecting door or other means for air to pass between the rooms (eg unsealed electrical conduits or chases). Glass is not to be used for the window as it will be etched and frosted by acid fumes. The location/orientation of the control cubicles and fluoride dosing equipment should allow operators to have a clear view of the dosing equipment when operating the control panel.

5.1.5.2 The installation (eg. relative locations, mounting height, all round access etc.) of all equipment, valves, controls and access points shall facilitate easy access for all expected operational and maintenance requirements.

Careful consideration needs to be given to the finished physical layout of equipment within the fluoridation plant room (ie. the sum of the design and the installation phases) so that safety risks are minimised. This includes providing clear access to equipment for both operational duties as well as for maintenance staff. For example, not creating trip hazards, or locating items which people may walk into or hit their head on, locating all valves and controls such that they are easily accessible and operated, etc.

5.1.5.3 Where a dry fluoridating agent is used there must be an appropriate dust extraction system(s) to prevent escape of powder into the fluoridation room and to maintain an acceptable breathing atmosphere. The dust extraction equipment shall operate from the time the bags are opened to

when the bags are unloaded into the storage hoppers.

The design of the dust extraction systems should take into account the total process from when the bags are unloaded into storage hoppers, powder transport from the hoppers to the feeders and from the feeders into the dosing solution.

In some situations the use of two dust extraction systems may need to be considered – one for the bag loading and hopper equipment, and one for the atmosphere in the fluoridation room.

5.1.5.4 Where a dry fluoridating agent is used the design of the fluoridation plant room shall remove any potential for build up of powder from air deposition over time wherever possible.

The design of the fluoridation room should ensure as far as practicable:

- smooth ceilings and walls coved to the floor (eg. brick walls would need to be rendered smooth) and painted with gloss paint of a suitable colour which clearly reveals any dust,
- where practicable no or minimum horizontal or gently sloping surfaces such as window ledges or steel beams,
- smooth cement floor (but including some appropriate preparation to provide a non slip surface eg steel trowelled incorporating carborundum) sloped to a drain or sump located adjacent to a wall,
- use of flush surfaces where practicable (eg. windows and doors flush with walls, design of internal structures and equipment mountings etc.)
- use glass brick to provide natural light rather than windows

5.1.5.5 Where hydrofluosilicic acid is used the associated corrosive fumes shall be removed from the fluoridation plant room via mechanical ventilation. Venting of fume sources (eg. internal storage tanks) to an appropriate outside location through a suitable absorption filter or water trap.

Hydrofluosilicic acid is quite corrosive and will give off acidic fumes, which will both affect the atmosphere in the fluoridation plant room as well as significantly increasing corrosion rates of equipment in the room. Firstly the source of fumes from any permanent internal storage tank should be minimised through sealing of the tank, extending the vent outside the building, and putting a water seal on the tank overflow outlet (if the bunded area is internal to the room). Similarly drop tubes and pressure relief lines etc need to be enclosed and piped back to the main storage or day tanks. Secondly an acid resistant exhaust fan should be installed to remove the fumes from the fluoridation plant room. The location of the fan and room vents should be chosen to maximise cross flow ventilation of the room. Venting from storage tank and day tank are required to be exhausted through suitable absorption filters located at accessible positions for maintenance. A water trap arrangement can also be used to effectively remove the acidic gases, but it should be designed with a suitable float valve to automatically maintain a set water level. The design should also allow operators to easily inspect and drain the tank when needed.

5.1.5.6 The fluoridation room shall be designed to allow easy cleaning and removal of spilt fluoridation chemical through hosing down of the lower walls and floor. Refer to Section 7 below concerning requirements on the fate of this water.

A tap and hose should be provided in the fluoridation plant to facilitate cleaning and decontamination of spilt fluoridating agent as required. If any liquid waste is collected in a bunded area then a sump should be provided to allow complete removal via a sump pump. The location of the sump shall not require access into the bunded area to operate, and preferably should be at an accessible edge of the bunded area if feasible.

5.1.5.7 Where a dry fluoridating agent is used, the design of the plant shall minimise the need for any manual handling. Where manual handling is appropriate the design shall minimise the number of lifts required, the amount of bending, and the distance and height through which bags are lifted.

The design should consider where needed 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 if bags are taken off a pallet for loading into the storage hopper – this minimises the need to bend further the emptier the pallet becomes.

5.1.5.8 Access to the fluoridation room or specific areas where the fluoridation equipment is installed shall be restricted through provision of a security locking system.

Control of access to the fluoridation chemicals and dosing equipment is an effective control measure to minimise risks to untrained staff and the public, as well as minimising the potential for unauthorised changes to the fluoridation dose rate.

5.1.5.9 Appropriate signage shall be provided to indicate the presence of the fluoridating agent, and that authorised entry only is permitted.

Signage is required under various legislation (OH&S Act 2000, and associated Regulations) depending on the chemical and quantities stored.

5.1.5.10 Fluoride shall not be allowed to flow to lagoons where supernatant is returned to the head of the works.

It is not uncommon for general drainage from chemical handling areas etc to flow to sludge lagoons as a way of providing emergency containment. In the event of a major spill this arrangement can lead to overdosing of the treated water if the plant returns its supernatant to the head of the works. This requirement refers primarily to handling of fluoridating agent spillages and does not apply to fluoridated treated water used to backwash filters.

5.1.5.11 The plant design shall allow for any requirements identified under Section 6 of this Code.

5.1.6 The design of the plant shall minimise the risk of fluoridating agents escaping to the environment (refer also to Section 7).

5.1.6.1 Where a liquid fluoridating agent is used then appropriate bunding shall be provided to contain any spillage. The design of bunding must facilitate the safe removal of any spillage.

Design of environmental containment should take into consideration the potential spillage volumes during delivery and unloading, the maximum volumes stored on site, the volume that may spill if the dosing pump suction or delivery pipe work should fracture.

Apart from being easier for operational staff, the provision of accessible pump out sumps to allow effective removal of spills can also be an important safety requirement.

5.1.6.2 Where dry fluoridating agents are used powder should not be allowed to escape from the fluoridation room to the external atmosphere.

The use of doors with rubber seals and airtight windows should be considered. The use of dust extraction should effectively deal with this issue.

5.1.6.3 The location and design of absorption trenches shall not allow fluoride to be carried into a water supply well or be a hazard to stock or local wildlife.

The use of absorption trenches should be considered a last resort for disposal of concentrated fluoride spillage. Complete containment via bunding and/or small containment tank(s) is preferred over uncontrolled release to an absorption trench.

5.1.6.4 The plant design shall allow for any requirements identified under Section 7 of this Code.

5.1.7 The fluoridation plant complies with all legislative requirements.

5.1.7.1 The water utility shall ensure the fluoridation plant complies with all legislative requirements.

The Fluoridation Act, Regulation and Code of Practice do not contain or reference all legislative requirements that a water utility may have to comply with in the design, construction and operation of a fluoridation plant (for example building codes). The responsibility for identification of, and compliance with, relevant legislative requirements lies with the water utility.

5.2 Description and specific requirements for typical fluoride feed systems

Typically four generic types of fluoride dosing systems are in use. Generic fluoridation plant process and instrumentation diagrams are contained in Appendix D. The choice of which to use includes issues such as size, availability of fluoridating agent, costs, staffing availability/limitations, ease of operation, management limitations etc. The minimum requirements for each of these four are described below:

5.2.1 Dry fluoridating agent feed systems

5.2.1.1 Dry fluoride feed systems shall include a dust extractor system, a bag loader or a vacuum loading system, a storage/feed hopper, a volumetric or gravimetric dry feeder, a dissolving tank with mechanical stirrer, a weight loss system to monitor the weight of fluoridating agent used, a potable or filtered dilution water source, and a positive displacement solution transfer pump (if not gravity fed).

5.2.1.2 For this type of system a direct dust extraction capability from the bag loader when it is opened for manually filling the storage hopper must be available. Where a vacuum bag loading system is used an appropriate dust extraction system integrated with the storage hopper shall be provided.

5.2.1.3 The storage hopper must have sufficient capacity for between 48 to 72 hours operation at the maximum water flow rate approved by the Secretary of NSW Health.

The 72 hours hopper capacity is required where maximum water flow rate is less than 15 ML/d and the hopper capacity can be reduced down to 48 hours as the maximum water flow rate increases to more than 30 ML/d.

5.2.1.4 The dry feeder, tank solution level, mixer, and transfer pump must be electrically interlocked to ensure total fluoride dosing system shut down.

5.2.1.5 Where sodium silicofluoride is used, a water softener shall be provided if the service water hardness exceeds 200mg/L as $CaCO_3$.

5.2.2 Fluoride solution feed systems

5.2.2.1 Fluoride solution feed systems shall include two batching tanks with mechanical mixers, a make-up water meter, a potable or filtered make-up water source, a graduated calibration tube, and a metering pump with pressure relief and a loading valve on the delivery side of the pump.

5.2.2.2 Each batching tank must have more than 24 hours and up to a maximum capacity of 36 hours operation at the maximum water flow rate approved by the Secretary of NSW Health.

5.2.2.3 The solution tank and the metering pump must be electrically interlocked to ensure total system shut down when the tank is empty.

5.2.3 Fluoride saturator systems

5.2.3.1 Fluoride saturator systems shall include a saturator tank with granular support media, a system to transfer granular sodium fluoride from bag into saturator tank, a make-up water meter, a potable or filtered make-up water source, a graduated calibration tube, a filter strainer and a metering pump with pressure relief, back pressure / anti-siphon valve and flow switch on the delivery side of the pump.

5.2.3.2 Where make-up water hardness exceeds 25 mg/L as calcium carbonate, a water softener shall be provided.

> If the make-up water is too hard then operating problems due to precipitation of calcium fluoride may cause operational problems and result in variation in the treated water fluoride concentration

5.2.3.3 The saturator tank must have the ability to visually check the level of undissolved fluoridating agent in the tank.

5.2.4 Hydrofluosilicic acid dosing systems

5.2.4.1 Hydrofluosilicic acid dosing systems shall include either:
For small plants a direct feed arrangement from carboys/drums, a weighing platform for the acid container, a graduated calibration tube, a metering pump with pressure relief and a backpressure / anti-siphon valve on the delivery side of the pump, and a potable or filtered dilution water source if dilution is needed to fully disperse the added fluoride before the water reaches the closest consumer, or
For larger plants a bulk storage tank, a day tank, weighing platform for the day tank, a graduated calibration tube, a metering pump with pressure relief diaphragm pressure gauge and a backpressure / anti-siphon valve on the delivery side of the pump, and a potable or filtered dilution water source if dilution is needed to fully disperse the added fluoride before the water reaches the closest consumer.

> The use of dilution water improves dispersion at the injection point, improves safety and reduces environmental risk should the dosing line rupture between the fluoride dosing room and the injection point. Raw water should not be used for dilution as it may create a health risk due to by-passing of other treatment processes on site (filtration and disinfection).

5.2.4.2 Transfer of Hydrofluosilicic acid from bulk tank to day tank shall be initiated manually and stop automatically. The transfer may be by pump or gravity as appropriate and shall incorporate a fail-safe motorised valve on the storage tank outlet and full storage measurement in the day tank. Interlocks shall be provided to automatically stop the transfer prior to overflow of the day tank. The day tank must have more than 24 hours and up to a maximum capacity of 36 hours operation at the maximum water flow rate approved by the Secretary of NSW Health

> Should an overdosing incident occur the requirement for manual instigation of transfer from the storage tank to the day tank effectively limits the potential overdose volume to that of the day tank rather than

that of the storage tank. The use of the fail-safe motorised valve on the tank outlet with interlocks to the transfer pump and full storage level in the day tank are focused on preventing spillage due to human error

5.2.4.3 A diaphragm type pressure gauge followed by a back pressure / anti siphon valve shall be provided on the discharge side of the metering pumps.

This valve is generally required for positive displacement metering pumps to provide accurate metering. It is also required to prevent the possibility of siphoning of fluoride through the dosing pump into the treated water when the plant is off, which could result in an overdosing incident. Where a dilution water supply is used this valve can also be used to minimise the possibility of back flow of water into the fluoride day tank.

The pressure gauge is required to facilitate the setting of the back pressure / anti-siphon valve.

On larger dosing systems the use of an external pressure relief valve and pulsation dampener upstream of the pressure gauge should also be considered to help protect the dosing pipe work from the pressure peaks and vibration often associated with positive displacement pumps, and from any downstream blockages that might occur. To further reduce the risk of siphoning and to reduce the possibility of spillage from pipe breaks while the plant is off, the use of a fail-safe motorised valve on the outlet of the day tank which is interlocked with the dosing pump operation should be considered.

5.2.4.4 Flushing points before and after the metering pumps shall be provided to allow safe maintenance.

The sudden release of stored pressure after the metering pumps is a key safety risk. The provision of well designed flushing points on both the suction and delivery sides of the metering pumps gives operators and maintainers the ability to safely flush water through the pumps and pipe work, release the high pressure trapped between the metering pump and the back pressure/anti siphon valve, and drain the pipe work prior to carrying out any maintenance.

5.2.4.5 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 plant building.

5.2.5 Fluoride Dosing Pipework

5.2.5.1 Where pipework needs to be painted to protect against UV damage it should be painted the colour Magenta P11 to AS 2700S.
Self adhesive pipe markers with the words sodium fluoride solution/ sodium silicofluoride solution/ hydrofluosilicic acid as appropriate and directional arrows shall be provided along the pipe at not more than 3 metres apart or at change of direction.

6 Occupational Health and Safety

6.1 Primary Requirement

6.1.1 The water utility shall provide a safe working environment and safe working practices for both plant operators and untrained staff/public.

6.1.1.1 The water utility must comply with the (NSW) Occupational Health and Safety Act 2000 and regulations made under it from time to time (the OH&S legislation)

The OH&S legislation will impact all aspects of the fluoridation plant, including design, operational and maintenance procedures, training, auditing, and record keeping. Water Supply Authorities need to regularly review the requirements of the OH&S legislation to ensure compliance. It should also be noted that at the time of issue of this Code there is a proposed move to nationally uniform OH&S legislation by the end of December 2011.

In the area of safety, and the handling and storage of dangerous goods, The OH&S legislation will have precedence over the Fluoridation Act, Regulation and Code of Practice. If clarification is required in these areas then Work Cover NSW will provide the defining interpretation. On this basis no other minimum standards are stated under this section. Particular and specific requirements under OH&S legislation should therefore be referred to, and the following should be considered only as general information, rather than being conclusive as to other regulatory requirements.

The following guide notes in this section of the Code however provide a basis for a water utility to assess what control measures it should employ to manage occupational and safety risks associated with fluoridation systems. The issues and control measures discussed are focussed on meeting some of the key elements of the OH&S legislation. They are in no way exhaustive, and the use of these control measures in no way infers that this is sufficient to comply with the OH&S legislation.

The issues and control measures discussed are presented under the following dot points:

- The water utility should carry out and document a site- specific safety hazard risk assessment covering all aspects associated with the design and operation of the fluoridation plant. Where risks are identified appropriate control measures (based on the hierarchy of controls) should be implemented.

Based on the hierarchy of controls hazards should be eliminated wherever possible, followed by use of engineering controls. Fluoridation plant designers should only rely on personal protective equipment as a risk control measure as a last resort.

For large and complex designs, the involvement of a range of people in the hazard assessment (eg plant operators, managers and technical

experts etc) may provide an improved end result over that achieved by one person. Such hazard assessments, if needed, should be done as part of the design and commissioning processes for new plants.

The hazard risk assessment for the fluoridation plant and the effectiveness of implemented control measures should be reviewed on a regular basis.

- The water utility should control access to the fluoridation plant and equipment in order to minimise the risk of untrained staff or public being injured.

The fluoridation plant site should be sufficiently secured to minimise the risk of unauthorised entry. These areas should be kept locked to prevent unauthorised entry.

In particular the carrying out of maintenance work needs to be controlled to prevent injury to maintenance staff. Determining control measures under this requirement should normally be considered at the same time as those required for protecting the process from being impacted. Best practice may involve the use of some form of work permit system that includes a systematic hazard risk assessment of the work to be done.

In this regard the operator and the maintenance staff should assess the hazards together and agree on any special controls required while the work is being carried out (eg isolation of the storage tank, draining or release of pressure in dosing pumps and lines, mechanical and electrical isolation, use of personal protective equipment, not working alone, etc). The degree of control required may also reflect the knowledge and training of the maintenance staff (eg. are they experienced internal staff, under long term maintenance contracts, or a "one off" contractor who has never previously been to the plant etc).

- The water utility should ensure standard operating

  procedures required by this Code include all relevant safety requirements.

- The water utility should ensure the plant operators are adequately trained as to the hazards associated with the fluoridating agent, and should ensure a current Material Safety Data Sheet for the fluoridating agent is easily available to staff on site at all times.

- The water utility should ensure the atmosphere in any area where the fluoridating agent is stored or used is acceptable for staff to work in. For dry fluoridating agents the fluoride dust concentration should not exceed the recommended exposure limit specified by the National Occupational Health and Safety Commission.

At the time of issue of this code the current recommended exposure limit is 2.5 mg/m^3. These exposure limits are however called up by the OH&S Act and those documents, rather than this Code, must be referenced for current information.

Compliance with this requirement will generally require separate dust extraction for the fluoridation plant room and any powder bag loader. If the water utility is concerned about air quality, air sampling and

analysis can be performed. Experience to date indicates that routine air testing is not required where fluoridation plants are operating as designed. For hydrofluosilicic acid plants exhaust fans should be used to ventilate the fluoridation plant room. This will not only benefit the air quality for staff but should also reduce corrosion rates due to acidic fumes.

- The water utility should ensure operators are supplied with appropriate personal protective equipment, and that operators are trained in its use.

When selecting appropriate PPE consideration should be given to the following items:

- Elbow length impervious rubber or plastic gloves,
- Long sleeve shirt, trousers, and full length impervious rubber or plastic apron, or as an alternative, a disposable full suit system,
- Impervious rubber or plastic boots
- for plants using dry fluoridating agents, a full face mask with type 3 respiratory filters (as per AS/NZS 1715), or as an alternative, a chemical goggle and a half mask with P3 type respiratory filter (as per AS/NZS 1715)
- for plants using liquid fluoridating agents, a full face shield or splash proof safety goggles

Where respirators are used it is important that they are changed regularly and that adequate stocks of filters are kept on site. Irrespective of condition filters should be changed at least as frequently as every 13 weeks.

- The water utility should provide adequate routine washing and emergency eyewash/shower decontamination facilities at the fluoridation plant site using a potable water supply.

Emergency eyewash/showers should be available where ever fluoridating agents are stored and handled. The water supply to these units should be permanently connected. The supply pipe work should not create additional risks (eg burns due to pipe work being exposed to the direct sun etc).

When handling fluoridating agents PPE, and clothing can become contaminated, particularly in plants using dry fluoridating agents. It is important that PPE, and clothing in particular, is routinely cleaned and kept free of contamination due to the fluoridating agent (eg rinsing of rubber/plastic equipment, washing of clothing etc).

Care should also be taken in preventing any fluoridating agent contamination being carried into other parts of the plant where staff/public frequent, such as control rooms, lunchrooms, vehicles etc. This may necessitate changing clothing after handling the fluoridating agent.

Similarly operators should be aware of the importance of effectively removing any fluoridating agent on their hands. The use of soap and nail brushes after contact with dry fluoridating agents is suggested.

7 Environmental safety

7.1 Primary Requirements

7.1.1 The environment is protected from impact due to the fluoridation plant.

7.1.1.1 The water utility must comply with the Protection of the Environment Operations Act 1997 (PEO Act) and other environmental protection legislation or regulations made from time to time

The PEO Act and other environment protection Acts and Regulations may impact all aspects of the fluoridation plant, including design, operational and maintenance procedures, training, auditing, and record keeping. Water supply authorities need to regularly review the requirements of these Acts and Regulations to ensure compliance.

In the area of protection of the environment these Acts and Regulations will have precedence over the Fluoridation Act, Regulation and Code of Practice. If clarification is required in these areas then the Department of Environment Climate Change and Water (DECCW) and Work Cover NSW will provide the defining interpretations. On this basis no other minimum standards are stated under this section. Specific requirements under legislation administered by those authorities should therefore be referred to, and the following should be considered only as general information, rather than being conclusive as to other regulatory requirements.

The following guide notes in this section of the Code however provide a basis for a water utility to assess what control measures it should employ to manage environmental risks associated with fluoridation systems. The issues and control measures discussed are focussed on meeting some of the key elements of the Acts and Regulations involved. They are in no way exhaustive, and the use of these control measures in no way infers that this is sufficient to comply with these Acts and Regulations.

The issues and control measures discussed are presented under the following dot points:

- The water utility should carry out and document a site- specific environmental hazard risk assessment covering all aspects associated with the design and operation of the fluoridation plant. Where risks are identified appropriate control measures (based on the hierarchy of controls) should be implemented.

Wherever possible hazards should be eliminated, followed by use of engineering controls. Reliance on procedural controls alone should be a last resort.

Where feasible the involvement of a range of people in the hazard assessment (eg plant operators, managers and technical experts etc)

may provide an improved end result over that achieved by one person. Such hazard assessments should be done as part of the design and commissioning processes for new plants.

The hazard risk assessment for the fluoridation plant and the effectiveness of implemented control measures should be reviewed on a regular basis.

- The water utility should ensure the fluoridation plant and equipment is designed and operated to both minimise the risk of fluoridating agent spills or leaks and to contain any spills or leaks should they occur.

The fluoridating agent should be stored in a designated storage area separate from other chemicals. Chapter 6A of the Occupational Health and Safety Regulation 2001 (administered by Work Cover NSW) specifies various requirements for the storage of fluoridating agents, such as bunding, signage, and licensing.

In designing a fluoridation plant, locating all plant components that contain concentrated fluoridating agent (including the feeding equipment) within the storage bund area may be an effective way of reducing risks of contamination to the environment.

Where powdered fluoridating agents are used the bag loading equipment and the fluoride plant building atmospheres should be contained and filtered. If powder is spilt then it should be removed either by hosing down, or by vacuuming. Sweeping is not recommended.

The plant design must also take into consideration the risks associated with fluoridating agent transport and unloading., which can be substantial. Drainage of the unloading area may be needed.

Where procedural controls are to be used they should be included in the routine operational SOPs.

Where appropriate an emergency response plan should also be developed (refer to Section 10.3)

- The water utility should control access to the fluoridation plant and equipment in order to minimise the risk of untrained staff or public causing a fluoride spill to the environment.

The fluoridation plant site should be sufficiently secured to minimise the risk of unauthorised entry. These areas should be kept locked when unattended to prevent unauthorised entry.

In particular the carrying out of maintenance work needs to be controlled to prevent accidental release of fluoride to the environment. The control measures under this requirement should be developed at the same time as those required to protect the plant from poor maintenance. Best practice may involve the use of some form of work permit system that includes a systematic hazard risk assessment of the work to be done.

In this regard the operator and the maintenance staff should assess the hazards together and agree on any special controls required while the

work is being carried out (eg isolation of the storage tank, draining or release of pressure in dosing pumps and lines, temporary bunding, etc). The degree of control required may also reflect the knowledge and training of the maintenance staff (eg. are they experienced internal staff, under long term maintenance contracts, or "one off" contractor who has never previously been to the plant etc).

- The water utility should prepare, document and implement an environmental waste disposal plan for fluoridating agent spills and leaks, contaminated fluoridating agent and fluoridating agent containers.

The options for disposal of fluoridating agent containers varies from returning them to the supplier, engagement of a contaminated waste disposal contractor, local waste tips, to that of internal disposal on site by burial. Concentrated fluoride powder is poisonous to wildlife and thus care must be taken with some disposal options. The plan should follow the waste fluoridating agent and containers to their final disposal irrespective of whether private waste disposal contractors are employed or not.

- The water utility should ensure standard operating procedures required by this Code (refer to Section 10.2) include all relevant environmental control requirements.

8 Control of fluoridating agent

8.1 Procurement of Fluoridating Agent

8.1.1 Any impurities in the fluoridating agent shall not cause health problems for consumers or result in non-compliance with the Australian Drinking Water Guidelines. Physical characteristics and variations in strength should not significantly increase risk of reliably maintaining the required fluoride concentration in the treated water.

8.1.1.1 The water utility shall develop and use a suitable chemical specification for purchasing the required fluoridating agent. The latest American Waterworks Association standard specifications for the various fluoridating agents are to be treated as a minimum requirement.

Metals are the main impurities of health significance to be found in fluoride chemicals, particularly with hydrofluosilicic acid where the levels of various metals can vary significantly.

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.

The following specification requirements are provided for consideration.

Commercially Available Product	**Sodium Fluoride (NaF)**	**Hydrofluosilicic Acid (H2SiF6)**	**Sodium Silicofluoride (Na2SiF6)**
Product purity % by weight	97-99 (dry basis)	20-30	98-99 (dry basis)
Moisture % by weight	max 0.5		max 0.5
Insoluble matter % by weight	max 0.6		max 0.5
Heavy metals % by weight as lead*	max 0.04	max 0.02	max 0.05
Hydrogen fluoride (HF) % by weight		max 1.0	

*These levels ensure that at a fluoride ion dose of 1.00 mg/L the maximum concentration of metals added to the water would be in the order of 1 µg/L expressed as lead. The Australian Drinking Water Guidelines set a guideline value for lead of 10 µg/L.

Water supply authorities should include the requirement for regular full chemical analysis by suppliers in supply contracts. It is also good practice to periodically obtain independent chemical analysis.

8.2 Storage of Fluoridating Agent

8.2.1 Fluoridation plants shall not run out of fluoridating agent.

8.2.1.1 A minimum of 3 months storage of fluoridating agent shall be maintained.

The supply risk is a function of a number of issues including the quantities involved, transport distance, procurement strategy and general availability of the agent. Thus for some plants more than three months storage may be warranted.

For larger plants where the supply risks are low, long-term procurement contracts are maintained, and the cost of storage infrastructure significant, NSW Health will consider reducing this requirement.

8.2.2 Fluoridating agents are appropriately stored to minimise deterioration.

8.2.2.1 Dry fluoridating agents must be stored in a secure dry environment.

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 treated water. In more extreme circumstances the bags can become unusable and would need to be disposed of. In some situations the use of room heaters can minimise such problems.

9 Measurement of fluoride in the treated water

9.1 Sample requirements

9.1.1 A representative sample of treated water that directly reflects the real time dosing performance of the fluoridation plant shall be available at all times.

9.1.1.1 The sampling point location should be far enough downstream of the fluoride injection point to ensure the fluoride is well mixed, but prior to any service reservoir or tank if possible.

For good control the plant operator needs to be able to directly relate the measured fluoride level to plant settings at a given point of time, in order to know how much to adjust the dosing settings. If the sample point is too far downstream, or if the sample is from or after a service reservoir then this becomes more difficult.

Pipe wall effects can impact the sample quality. It is good practice to use a stainless steel insertion probe, particularly if the sample point is also used for other parameters such as microbiological indicators.

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 (eg. compare results taken from each end of the sample line).

9.2 Analytical requirements

9.2.1 A reliable method for determining fluoride concentration in the treated water shall be provided on site at all times.

9.2.1.1 An appropriate bench area shall be provided at, or in close proximity to, the fluoridation plant to allow routine fluoride concentration analyses to be performed.

The area should have adequate bench space to leave the analytical equipment appropriately set up. It will require a sink with both water supply and waste, and sufficient storage for consumables (glassware, chemicals, spare parts etc.). If possible the area should not be exposed directly to sun or high temperature extremes – air conditioning is preferred. It is good practice to store samples and reagents at low temperature (2-8 degrees Centigrade).

9.2.1.2 Unless otherwise approved the ion selective electrode method shall be used for determining the fluoride concentration in treated water. The method should conform to that described in the latest edition of Standard Methods for the Examination of Water and Wastewater or as described in Appendix E.

The ion selective method is preferred as it is reliable, less technique sensitive, and less impacted by interfering substances. If an on-line

meter is installed, it should be used as an added safety feature to send a warning signal to the operator for attention if it detects a fluoride concentration of more than 1.5 mg/L. The operator may take the daily reading from an on-line meter where it can be demonstrated to operate reliably to the satisfaction of NSW Health and NSW Department of Industry Water.

9.2.1.3 The minimum requirements for equipment and reagents to carry out analyses are:

- *An ion selective meter that can be used for fluoride and temperature probes, and that can display in millivolts (and preferably fluoride concentration), and degrees Celsius as required.*
- *Fluoride selective 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, and electrode filling solution)*
- *Calibration standards (0.20 and 2.00 mg/L standard fluoride solutions,)*
- *A quality control standard solution (1.00 mg/L)*

Appropriate spare equipment/parts should be available on site such that measurement capability should not be lost for more than a day or two due to failures. Where a water utility makes up or dilutes its own solutions then additional facilities to those above will be required and normal laboratory good practice should apply.

Only plastic beakers, sample bottles etc should be used for fluoride samples as the use of glassware may lead to lower results due to fluoride interacting with the glass.

If the plant operators also need to measure pH then there is an advantage in using an identical meter to that used for fluoride probes in that it in effect provides a backup meter for both parameters.

9.2.2 The calibration standards are accurate, the quality of the total ionic strength adjuster and electrode filling solutions and the operation of the fluoride meter are reliable.

9.2.2.1 Appropriate regular quality assurance checks and balances are in place to ensure the accuracy and reliability of fluoride measurements in the treated water.

Whether the fluoride standards and chemical reagents are bought or made up by a water utility it is good practice to carry out regular quality assurance checks. Simple checks such as keeping track of batch numbers, age of the chemicals, comparison of results when changing from one batch to another, asking for quality assurance documentation from the manufacturers etc, all help to give

confidence in the fluoride results obtained.

Similarly keeping calibration records including the slope and sensitivity readings on the meter display can help identify whether a fluoride meter/electrodes have changed in performance and will require maintenance or replacement. If requested NSW Health can assist in the development of these checks.

9.2.3 All operating staff at a fluoride plant follows the same procedure when calibrating the fluoride meter and analysing fluoride samples.

9.2.3.1 The water utility must develop, train, and implement standard operating procedures (SOPs) for carrying out calibration of the fluoride meter, and for routinely determining the fluoride concentration in a treated water sample. All operators must 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. If requested NSW Health can assist in the development of these SOPs. A sample SOP is attached as Appendix E.

9.2.4 The potential for incorrect fluoride results due to temperature differences between the calibration standards and the treated water samples is minimised.

9.2.4.1 The analysis procedure should ensure the fluoride calibration standard(s) and the treated water sample are at the same temperature before proceeding with the analysis. Standard solutions and samples that have been stored in a refrigerator must be brought to the same temperature (eg room temperature is satisfactory) before analysis.

A significant error can occur when the meter has been calibrated using fluoride standards at a different temperature to that of the treated water sample. The error can be as large as 2% per degree of temperature difference.

10 Plant operation and process control

10.1 Fluoridation plant operating targets

10.1.1 The fluoridation plant is operated to maintain a consistent fluoride concentration through out the distribution system.

10.1.1.1 The water utility shall

- *Use a fluoride operating target of 1.00 mg/L in treated water, unless otherwise specified by the Secretary of NSW Health in the Instrument of Approval.*
- *set a target that, over a calendar year, greater than 95% of all routine fluoride samples (both treated water and distribution) fall within the fluoride concentration operating range of 0.90 to 1.50 mg/L, unless otherwise specified by the Secretary of NSW Health in the Instrument of Approval.*

These two targets are the default requirements unless NSW Health approve otherwise.

The fluoride target is specified as a concentration in the treated water rather than a dose rate in order to allow for any background level of fluoride present. Fluoride occurs naturally and may be present in the raw water. Fluoride may also be present due to recirculation of filter backwash supernatant to the head of the filtration plant as treated water (containing fluoride) is normally used for backwashing of filters. It is the responsibility of the water utility to ensure any fluoride already present is taken into account when determining the required dose rate for the fluoridation plant. In some situations this may need to be checked and documented on a routine basis

One important issue for a water utility is how a failure to dose (or under dosing) due to equipment breakdown might be handled in determining the 95% compliance of all samples. A short-term stoppage will not appreciably affect the oral health benefit. However NSW Health expects a water utility to operate in a professional and competent manner and such stoppages should not occur on a frequent basis. Consequently NSW Health considers the non-compliance allowance of 5% of samples over a year to be reasonable.

However, should a particular situation arise where either, the water utility believes the monitoring results do not adequately reflect the plant performance, or, there has been a significant failure to dose due to largely uncontrollable problems (eg damage to plant from fire etc) then NSW Health will consider an exemption from normal compliance targets upon request.

10.2 Routine operational requirements

10.2.1 The fluoridation plant reliably achieves the required fluoride concentration in the treated water on a continuous basis with no over or under dosing.

10.2.1.1 The water utility shall carry out daily plant inspections and checks to assess whether the process performance has been satisfactory, and in particular whether any significant overdosing has occurred which would require emergency action to be taken.

Regular plant inspections are necessary to ensure effective process control (eg. target fluoride dose = instantaneous fluoride dose via drop tests = calculated average daily fluoride dose), to identify whether equipment is operating normally (eg. pressure and level readings), and to identify the need for maintenance (eg. leaks, change in sound and vibration of operating pumps, mixers etc).

10.2.1.2 The water utility shall maintain a daily record (irrespective of any approved change to the daily inspection requirement) of:

- *The volume of water treated*
- *The quantity of fluoridating agent added over the same time period*
- *The corresponding average calculated fluoride dose*
- *The fluoride analysis result from the treated water sample taken during this time period*
- *The stock of fluoridating agent on hand*

This information shall be recorded on either the standard forms attached in Appendix B (Form 2 for solution feed systems, or Form 3 for dry feed systems, and Form 4 for the treated water analysis) or on a site-specific plant log sheet. The records may be in paper or electronic form but must be maintained by the water utility (refer to Section 13).

It is the responsibility of the water utility to ensure the fluoridation process is adequately monitored and maintained such that any discrepancy, equipment reliability issue, or unacceptable variability in the final fluoride concentration is quickly identified and effectively rectified.

10.2.1.3 The water utility shall ensure that the fluoridation plant and equipment is adequately maintained to achieve reliable operation.

There are various strategies used to manage maintenance. Good practice would encourage the use of routine condition monitoring/assessment, preventative maintenance, critical spares inventory, and reliable maintenance records.

10.2.1.4 For fluoride saturator systems specifically the level of fluoridating agent in the saturator must not be allowed to fall below 150 mm above the support media.

10.2.2 Fluoride concentrations reaching consumers in the distribution system match the treatment plant operating target.

10.2.2.1 Unless otherwise approved by NSW Health the water utility shall collect and analyse a minimum of two samples that are well separated in the system per week. The results shall be recorded on Form 4 (refer Appendix B) or on a site-specific form. The records may be in paper or electronic form but must be maintained by the water utility (refer to Section 13).

10.2.2.2 Unless otherwise approved by NSW Health the water utility shall send a duplicate of one of its distribution water samples to the NSW Forensic and Analytical Science Service (NSW Health Pathology) within the first week of each month. A NSW Health Drinking Water Monitoring Program label is to be attached to the sample (either an Allocated Chemical or an Allocated Fluoride label type). The fluoride result obtained by the water utility shall be recorded on the label.

This sample provides both quality assurance on analyses carried out by the water utility, as well as an independent assessment of fluoride levels across NSW. The results will be available on the NSW Drinking Water Database.

10.2.3 All operating staff at a fluoride plant follows the same procedures when carrying out routine operational duties.

10.2.3.1 The water utility must develop, train, and implement standard operating procedures (SOPs) for carrying out routine operational duties within the fluoridation plant. All operators must 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 (eg. topping up of day tanks, hoppers, saturators, ordering new stocks etc.), process control decisions, dose corrections, and record keeping.

10.2.4 The fluoridation plant and equipment shall not be operated by unqualified persons.

10.2.4.1 Only qualified operators shall operate the fluoridation plant and equipment. Access to the fluoridation plant and equipment shall be controlled to minimise the risk of over or under dosing of fluoride into the treated water from incorrect operation of the fluoridation equipment, or damage to the facility, from unauthorised persons.

The design and installation of the fluoridation plant should 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.

The fluoridation plant should be kept secured when unattended to prevent unauthorised entry. Entry to the fluoridation plant by untrained persons (staff and public) needs to be controlled both for protection of the process and for their own safety.

Maintenance work needs to be carefully controlled to prevent impacts on the fluoridation process. The responsibility lies directly with the water utility and plant operator(s) to ensure maintenance staff do not impact or put the fluoridation process at risk or put them or the environment at risk – refer Sections 6 and 7. Determining control measures under this requirement should normally be considered at the same time as those required for safety management. Best practice would involve the use of some form of work permit system that includes a systematic risk assessment of the potential impact on the fluoridation process from the work to be done.

In this regard 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 (eg 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 (eg. whether maintenance staff are left unsupervised or not) will depend on the knowledge and training of the maintenance staff (eg. are they experienced internal staff, under long term maintenance contracts, or "one off" contractor who have never previously been to the plant etc). However, irrespective of what control measures are put in place maintenance staff shall not be allowed to operate the fluoridation plant. In some circumstances it may be beneficial for key maintenance staff to obtain the Fluoride Plant Operators Certificate.

10.2.4.2 The water utility shall ensure that it has a sufficient number of qualified people available to enable operation of the fluoridation plant at all times. A <u>minimum</u> of two qualified people is required.

The number of qualified people required will depend on the particular staffing arrangements used by a water utility (eg. single operator, team based etc). As a minimum two qualified operators are required to ensure periods of sickness, annual leave, weekends, and other issues such as training and meetings are covered.

It is also recommended that the fluoridation plant operator's supervisor (or other appropriate manager) obtain the operators qualification in order to provide a detailed awareness of requirements under the Fluoridation Act to more senior relevant management of the water utility (as well as providing operational support in an emergency).

10.3 Emergency response requirements

10.3.1 Consumers should not receive fluoride concentrations over 1.5 mg/L. Any over or under dosing incidents are quickly identified and effectively managed to minimise any impact on consumers (Appendix C – Form 5 & 6)

10.3.1.1 The water utility shall develop an emergency response plan to minimise (or preferably prevent) fluoride concentrations over 1.5 mg/L reaching consumers in the event of an overdosing incident. The response plan should form part of the water utility's overall emergency management strategy and plans, and must include liaison with the local Public Health Unit (refer to Fluoride Communication Protocol flow diagram).

In approaching emergency response planning it is suggested that emergency risk management principles be followed. These can be summarised as a cyclic process involving **hazard analysis, prevention, preparation, response, and recovery.**

The options to respond effectively to an overdosing incident are often related to how the distribution system is designed and operated, in particular the location and size of service reservoirs that can dilute small events. The ability to quickly remove water from the system can be affected by environmental considerations such as quantity of water involved and chlorine residual levels. In many cases the most important element is the speed with which an incident is identified. A small amount of careful planning in the design of both the plant and routine operational duties can significantly reduce the impact of an overdosing incident.

NSW Health requires that the water utility liaise with the local Public Health Unit in developing the emergency response plan, and where appropriate in its execution.

The responsibility to respond in an emergency lies primarily with the water utility.

11 Reporting requirements

11.1 Routine reporting and communication requirements

11.1.1 Effective routine communication is maintained between NSW Health and water supply authorities

11.1.1.1 Water supply authorities shall follow the Fluoride Communication Protocol for routine reporting and communication with NSW Health or communication with NSW Department of Industry Water on technical matters. Water supply authorities shall follow Appendix A of this Code of Practice when approval is sought to fluoridate for the first time or to modify an existing plant.

Contact the **NSW Health Water Unit** for information, reporting and routine correspondence on the Code of Practice.

Telephone 02 9391 9939 Fax 02 9391 9960
email: waterqual@doh.health.nsw.gov.au

Written correspondence should be addressed to:

Manager, Water Unit
NSW Health
Locked Bag 961
NORTH SYDNEY NSW 2059

Contact the **NSW Department of Industry Water** for further information on to technical or design issues.

Telephone 02 9842 8495
email: bill.ho@dpi.nsw.gov.au

Written correspondence should be addressed to:

Manager Water & Sewerage
NSW Department of Industry
Locked Bag 5123
PARRAMATTA NSW 2150

Fluoride Protocol – Roles and Communication

Organisation	Contact details	Roles and Responsibilities
Water utility		• Report monitoring results to Water Unit (reported electronically or in hard copy: Form 4) and send monthly sample to the laboratory • Report any incidents to the Water Unit (Form 5) • Fluoride overdose response (Form 6)
NSW Department of Industry Water (DoI Water)	Ph: 02 9842 8495 Email: bill.ho@dpi.nsw.gov.au	• Provide technical advice to water utility and other agencies • Approval of Form 1 • Approval of tender specification • Approval of tender acceptance • Inspection of plants for approval to operate • Plant operation support
Public Health Unit (PHU) NSW Health	1300 066 055 http://www.health.nsw.gov.au/Infectious/pages/phus.aspx	• Assist water utility with compliance with reporting and monitoring and response to incidents • Follow up any non-compliance with water utility
Water Unit, NSW Health	Ph: 02 9391 9939 Fax: 02 9391 9960 Email: waterqual@doh.health.nsw.gov.au	• Confirm monitoring results and frequency • Follow up any non-compliance • Provide technical support • Report on monitoring to FPWSAC • Provide advice on health questions related to fluoridation • Provide advice on funding for new plants
Fluoridation of Public Water Supplies Advisory Committee (FPWSAC)	C/- Water Unit, NSW Health (As above)	• Approve and regulate fluoridation by water utility • Provide advice to the Minister for Health

11.1.2 Routine fluoridation plant performance data is provided to NSW Health in a timely manner.

11.1.2.1 Unless otherwise approved by NSW Health, the water utility shall report to NSW Health within the first week of each month the results of all fluoride analyses carried out for the previous month, that is, results for the treated water samples leaving the fluoridation plant and samples taken in the distribution system recorded on Form 4 (or its equivalent). Where possible this data should be directly entered into the online NSW Drinking Water Database. If this is not possible the water utility must submit a paper copy of Form 4 (or its equivalent) to the NSW Health Water Unit.

The use of the on-line NSW Drinking Water Database provides some additional benefits over paper records in that there is the capacity for a water utility to generate standard reports in electronic form which it can use for internal assessment and management reporting.

11.1.3 Exception reports are provided to NSW Health in a timely manner.

11.1.3.1 The water utility shall advise NSW Health Water Unit in writing within three working days of any:

- *overdosing incident that resulted in the fluoride concentration exceeding 1.5 mg/L in the treated water entering the distribution system,*
- *any failure to fluoridate for a period greater than 24 hours,*
- *any failure to maintain the fluoride concentration above 0.9 mg/L (the minimum fluoride concentration stated in the Instrument of Approval) that extends for a period greater than 72 hours.*

The notification should include details of the incident (extent, times, water volume affected etc), what remedial action has been taken, and what actions the water utility intends to take to minimise the risk of the same event occurring again.

Information gathered over time will assist NSW Health in identifying risks and improvements, which may be relevant to other water supply authorities as well as providing input into future reviews of the Code of Practice.

12 Operator training and qualification

12.1 Training requirements

12.1.1 Fluoridation plant operators are competent to operate a fluoridation plant.

12.1.1.1 A qualified operator is an operator who holds a Fluoride Plant Operator's Certificate issued by NSW Health. All fluoridation plant operators must obtain this certificate.

NSW Health will issue a Fluoride Plant Operators Certificate to those persons who

(a) Have passed a fluoride training course conducted by NSW Health, or

(c) Successfully completed such other fluoridation training courses as may be approved by the Secretary of NSW Health as being the equivalent of (a).

12.1.1.2 The water utility shall provide on the job training under the direct supervision of a qualified operator in how to operate the fluoridation plant. Unless approval is gained from NSW Health, operators being trained shall not operate the fluoridation plant by themselves and must attend the next available NSW Health training course.

In the normal course of events it is expected that new operators would receive on the job training until they can attend a NSW Health operators training course.

Should an emergency situation arise due to sudden departure of qualified staff NSW Health will consider interim conditional approval to operate for a new operator on a case-by-case basis until the next training course. The water utility would need to provide details of the person's relevant experience, and controls put in place to support that person.

13 Record keeping and availability

13.1 Record keeping requirements

13.1.1 Appropriate records documenting the fluoridation plant performance are maintained.

13.1.1.1 The water utility shall maintain the key records corresponding to the information recorded on Forms 2,3 and 4 for two (2) years. The records may be in electronic or hardcopy form.

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.

13.1.1.2 The water utility shall ensure all records created are in an auditable form.

In applying quality management principles it is important that records are traceable to the date they were created and to those who generated the records.

13.1.2 Records of the fluoridation plant performance are available to NSW Health

13.1.2.1 The water utility shall make all records associated with the fluoridation plant available to NSW Health upon request.

14 Quality assurance and auditing

14.1 Audit requirements

14.1.1 The water utility complies with the requirements of the Fluoridation Act, Regulations, and the requirements of this Code of Practice on an on-going basis.

14.1.1.1 The water utility shall carry out and document an audit to assess compliance with the latest version of the Fluoridation Act, Regulation, and Code of Practice on a regular basis. These audits shall be stored and made available to NSW Health on request.

Regular auditing is a key part of quality management principles in that it helps to maintain an initial level of performance, identify risks and associated control measures that may need to be reassessed, and identify opportunities for improvement. It is suggested that this process be carried out every two to three years or when the Code has been changed, which ever is the least.

An important part of the process is the inclusion of all stakeholders (plant operators, supervisors, managers, technical experts, etc) in the analysis of the results and the development of any identified opportunities for improvement. This process is also useful as a training refresher for operating staff as to the requirements of the Code.

14.1.1.2 NSW Health may from time to time carry out an independent audit of the water utility's compliance. The water utility shall provide such assistance as may be required.

Glossary of Terms

Fluoridating Agent
The substance that is added to drinking water to achieve fluoridation. Fluoridating agents include the dry (or powder) fluoridating agents Sodium Fluorosilicate (also called Sodium Silicofluoride) (Na_2SiF_6) and Sodium Fluoride (NaF) as well as "liquid fluoride" or "fluoride acid" Hydrofluosilicic Acid (H_2SiF_6).

Fluoridation
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.

Fluoridation Act
The NSW *Fluoridation of Public Water Supplies Act 1957* sets out the composition and functions of Fluoridation of Public Water Supplies Advisory Committee (the Committee). Under the Act, the Committee has powers to approve and regulate fluoridation by public water supply authorities.

Fluoridation Regulation
The current *NSW Fluoridation of Public Water Supplies Regulation* sets out requirements for risk minimisation, accuracy of dosing, and reporting requirements and refers to detailed requirements under this Code.

Fluoridation Code of Practice
The current NSW Code of Practice for the Fluoridation of Public Water Supplies sets out the details of requirements for risk minimisation, accuracy of dosing, and reporting requirements as required by the Fluoridation Regulation.

Fluoridation Plant
The building and equipment involved in 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.

Guide Note
Guide notes provide explanatory notes to assist water authorities in meeting the required outcomes and minimum standard requirements. They may also include suggestions regarding best practice (i.e. surpassing the minimum standard requirements). Also included in the guide notes, for information, are some requirements covered under other legislation (such as dangerous goods requirements covered in the OH&S Regulation 2001). The guide notes are not legislative requirements under the Fluoridation Act.

Instrument of Approval
The document issued by the Secretary of NSW Health, and published in the Government Gazette, which sets out details and conditions of approval under which a water utility may fluoridate a water supply.

Minimum Standard
Minimum standards are the minimum requirements considered necessary to achieve the required outcomes. Minimum standards are set out in italic font. Achievement of the minimum standard in the Fluoridation Code is a legislative requirement under the Fluoridation Act and Regulation.

PLC
Programmable logic controller

Required Outcome
The required outcomes are the fundamental intent of the controls required in the Fluoridation Code. The required outcome for each section of this Code is set out in bold.

SCADA
Supervisory control and data acquisition

Water Utility
A water utility as defined under the Water Management Act 2000 means (a) a water utility, or (b) a council or county council exercising water supply functions under Division2 of Part 3 of Chapter 6 of the *Local Government Act 1993* or (c) a licensed network operator within the meaning of the *Water Industry Competition Act 2006*

APPENDIX A

Protocol and Application Process

For a water utility seeking approval to:

Fluoridate a water supply for the first time

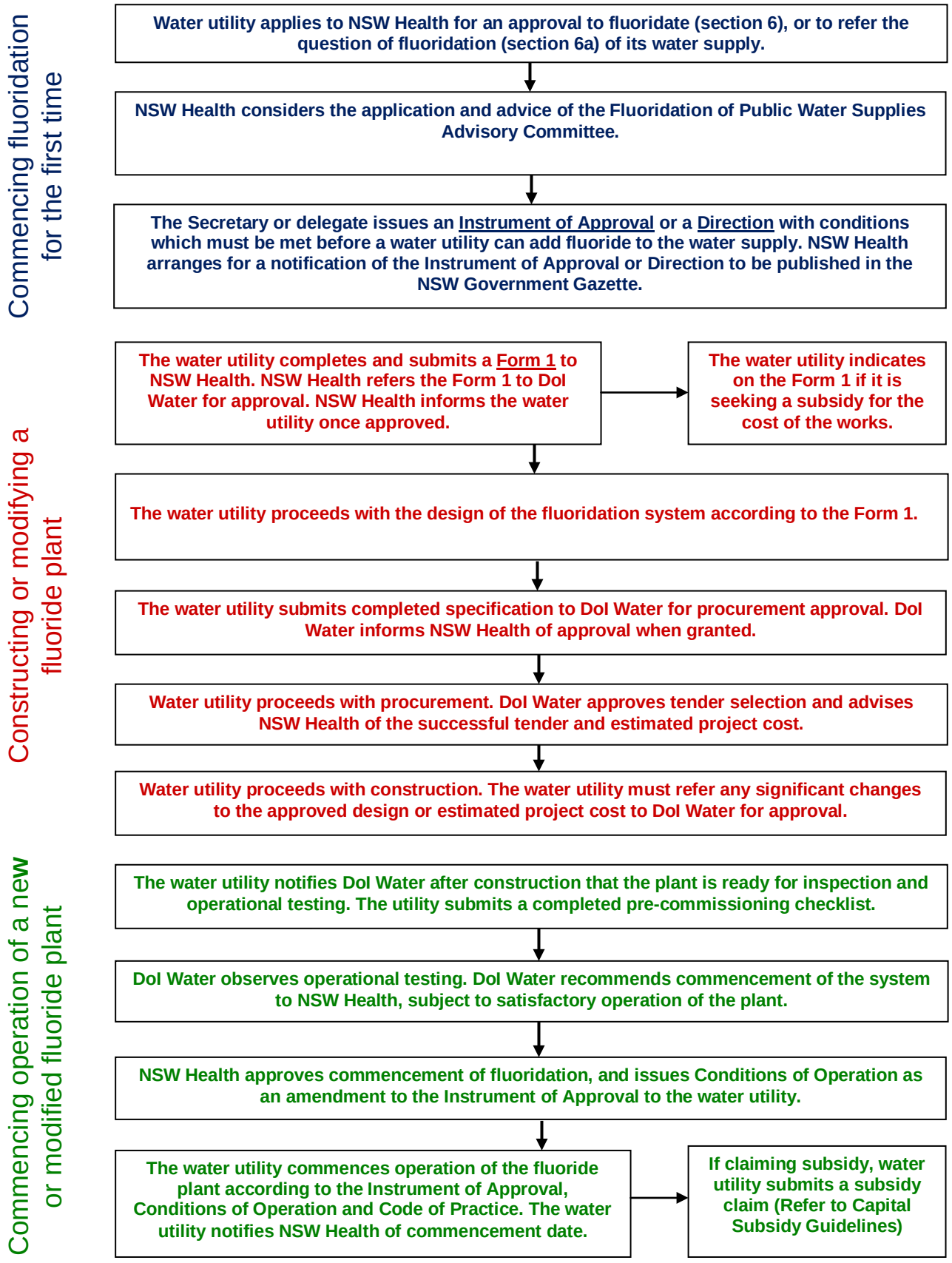
or

Modify an existing fluoridation plant

or

Commence operation of a new fluoridation system

Application process for approval, construction and commencement of fluoridation



FORM 1 – APPLCIATION TO FLUORIDATE

Technical application for a new or upgraded fluoridation system

Water utility:	
Water supply:	
Fluoride plant location:	
Is supply currently fluoridated?	Yes ☐ No ☐
Type of works:	Upgrade to existing system ☐ Replacement of existing system ☐ New fluoridation system ☐ Change in chemical concentration ☐
Plant designer:	
Contact details:	
Is utility seeking subsidy for the works?	Yes ☐ No ☐ (Refer to Fluoride Capital Works Subsidy Guidelines)
Submitted by: (Water utility Director)	
Contact details:	
Date:	

1. Employee responsible for supervision of addition of fluorine:

   Name: _____

   Qualifications: _____

2. Name of proposed operator or operators: _____

   List qualifications of each proposed operator: _____

3. Approximate number of persons to be served: _____

4. Towns and municipalities to be served: _____

5. Estimated water consumption in megalitres per day:

   Min. _____ Avge. _____ Max. _____

6. Instantaneous flow rate at point of fluoridation with plant operating:

   Min. _____ Avge. _____ Max: _____

7. Gravity or pumped supply: _____

8. List of other chemicals now used in treatment of supply: _____

9. What provision, if any, exists for the testing and control of the water supply: _____

10. Proposed location of fluoridation equipment: _____

11. Location of precise point of fluoridation: _____

12. Provide a drawing showing the location of the fluoridation plant, the proposed fluoride dosing point, the water flowmeter, fluoride dosing interlock (eg. Flows witches)

13. Describe flow signals to be used to provide automatic control of the starting and stopping of the fluoride dosing system including interlock of signals (describe type of meter to be used and other hydraulic details pertaining to the automatic control of specific fluoridation equipment not clearly shown on plans): _____

14. Method to be followed in preventing back-siphonage or backflow of fluorine solution into potable water supply serving chemical feeder:

    _____

15. Name of manufacturer of equipment: _____

16. Dry feed fluoridation equipment: Capacity in kg/24 hrs with plant operating

    Min. _____Max _____.

17. Solution feed fluoridation equipment: Capacity in L/24 hrs with plant operating

    Min._____Max_____.

18. Fluoridation chemical to be used: _____

19. Type of toxic dust respirators to be used: _____

20. (a) Details of equipment used for metering quantity of water fluoridated: _____

    (b) Date of installation of metering equipment: _____

21. Method to be used in testing water for fluoride content: _____

APPENDIX B

Fluoridation records: Forms 2 to 4

Form 2: Daily log sheet for solution feed system

Form 3: Daily log sheet for dry feed system

Form 4: Daily analysis of fluoride ion content

Form 2
(For solution feed system)

DAILY LOG SHEET
(Code of Practice for Fluoridation of Public Water Supplies)

Water Utility _____

Fluoridation Plant Operation Log For The Week Ending

Sun	Mon	Tue	Wed	Thur	Fri	Sat	Weekly Summary	Day
								Date
								Time
								No.1 Water Meter Today
								No.1 Water Meter Yesterday
								Water Throughput
								No.2 Water Meter Today
								No.2 Water Meter Yesterday
								Water Throughput
								Total Water Treated
								No.1 Fluoride Tank Yesterday
								No.1 Fluoride Tank Today
								Usage No.1 Tank
								No.2 Fluoride Tank Yesterday
								No.2 Fluoride Tank Today
								Usage No.2 Tank
								Total Usage
								No.1 Fluoride Tank Additions
								Total In No.1 Tank
								No.2 Fluoride Tank Additions
								Total In No.2 Tank
								Total Additions
								Tank Cleaning Losses
								Unopened Bulk Stock
								Container In Use
								Additions To Stock
								Spillage or Weight
								Total Today
								Feeder Setting
								Calculated
								Raw or Clear
								Treated Water
								1.
								2.
								3.
								4.
								5.
								Operator's Initials

Fluoride Chemical Used .....Source .....Purity .....

Remarks .....

Operator .....Supervisor .....

This form is to be retained by the water utility for two years (do not send to NSW Health)

Form 3
(for dry feed system)

DAILY LOG SHEET

(Fluoridation of Public Water Supplies Act 1957)

Water Supply Authority ______________________

______________________ Fluoridation Plant

Operation Log For Week Ending ____________

Day	Date	Time	Water Throughput Cubic Metres: No.1 Meter Reading	Water Throughput Cubic Metres: Throughput Since Last Reading	Water Throughput Cubic Metres: No.2 Meter Reading	Water Throughput Cubic Metres: Throughput Since Last Reading	Water Throughput Cubic Metres: Total Water Treated	Fluoride Chemical in Kilograms: Weight In Hopper: Before Addition	Fluoride Chemical in Kilograms: Weight In Hopper: After Addition	Fluoride Chemical in Kilograms: Chemical Used Since Last Reading	Fluoride Chemical in Kilograms: Chemical Added To Hopper Since Last Reading	Fluoride Chemical in Kilograms: Bulk Stock After Additions To Hopper	Fluoride Chemical in Kilograms: New Chemical Received Since Last Reading	Fluoride Chemical in Kilograms: Spillage or Weight Variations	Feeder Setting	Fluoride Ion Content, mg/L: Calculated	Fluoride Ion Content, mg/L: By Analysis: Raw or Clear Water	Fluoride Ion Content, mg/L: By Analysis: Treated Water	Fluoride Ion Content, mg/L: By Analysis: Distribution System 1.	Distribution System 2.	Distribution System 3.	Distribution System 4.	Distribution System 5.	Operator's Initials
Sat																								
Sun																								
Mon																								
Tue																								
Wed																								
Thu																								
Fri																								
Sat																								
Weekly Totals																								

Fluoride Chemical Used .... Source .... Purity ....

Remarks ....

Operator .... Supervisor ....

This form is to be retained by the water authority for two years (do not send to NSW Health)

FORM 4

DAILY ANALYSIS OF FLUORIDE ION CONTENT
(Code of Practice for Fluoridation of Public Water Supplies)

Water Utility _____
Water Treatment Plant _____
Month _____ Year _____ Operator's Signature _____

Date	Daily Fluoride Concentration	Weekly Point 1	Point 1 Site code	Weekly Point 2	Point 2 Site code	Other	Sign
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							

This form is to be completed and, by the first week of the next month, data entered into the NSW Drinking Water Database or a copy of this form forwarded to waterqual@doh.health.nsw.gov.au or posted to

The Clerical Officer
Water Unit, NSW Health
Locked Mail Bag 961
NORTH SYDNEY NSW 2059

A copy of this form is to be retained by the water utility for two years.

APPENDIX C

Fluoridation Incident Management: Forms 5 and 6

Form 5: Fluoride Dosing Incident Notification

Form 6: Fluoride Emergency Response Plan

FORM 5

FLUORIDE DOSING INCIDENT NOTIFICATION

TO	The Clerical Officer, Water Unit, NSW Health	**FROM** (contact name)
FAX	02 9391 9960	(Water Utility)
TEL	02 9391 9939	(Water Supply System) (treatment plant)
Email:	waterqual@doh.health.nsw.gov.au	FAX
DATE		TEL
PAGES		Email:

Notification of:

- ❑ *Commencement of fluoride dosing* _____ time _____ date
- ❑ *Overdosing incident resulting in fluoride exceeding 1.5 mg/L in the treated water entering distribution system*
- ❑ Failure to fluoridate (greater than 24 hours)
- ❑ *Plant out of operation for repair/maintenance*
- ❑ *Under dosing incident resulting in fluoride below 0.9 mg/L (the minimum concentration in the Instrument of Approval) for greater than 72 hours*
- ❑ Normal fluoride dosing recommenced at _____ time _____ date (following interruption)

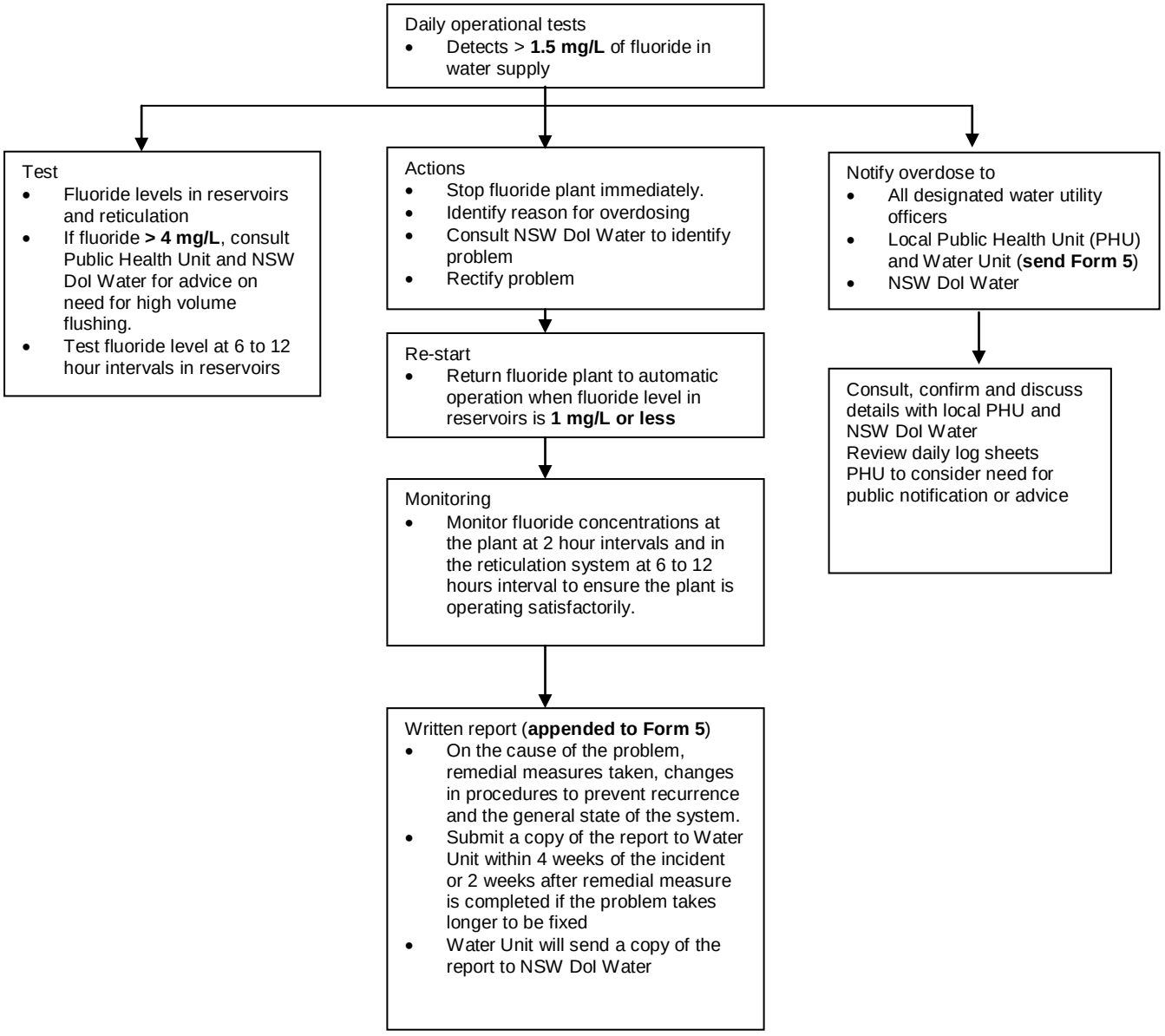
Details:
(include *extent, times, water volume affected, what remedial action has been taken, and what actions the water utility intends to take to minimise the risk of the same event occurring again).*

(Attach additional page if needed)

Submit form within three working days of the fluoride dosing event. A copy of this form is to be retained by the water utility for two years.

Form 6

Fluoride Overdose Response Plan (template guide)



Contact List

	Office Phone	Mobile	Email
Water utility officer			
Water utility officer			
Water utility officer			
Local Public Health Unit			
NSW Health Water Unit	02 9391 9939		waterqual@doh.health.nsw.gov.au
NSW DoI Water (Parramatta)	02 9842 8495		bill.ho@dpi.nsw.gov.au
NSW DoI Water (Regional)			

Further reference: NSW Health response protocol for the management of physical and chemical quality
http://www.health.nsw.gov.au/environment/water/Pages/nswhrp-chemical.aspx

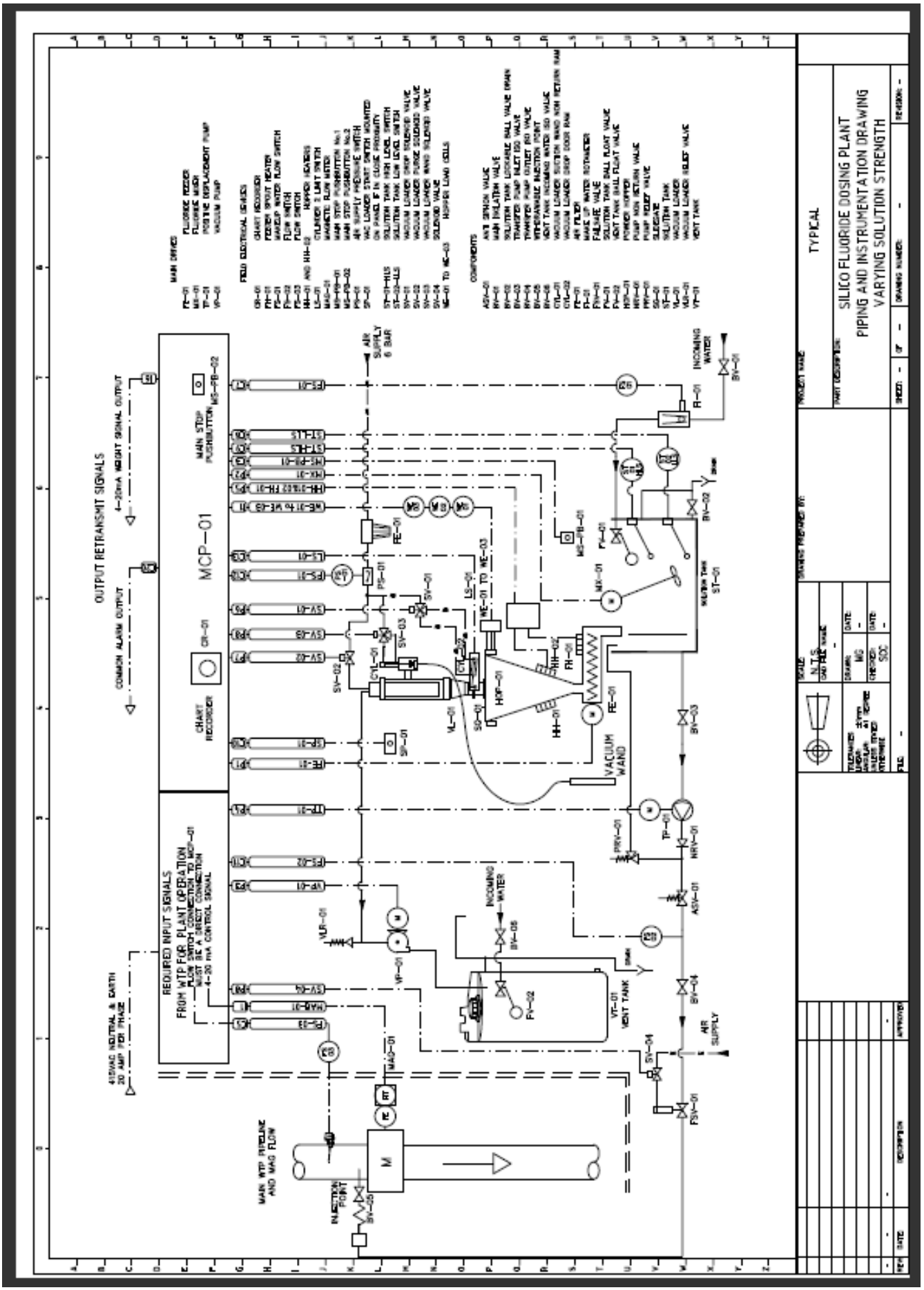
APPENDIX D

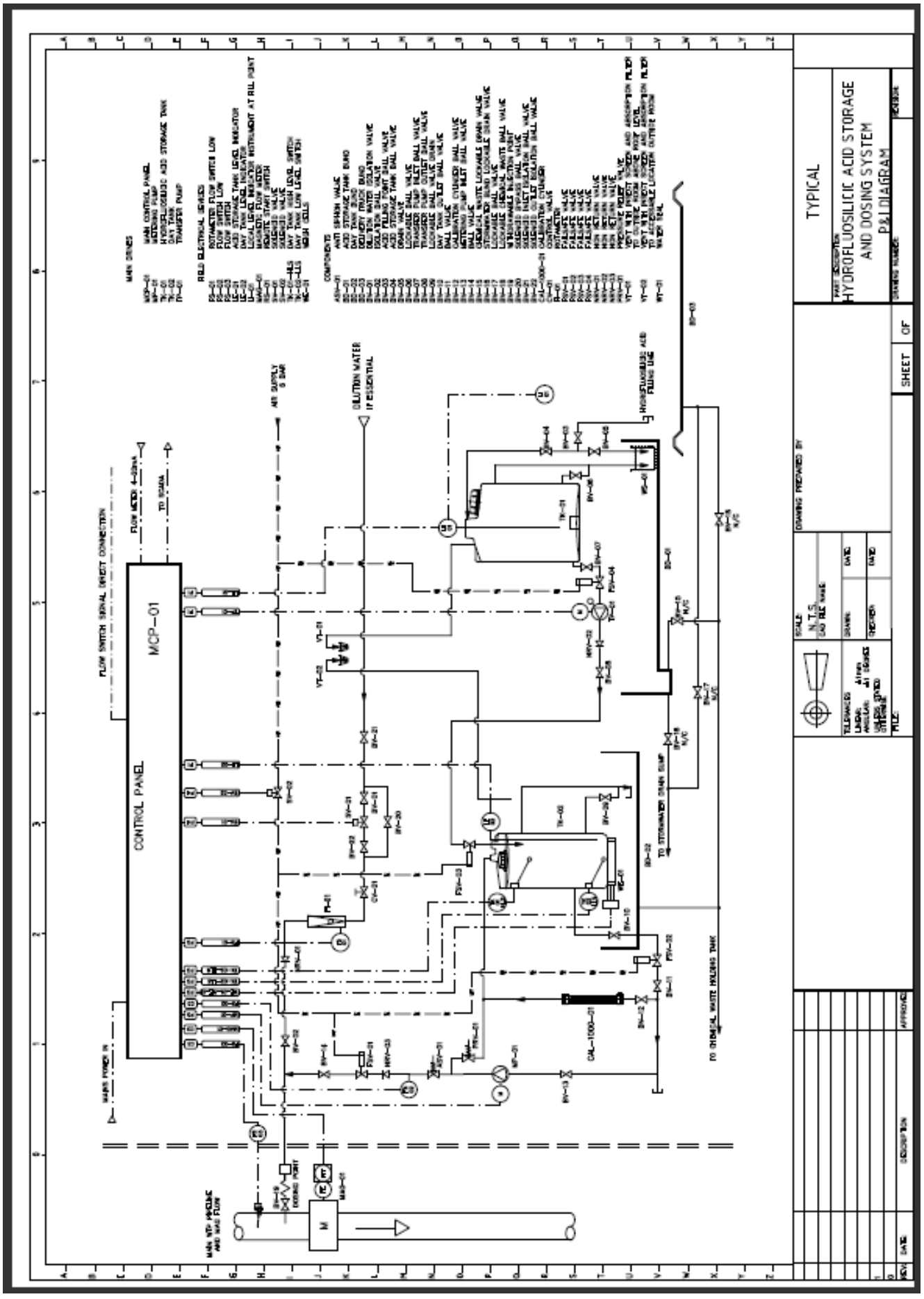
Generic fluoridation plant process and instrumentation diagrams (P&IDs)

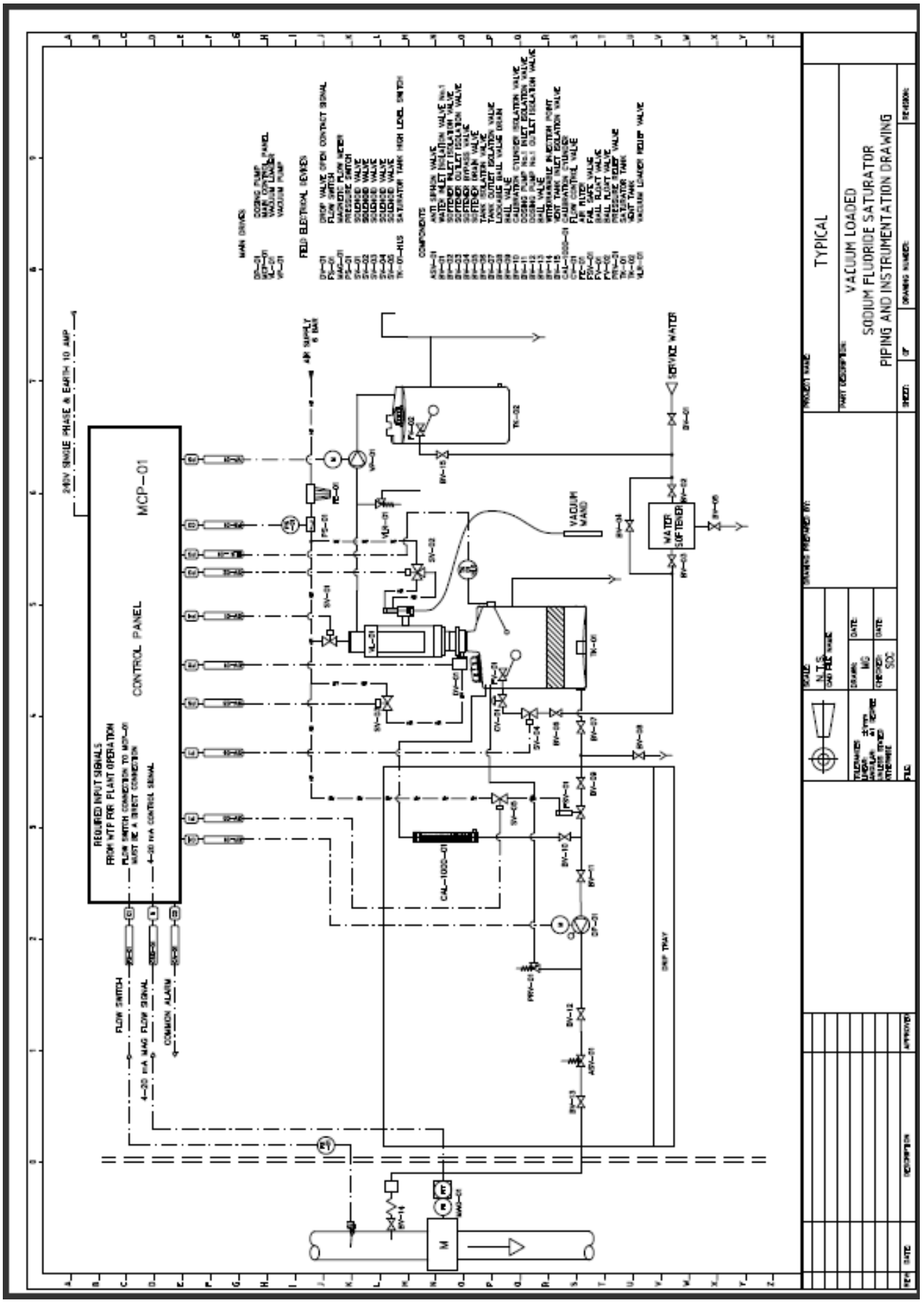
A Dry powder fluoride feeding system

B Hydrofluosilicic acid storage and dosing system

C Fluoride saturator system


TYPICAL
SILICO FLUORIDE DOSING PLANT
PIPING AND INSTRUMENTATION DRAWING
VARYING SOLUTION STRENGTH
MCP-01
OUTPUT RETRANSMIT SIGNALS
REQUIRED INPUT SIGNALS
FROM WTP FOR PLANT OPERATION
MAIN WTP PIPELINE AND MAG FLOW
VACUUM WAND
VENT TANK
INCOMING WATER
AIR SUPPLY


TYPICAL
HYDROFLUOSILICIC ACID STORAGE AND DOSING SYSTEM
P&I DIAGRAM
CONTROL PANEL
MCP-01
TO CHEMICAL WASTE HOLDING TANK
TO STORMWATER DRAIN SUMP
DILUTION WATER IF ESSENTIAL
AIR SUPPLY 6 BAR
SHEET OF


TYPICAL
VACUUM LOADED
SODIUM FLUORIDE SATURATOR
PIPING AND INSTRUMENTATION DRAWING
MCP-01
CONTROL PANEL
240V SINGLE PHASE & EARTH 10 AMP
AIR SUPPLY 6 BAR
SERVICE WATER
VACUUM WAND
WATER SOFTENER
DRIP TRAY
FLOW SWITCH
COMMON ALARM
REQUIRED INPUT SIGNALS
FROM WTP FOR PLANT OPERATION
MAIN DRIVES
FIELD ELECTRICAL DEVICES
COMPONENTS

APPENDIX E

Sample standard operating procedure (SOP) for fluoride measurement

Standard Operating Procedure (SOP)

Title: Determination of fluoride in drinking water by the method of ion selective electrode (ISE)

a. Introduction

These procedures are designed to give general instructions on how to perform the determination of fluoride in drinking water. They represent best practice.

Due to the large variety of instruments capable of performing this determination, these procedures cannot give specific instructions on the use of such instruments. The user must refer to and become familiar with the operating manual(s) of the specific instrument used in the plant.

b. Principles

The fluoride electrode has a single crystal of an insoluble fluoride salt at its base. When this sensing element comes into contact with a solution containing free fluoride ions, a potential develops across it and it is measured against a reference electrode immersed in the same solution.

The fraction of free fluoride ions to total fluoride ions in solution is dependent on the total ionic strength of the solution. By keeping the ionic strength high and constant the measured free fluoride ions is proportional to the concentration of fluoride in solution.

The presence of metal ions (e.g. iron and aluminium) causes interferences. The addition of appropriate buffers containing complexing agents limits the effect of interferences.

c Minimum Equipment Requirement

i. Meter: either direct readout or a pH/mV meter with a resolution of 0.1 mV;
ii. Fluoride selective electrodes (either a combined electrode, or separate measuring and reference electrodes);
iii. Magnetic stirrer with electrode holder;
iv. Magnetic teflon coated stir bars ;
v. 12 x 150 or 200 ml, beakers, preferably made of plastic;
vi. De-ionised or distilled water;
vii. Fluoride standards;
viii. Buffer;
ix. 100 ml, measuring cylinder;
x. 5 or 10 ml, dispensing pipette;
xi. 12 x 100 – 250 ml, plastic storage bottle with tight fitting cap;
xii. 4 cycle semi-log graph paper (not required for direct readout meters);
xiii. thermometer.

NB: Combined fluoride electrodes incorporate the ISE and Reference electrodes into a single unit.

d Type of Meters

Two types of meters are available: Direct Readout and pH/mV Readout.

Direct Readout: Once calibrated these instruments display the actual concentration of fluoride in solution.

pH/mV: These instrument display the potential difference in mV between the ISE and the reference electrode. The readings (in mV) for the standards are plotted on semi-log graph paper from which fluoride concentrations for samples are extrapolated.

e Recommended Checks Prior to Analysis

i. The electrolyte level in the reference electrode must be kept between 5 mm and 20 mm below the filling hole. Refill with the solution recommended by the electrode supplier.
ii. Ensure that the level of electrolyte in the electrode is always at least 20mm above the top of the solution being measured.
iii. Ensure that all the filler holes are unplugged prior to measurements. Replace plugs at completion of testing (to ensure free flow of electrolyte).
iv. Wipe the base of the ISE clean with a soft tissue, make sure to remove any crystallised material present.
v. Inspect the base of the ISE. The base should be free of any scratch or other mechanical damage. Replace electrode if damage is present.
vi. If the ISE has been stored dry, immerse it in a solution containing the High Standard for 10-15 minutes before analysis. This conditions the electrode.

f Recommended Calibration Standards

Accurate standards of known fluoride concentration are essential for the proper determination of fluoride in drinking water.

A minimum of two standards are necessary to calibrate the ISE instrument. The fluoride concentration in the High Standard should be close to the upper limits of the sought concentration. The fluoride concentration in the Low Standard should be 1/10th of that of the High Standard.

The most practical standards are:

i. **High Standard**: 2.0 mg/L fluoride
ii. **Low Standard**: 0.2 mg/L fluoride (Note: this standard can be prepared by diluting the High Standard 10 times, i.e. 100 mL High Standard diluted to 1000 mL with de-ionised or distilled water)

Calibration standards should be replaced yearly or when readings of the QC standard are consistently outside acceptable range. Upon receiving a new set of standards, decant at least 100 mL into a plastic storage bottle, cap the bottle tightly and keep in the fridge. These can be used whenever contamination of standards is suspected.

When not in use, keep standards in a fridge. Remove from fridge and allow reaching room temperature before use for calibration.

The above standards can be purchased through the Division of Analytical Laboratories, phone 02 9646 0424.

g Recommended Quality Control Standards

The Quality Control (QC) standards are used to check the meter and procedures. They need to be independent of the standards used for calibration and have to be close to the fluoride concentration sought.

The most practical QC standard is 1.0 mg/L fluoride.

Preferably this solution should be prepared from a stock fluoride solution other than the one used for preparing the calibration standards. This fluoride stock standard should be from a different manufacturer or from the same manufacturer but with a different batch number. This is important to ensure the validity and stability of the stock standard used to prepared the calibration standards

QC standard should be replaced every 12 months or when readings are consistently outside acceptable range. Upon receiving a new QC standard, decant at least 100 mL into a plastic storage bottle, cap the bottle tightly and keep in the fridge. This can be used whenever contamination of the QC standard is suspected.

When not in use, keep QC standard in a fridge. Remove from fridge and allow reaching room temperature before use.
The above QC Standard can be purchased through the Division of Analytical Laboratories, phone 02

9646 0424.

h The Function of Buffers

Buffers, often abbreviated to TISAB (Total Ion Strength Adjustment Buffer) in fluoride determination have three distinct functions, they:

i. Adjust and maintain constant pH of solution;
ii. Adjust and maintain high ionic strength of solution; and
iii. Free fluoride ions from complexes thus making them available for determination.

The principal cause of error in fluoride determination by ISE is the failure of the buffer to perform one or more of the above tasks.

The strength and hence the volume ratio of sample to buffer are critical factors.

i Recommended Buffers

Two buffers are in common use: **Low Level TISAB** and **High Level TISAB**

Low Level TISAB (also known as **TISAB II**) is recommended only for fluoride concentrations less than 0.4 mg/L and in the absence of iron and aluminium. It is used in the ratio of 1:1, i.e. 50 mL sample and 50 mL buffer.

High Level TISAB (also known as **TISAB IV**) is recommended for general use for samples containing up to 2 mg/L fluoride. It is suitable for samples containing up to 100 mg/L of iron and aluminium. Because of its considerably higher strength, the ratio of buffer to sample can be reduced to 1 in 50, i.e. 2 mL of buffer to 100 mL of sample or standard. It is the recommended buffer for fluoride determination.

TISAB IV can be purchased through the Division of Analytical Laboratories, phone 02 9646 0424.

j Preparation of Buffers

The preparation of buffers involves using hazardous chemicals. It should be attempted only by competent and trained personnel skilled in handling concentrated acids and alkalis. It must be carried out in a laboratory equipped with analytical balances, glassware and pH meter.

Due to the criticality of buffers, it is recommended that they be purchased ready-to-use.

Follow the instruction below to prepare buffers.

i **Low Level TISAB (TISAB II):** To 500 mL of distilled water in a 1L beaker add 57mL of Glacial Acidic Acid and 58 g of reagent grade Sodium Chloride. Allow the solution to cool to room temperature and using a calibrated pH meter adjust the pH of the solution to 5.0 – 5.5 using 5M Sodium Hydroxide. Pour into a 1 L volumetric flask and make to the mark with distilled water.

ii **High Level TISAB (TISAB IV):** To 500 mL of distilled water in a 1 L beaker add 84 mL of concentrated Hydrochloric Acid (36-38%), 242 g of Tris (Hydroxymethyl) Amino Methane and 230 g of reagent grade Sodium Tartrate. Stir to dissolve and allow the solution to cool to room temperature. Pour into a 1 L volumetric flask and make to the mark with distilled water.

k Calibration and Measurements Using Direct Readout Meters

Consult the meter instruction manual to ensure that electrodes are connected properly and all the functions of the meter are understood.

i **Using High Level TISAB IV**

1. Measure 100 mL of the Low Standard, transfer it to a beaker and add 2 mL of buffer.
2. Add a magnetic stir bar to the beaker, rinse electrodes with deionised water, blot them dry and immerse them in the solution. Start stirring and wait for a stable reading.
3. Follow instructions set out in the instruction manual on how to adjust the meter so that it reads the value of the Low Standard.
4. Repeat procedures from 1. to 3. using the High Standard.
5. Measure 100 mL of the QC Standard, transfer to a beaker and add 2 mL of buffer.
6. Add a magnetic stir bar to the beaker, rinse electrodes with deionised water, blot them dry and immerse them in the solution. Start stirring and wait for a stable reading.
7. The reading should be within 5% of stated value, e.g. acceptable values for a 1mg/L QC Standard are within the range 0.95 – 1.05 mg/L. Repeat calibration and Steps 5. and 6. till such time QC Standard falls within the acceptable range.
8. Continue with sample measurements using 100 mL of sample and 2 mL of TISAB IV. Record concentration of fluoride in mg/L.
9 When testing multiple samples, re-measure the QC Standard prepared in Step 5. above every 10 samples and after the last sample. The acceptance criteria stated in 7. above should be met. If they are not met, then ignore results, repeat calibration and sample measurements.

ii **Using Low Level TISAB II**

Follow identical steps as above but use equal volume of TISAB II to standard and sample (e.g. 50 mL of buffer with 50 mL standard or sample).

NOTE: The volume of samples, Low, High and QC Standards can be reduced from 100 to 50 mL provided a smaller beaker is used so that the liquid adequately covers the ISE. If this is done, then the volume of TISAB used should be reduced accordingly (i.e. from 2 mL to 1 mL).

At the conclusion of testing plug all the electrode holes and store the electrodes in a solution containing about 1 mg/L of fluoride (e.g. the High Standard solution used for calibration). In the event that the electrodes are not to be used for over a week, drain them and store them dry in their original container.

l Calibration and Measurements Using mV/pH Meters

Consult the meter instruction manual to ensure that electrodes are connected properly and all the functions of the meter are understood.

i **Using High Level TISAB IV**

1. Measure 100 mL of the Low Standard, transfer it to a beaker and add 2 mL of buffer.
2. Add a magnetic stir bar to the beaker, rinse electrodes with deionised water, blot them dry and immerse them in the solution. Start stirring and wait for a stable reading.
3. Record the mV reading.
4. Repeat procedures from 1. to 3. using the High Standard.
5. Subtract one reading from the other. A value between 55 and 60 mV indicates that the meter is working correctly otherwise check meters, electrodes and repeat calibration.
6. Plot the mV reading of each standard against the standard concentration. The standard concentrations are plotted on the log scale of the graph. Draw a straight line between the points.
7. Measure 100 mL of the QC Standard, transfer to a beaker and add 2 mL of buffer.
8. Add a magnetic stir bar, rinse electrodes with water, blot them dry and immerse them in the solution. Start stirring and wait for a stable reading.

9. Record the mV reading and extrapolate the concentration of the QC Standard from the graph prepared in 6.
10. The concentration should be within 5% of stated value (e.g. acceptable values for a 1mg/L QC Standard would be 0.95 – 1.05 mg/L). Repeat calibration and steps 7. to 9. till such time QC Standard falls within the acceptable range.
11. Continue with sample measurements using 100 mL of sample and 2 mL of TISAB IV. Record the mV of each sample and extrapolate the fluoride concentration in mg/L from the plotted graph.
12. When testing multiple samples, re-measure the QC Standard prepared in Step 7. above every 10 samples and after the last sample. The acceptance criteria stated in 10. above should be met. If they are not met, then ignore results, repeat calibration and sample measurements.

ii **Using Low Level TISAB II**

Follow identical steps as above but use equal volume of TISAB II to standard and sample (e.g. 50 mL of buffer with 50 mL standard or sample).

NOTE: The volume of samples, Low, High and QC Standards can be reduced from 100 to 50 mL provided a smaller beaker is used so that the liquid adequately covers the ISE. If this is done, then the volume of TISAB used should be reduced accordingly (i.e. from 2 mL to 1 mL).

m. Troubleshooting

Due to the large variety of instruments available for this type of analysis, it is not possible to provide detailed causes and solutions for all possible problems or symptoms. Please refer to instrument manual for details. Below are some of the common symptoms, their possible cause and possible remedies.

Symptom	Possible Cause	Remedy
Wrong QC results but calibration curve appears OK	Incorrect QC standard used	Check QC standard, use stored QC Standard
	Incorrect use of the calibration standards	Check calibration standards, use stored standards if not able to correct problem (e.g. if standards are contaminated)
	Incorrect use of TISAB or no TISAB added	Use TISAB in the same ratio for standards as per QC standard
	Incorrect use of semilog paper	Plot mV on the linear axis and make sure that the concentration on the log axis are properly marked, e.g. the distance between the point marked 0.5 and 1.0 MUST be the same as that marked 1.0 and 2.0.
	Incorrect recording of mV readings	Make sure that you record the sign of the mV (it can be +ve and –ve!)
Low or no slope	Contaminated standards	Check calibration standards, use stored standards if not able to correct problem (e.g. if standards are contaminated)
	TISAB was not used	Use TISAB in the correct proportion to sample
	Electrode malfunction	Check electrode, electrolyte levels and replace electrode/s if necessary
Noisy and/or unstable readings	Problems with the reference electrode or wrong electrode used	Check for correct electrode to be used with the specific fluoride electrode; air bubbles in electrode or incorrect electrolyte used. Empty and refill electrode
	TISAB was not used	Use TISAB in the correct proportion to sample
	Defective meter or poorly grounded	Check meter, see meter instruction manual
Reading slowly drifting in one direction only	Standard and samples not at room temperature and/or at different temperature	Allow sufficient time for solutions to reach steady room temperature
	Fluoride electrode dirty	Check and clean electrode, refer to instructions supplied with the meter
	Incorrect reference electrode filling solution used	Empty electrode and refill with correct solution
Meter will not read or reading off scale	Defective meter	Check meter, see meter instruction manual
	Electrodes not plugged in properly	Check connections of electrodes to meter
	Electrodes not in solution	Make sure electrodes are in solution and just few mm above stirring bar
	Reference electrode empty	Refill with correct solution
	Static electricity	Ground the meter correctly