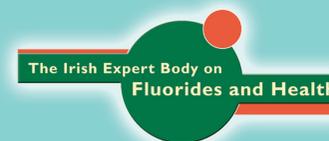




## CODE OF PRACTICE ON THE FLUORIDATION OF DRINKING WATER 2007



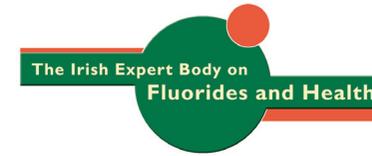
The Irish Expert Body on Fluorides and Health

An Corpán Oilte Éireannach um Fluairídí agus Sláinte

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## 1. Introduction

Fluoridation of drinking water, the main aim of which is the prevention and control of dental caries (dental decay), commenced in Ireland in 1964 after the introduction of the Health (Fluoridation of Water Supplies) Act 1960. The Act provides that health authorities shall arrange for the fluoridation of public piped water supplies. The Act also provides that sanitary (local) authorities may act as the agents of health authorities in fluoridating public piped water supplies. Currently approximately 73% of the population receives fluoridated water from public water supplies.

Dental caries (dental decay) is a common disease which affects the teeth. It commences as a destructive process of the dental enamel, and if left untreated, can affect the dentine (the tooth tissue beneath the dental enamel). The decay can progress more rapidly in the softer dentine and will eventually reach the dental pulp (nerve and blood vessels) in the centre of the tooth. This may lead to the death of the dental pulp (nerve) and can lead to a dental abscess. The process of dental caries (dental decay) is caused by acid which attacks the dental enamel (demineralisation) following consumption of sugary food and drinks. Dental caries (dental decay) can be painful, is expensive to treat, and can lead to loss of teeth, and impairment of function, including chewing, speech appearance, etc.

Fluoride makes teeth more resistant to tooth decay by slowing down the pace at which minerals are removed from enamel when attacked by acid (demineralisation) following consumption of sugary food and drinks. It also helps to repair the tooth enamel (remineralisation) when the acid attack is over. Fluoride also inhibits the process by which the bacteria produce acids. A key to the control of decay by fluoride is the maintenance of a low constant level of fluoride in saliva which can be achieved through use of fluoridated drinking water and fluoridated toothpaste.

There is currently no evidence that fluoridation of water at recommended levels has any adverse effects on health. An increase in dental fluorosis is seen as a result of increased use of fluorides in all forms. Dental fluorosis is one of many reasons for a change in the appearance of the tooth. It typically appears as fine white lines which are difficult to see. In countries with naturally occurring very high levels of fluoride (more than 10ppm) pitting or staining of enamel may occur. The levels of dental fluorosis seen in Ireland are primarily of the very mild forms, are cosmetic in nature, and do not require treatment. The Forum on Fluoridation recommendation to reduce the level of fluoride in drinking water was made to address the rising incidence of dental fluorosis noted in successive national surveys. A similar approach was taken in other areas such as Hong Kong and Toronto.

The permissible range of fluoride in drinking water has been defined in Regulations made under the Health (Fluoridation of Water Supplies) Act 1960, (S.I. No. 42 of 2007) as being not less than 0.6 p.p.m. and not greater than 0.8 p.p.m. Furthermore, the European Communities (Drinking Water) Regulations 2007 (S.I. No. 106 of 2007) set a parametric value (i.e. maximum limit) of 0.8 mg/l (p.p.m.) for fluoridated drinking water. Constant monitoring to ensure that the fluoride content of public piped water supplies is maintained within the correct limits is essential. Only water supplies under the control of local authorities are fluoridated. Some group water schemes may purchase water from a county council source while the distribution network remains under the control of the group. Other group schemes provide their own sources of water. The group water schemes do not come under the scope of the Act.

## 2. Purpose

The Code of Practice has been prepared to implement Recommendation 2 of the Forum on Fluoridation 2002, the purpose of which is to ensure efficient and effective implementation of the technical aspects on the procedure for the fluoridation of drinking water, by all personnel involved and hence to ensure that:

1. The fluoride concentration of fluoridated water supplied to the consumer will be within limits set by Irish and European legislation.
2. The potential for environmental contamination from hydrofluosilicic acid spillages is minimised
3. The risk of injury to fluoridation plant personnel from hydrofluosilicic acid is minimised.

Nevertheless it must be emphasised that this Code of Practice does not purport to be a guide to compliance with Safety Health and Welfare at Work legislation and should not be interpreted as such.

The key objective of this Code of Practice is the achievement of high quality fluoridated water supplies that will enhance the oral health of those members of the public who receive fluoridated drinking water.

## 3. Scope

The Code of Practice applies to all water treatment plants where fluoridation of public drinking water supplies, using hydrofluosilicic acid as the fluoride source, is, or is intended to be carried out.

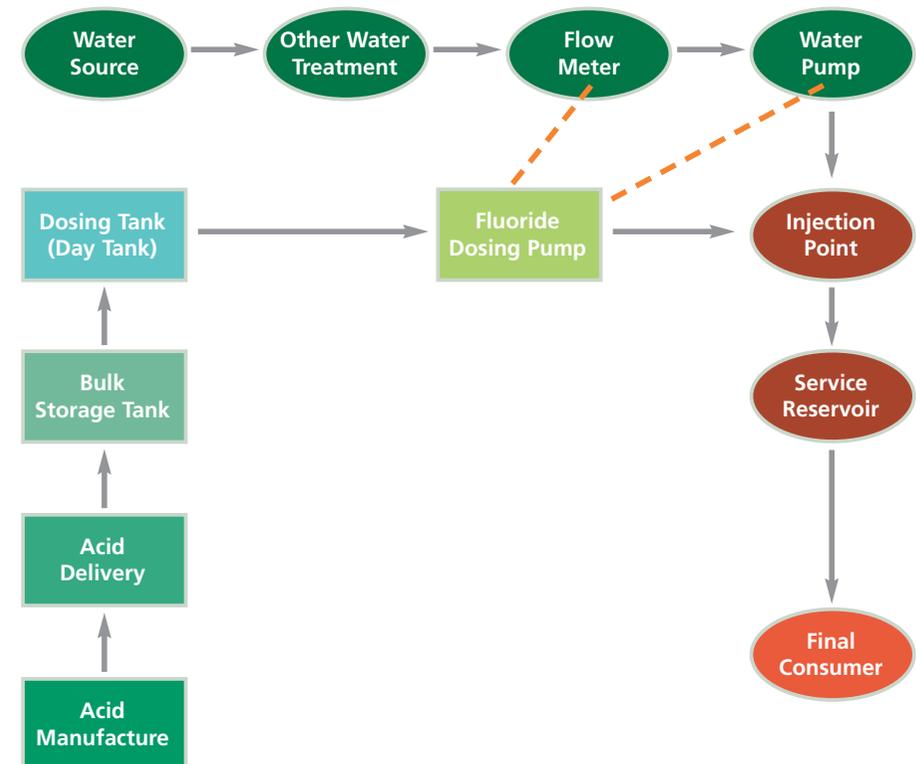
## 4. Responsibilities

1. The Health Service Executive is responsible for the fluoridation of drinking water supplied through public water supplies.
2. Where a local authority acts as an agent of the Health Service Executive in fluoridating public water supplies it is responsible for doing so in line with any legislation or regulations which may be in place and which govern the fluoridation of water supplies.
3. The local authority (and where appropriate its agent) as plant operator is responsible for implementing this Code of Practice (COP) and related Standard Operating Procedures (SOP).
4. It is the responsibility of all personnel involved with the fluoridation process to ensure compliance with the Regulations made under the Health (Fluoridation of Water Supplies Act) 1960 and they should be adequately trained.

## 5. Summary of the Process

Although the size and sophistication of water treatment plants varies widely, the fluoridation system employed is broadly similar at all locations, differing mainly in storage and pump dosing capacities. Figure 1 shows a simplified flow-diagram of the water fluoridation process. A brief description of the various stages is given below in sections 5.1 to 5.7.

Figure 1: Flow Diagram of a Typical Water Fluoridation Process



Ref: Parle (2001)

### 5.1 Hydrofluosilicic acid manufacture

Hydrofluosilicic acid is manufactured to specification as set out in regulations made under the Health (Fluoridation of Water Supplies) Act 1960. Detailed specifications for hydrofluosilicic acid can be obtained from the Material Safety Data Sheet (MSDS) or the Certificate of Analysis for the chemical. Some of the most pertinent characteristics are listed below (S.I. no. 116 of 2003 is the European Communities (Classification, Packaging, Labelling and Notification of Dangerous Substances) Regulations 2003):

Chemical Abstracts Service (CAS) number: 16961-83-4

EC number: 009-011-00-5

Hydrofluosilicic acid 10.9% w/w is a clear colourless, liquid free of precipitation, with a pungent odour

Specific Gravity@ 20°C 1.089 to 1.095

Chemical Formula:  $H_2SiF_6 \cdot nH_2O$

Classification: Corrosive.

Risk Phrases (3rd schedule of S.I. no. 116 of 2003): R34

Safety Phrases: (4th schedule of S.I. no. 116 of 2003): S1/2, S26, S27, S45.

### 5.2 Hydrofluosilicic acid delivery

Depending on the size of plant storage facilities and usage, acid is delivered by road tanker at intervals ranging from monthly to annually. The acid is transferred to water treatment plant bulk storage tanks by hose.

### 5.3 Hydrofluosilicic acid storage

Bulk storage on site must be in suitable tanks (e.g. high-density polyethylene or in rubber lined steel tanks), with capacity ranging from one month's to one year's, or even longer, supply. These tanks may be housed in a building or outdoors.

Tanks should be labelled as per Carriage of Dangerous Goods by Road Regulations 2004, S.I. No. 29 of 2004.

### 5.4 Day tank

To guard against the possibility of the entire contents of the bulk storage tank (i.e. up to several months dosage) accidentally discharging into the water supply the bulk storage tank is connected to a day tank (intended to contain one or, at most, a few days dosage capacity) which is normally refilled daily from the bulk storage tank, by plant personnel. This is done by opening a fill-valve on a pipeline connecting the bulk storage tank to the day tank. Day tanks are normally positioned on weighing scales to enable plant personnel to calculate weight of acid used each day and hence the expected fluoride concentration in the drinking water.

### 5.5 Fluoride dosing pump

The day tank feeds the fluoride dosing pump, which is an electronic diaphragm-type pump. This typically operates on the principle that an electronic signal, e.g. from a water flow-meter, attracts an armature to which the pump diaphragm is connected. This results in a specific quantity of acid being dosed from the

pump (i.e. pulse dosing). Both stroke length (i.e. the quantity dosed during each pulse) and speed (i.e. rate of pulses per minute) can be adjusted in most pumps (although in some models only speed can be adjusted). Pump stroke is normally set at 60% and externally controlled across the speed/milliamperage range from the flowmeter. Minor adjustments can then be made by adjusting the stroke setting.

Dosing pumps can operate in either 'manual' or 'external' mode. In manual mode, stroke (where adjustable) or speed settings can be adjusted by the plant operator as required. Such a mode has been used mainly when plant water output is constant or does not fluctuate greatly, hence adjustments should not require to be made very frequently. The pumps must also be operated in 'manual' mode during calibration.

External mode adjustment, on the other hand, is triggered by an electronic signal, for example in flow-proportional dosing, the dosing pumps receive an electronic signal proportional to the plant water flow rate as measured by a flow-meter. An increase in water flow therefore causes a proportional increase in the fluoride pump dose rate, and vice versa for decreased water flow rate.

Dosing pumps are situated adjacent to the day tank as they operate by vertical suction.

### 5.6 Fluoride Injection

From the dosing pump the acid travels through a length of tubing / pipe-work to the injection point into the water. Ideally this should be at a location with significant turbulence in order to maximise mixing. The injection point for fluoride generally occurs after all of the other treatment processes in the plant.

### 5.7 Service Reservoir

In most, but not all, water supply systems, in order to ensure reasonably constant water pressure and to be able to meet peak demand, the water is pumped to service / storage reservoirs, with capacities ranging from a few hours to a few days, before supply to the consumer. The relevance of this to fluoridation is the buffering effect that this would be likely to have on fluoride overdosing or underdosing. It also influences, by its capacity, the length of time required to return to optimal levels.

### 5.8 Critical Control Points in the Fluoridation Process

Hazard Analysis Critical Control Points (HACCP) is a risk management tool in widespread use in the food industry. In essence it involves conducting a risk assessment of a process to identify the critical control points (CCPs) that are crucial to product safety; defining acceptable limits at these points and implementing appropriate controls, monitoring, corrective actions and verification to ensure that the process is under control at all times. As the fluoridation process has the aim of supplying a product with a defined fluoride concentration, the HACCP approach can usefully be applied to it. Table 1 below summarises the hazards, CCPs, critical limits, controls and corrective actions that apply.

Table 1: Hazard Analysis Critical Control points in Drinking Water Fluoridation

CCP no.	CCP Hazard	Source of Hazard	Controls	Critical Limits <sup>1</sup>	Corrective Actions
1.	Variability in strength of hydrofluosilicic acid on arrival at treatment plant	Lack of control during manufacturing	Good manufacturing practice to ensure 10.9% strength $\pm$ 0.3%  Certificate of Compliance from supplier  Monitoring as per Protocol for the Independent Testing of hydrofluosilicic acid (Appendix 5)	10.6 - 11.2% strength hydrofluosilicic acid	Notify supplier; notify HSE; Adjust dosing in plant to allow for variation in strength of acid  As per Protocol for the Independent Testing of hydrofluosilicic acid (Appendix 5)
2.	Variation in fluoride concentration of water source used for abstraction	Natural background fluoride fluctuation  Contamination by hydrofluosilicic acid spillage / leak from treatment plant	Monitor & allow for in dosing calculations.  Plant security, construction of tanks, pipes & equipment from suitable materials; Access for leak detection; secondary containment of leaks / spillages; Appropriate siting; Suitable fill valves	0.8mg/l F in water supplied to consumer <sup>1</sup>	See corrective actions protocol Table 2, section 6.6.4 of this code of practice
3.	Fluoride pump overdose / underdose	Dose rate incorrectly set or adjusted Lack of system interlock Siphonage Excessive day tank capacity  Malfunction of control systems	Training, calibration, interlock between water flow & F dosing; Anti-siphonage valves; Reduce day tank capacity; regular monitoring of F conc. in water	0.6 - 0.8 mg/l F in treated drinking water <sup>1</sup>	See corrective actions protocol Table 2, section 6.6.4 of this code of practice
4.	Inhalation or skin / eye contact with hydrofluosilicic acid	Tank filling operations; Checking pipes, tanks and pumps	Proper design of equipment; Training; personal protective equipment; safe work procedures	Airborne conc. max of 2.5 mg/m <sup>3</sup> (as F)	See section 10 of this code of practice

## 6. Dosing Installations and Process Control - Technical Specifications

## 6.1 Site security

## 6.1.1 Prevention of unauthorised access

Perimeter fencing, gates and piers should be capable of keeping out would-be intruders. Bulk hydrofluosilicic acid storage tanks and associated pipework sited outdoors should also be enclosed by suitable security fencing, which should also be capable of preventing accidental impact damage from delivery vehicles etc. Plant buildings should have secure doors and windows.

## 6.1.2 Alarm systems

All sites not staffed continuously 24 hours a day, 7 days a week should be fitted with suitable intruder alarm systems with off-site telemetry.

## 6.2 Delivery and bulk storage of hydrofluosilicic acid

## 6.2.1 Delivery to water treatment plant

Transportation should be in accordance with the provisions of the Carriage of Dangerous Goods by Road Regulations 2004 (S.I. no. 29 of 2004) and International Agreement on the Carriage of Dangerous Goods by Road (ADR) 2005 (or any subsequent amendments to these). There must be safe access for transfer of bulk quantities of hydrofluosilicic acid from the delivery vehicle to the water treatment plant bulk storage facility. In particular, this process should only take place in an area where any spillages can be contained and collected for safe and environmentally acceptable disposal e.g. in a bunded area.

It is recommended that "stand" pipes (filler pipes) be provided at the waterworks as it will allow for easy coupling of the tanker hose. The "stand" pipes should be located at ground level, be suitably identified, bunded and secured.

It is necessary to ensure that there is sufficient capacity in the bulk tank to accommodate the volume of hydrofluosilicic acid in the delivery. Reliance must not be placed on tank recorders and level displays alone; these readings should be cross-checked against the usage records for the daily transfers to the day tank.

The tank should not normally be filled above 90% capacity.

All tanks should have a fill pipe with non-return valve, with the fill nozzle accessible at low level. Drip containment is required if this nozzle is not within the tank bund.

Deliveries should only take place under the supervision of, and in the presence, for the entire duration of the operation, of a competent staff member from the water treatment plant who should ensure that the correct chemical has been delivered by checking the documentation. Both delivery and reception personnel must be adequately trained (see section on training).

## 6.2.2 Construction, capacity and location of tanks

Each fluoridation plant should have a minimum bulk storage capacity of one month's supply of hydrofluosilicic

acid. Each plant should have a procedure in place to ensure that replenishment orders are placed in sufficient time to avoid on-site chemical supply being exhausted. Daily visual (or telemetric, where provided) checks should be carried out on the chemical level in the tank and on the tank and bund area for evidence of leaks and such checks should be documented (e.g. on a standard checklist) and records retained on-site. Bulk storage tanks should be constructed of a suitable acid-resistant material e.g. high density polyethylene, rubber-lined metal. An overflow pipe discharging into the tank bund should also be fitted.

New tanks should have fill-points designed to prevent filling with any material other than hydrofluosilicic acid.

At the time of installation and commissioning of the tank, the expected working lifetime of the tank should be ascertained and recorded, with a view to having a replacement schedule in place.

The tank should be labelled with the name of the chemical and appropriate hazardous warning symbols and also the volume of the tank.

If tanks are sited outside, the tank, bund and associated pipework should be adequately secured against accidental impact damage or vandalism. It is also desirable that these external tanks be roofed to exclude as much rainwater as possible from the bund.

Tanks should be so sited that all parts of the outer tank surface are accessible for visual inspection of leaks. In order to facilitate measuring the quantity to be filled from the delivery tanker, an easily readable graduated contents level indicator with high and low level alarms should be fitted to all bulk storage tanks. It is important that the draw-off point (for supplying the day tank) from the bulk tank should be situated close to the base of the tank, otherwise the effective capacity of the tank will be reduced

#### 6.2.3 Bunding

In order to safely contain the hydrofluosilicic acid, should a leak occur, the bulk storage tank, should be accommodated in an acid resistant bund capable of accommodating at least 110% of tank capacity.

Bunds should be regularly inspected for the build up of liquid (such as rainwater, in the case of tanks sited outside) and should be periodically emptied, by pumping (as there should be no outlet valve from the base of the bund), when required. The capacity of the bund should not be compromised by liquid retained in the bund from other sources such as rainwater. Drainage from banded areas should be diverted for collection and safe disposal. The contents of a bund should only be discharged to a surface water drain where the sanitary authority is satisfied that there is no potential for pollution of the receiving waters from the discharge (e.g. the water should be tested for fluoride content prior to discharge).

All banded areas should be integrity tested in accordance with BS8007 prior to commissioning and thereafter should be retested every 5 years in accordance with the guidelines set out in the EPA Publication "Storage and Transfer of Materials for Scheduled Activities".

#### 6.2.4 Lighting

Suitable and sufficient artificial lighting should be provided to enable inspection of all parts of the tank, pipework and bunding for leaks and for reading of the contents level indicator.

#### 6.2.5 Ventilation

Where tanks are sited indoors, the tanks should be closed and there should also be a ventilation pipe discharging direct to the outside of the building at the top of the tank.

### 6.3 Day Tank

#### 6.3.1 Construction

The tank should be constructed of a suitable acid-resistant material. To allow visual assessment of the level of acid in the tank, it should either be translucent, with an easily readable graduated volume scale on the tank exterior, or have a suitable alternative contents volume indication system. The fill-pipe into the day tank should be sited so that it cannot impede movement of the weighing scales, as this may affect accuracy of weighing.

#### 6.3.2 Filling from the bulk tank

It is recommended that the day tank be filled by pumping from the bulk storage tank rather than by gravity filling. In the absence of a suitable fully automated system, the button to operate the pump should be sited in clear view of the day tank. In order to prevent the pump being inadvertently left running the pump should have a 'dead man's handle' type operation i.e. only be able to operate while the button is held pressed in place by a plant operative. It is recognised that a large number of fluoridation plants have used gravity filling for many years with no evidence of adverse incidents and that conversion from gravity filling may present difficulties. In such situations it is deemed acceptable to continue, in the short to medium term (suggest 5 – 7 years), to use gravity filling in existing plants, provided that the fill valve has a spring lever (i.e. dead man's handle) which will ensure that it can only fill while a plant operative is physically holding the lever open.

#### 6.3.3 Capacity

Day tank capacity needs to be minimised in order to reduce the potential for overdose from siphonage or dosing pump malfunction. Nevertheless, some compromise is required to reduce risk of underdosing (e.g. in the case of small plants not staffed on a 24 hour, 7 day basis, if plant were not visited each day, one day's capacity of HFSA in day tank would not be sufficient). A maximum of 3 days capacity will suffice in all cases but it must be stressed that the maximum capacity be as close to that sufficient to treat one day's maximum water output for the plant as practicable. It is also important to ensure that the level in the day tank does not become too low as this can cause an air-lock in the system. Where existing day tanks have capacities in excess of 3 days usage, a clearly identifiable and indelible maximum fill line (not exceeding 3 days capacity) should be affixed to the tank and a procedure implemented and monitored to ensure that filling above this line does not take place (incorporation of a high-level alarm would be one option). If the procedure is not / cannot be adhered to, the tank should be replaced by one of appropriate capacity.

#### 6.3.4 Ventilation

The day tank should be sealed and have a ventilation pipe direct to the outside air. This pipe should be able to accommodate day tank movement on the weighing scales. Having regard to requirements of the Health and Safety Regulations, adequate mechanical exhaust ventilation (i.e. capable of ensuring that the airborne concentration of fluoride, in the vicinity of the day tank does not exceed 2.5 mg/m<sup>3</sup>) immediately adjacent to the tank would also be acceptable.

### 6.3.5 Lighting

Suitable and sufficient artificial lighting should be provided to enable inspection of all parts of the tank and pipework for leaks, for reading of the contents level of the day tank, weighing the tank contents and for all activities associated with operation and maintenance of the fluoride dosing pumps.

### 6.3.6 Bunding

In order to safely contain the hydrofluosilicic acid, should a leak occur, the day tank, fluoride dosing pump and standby pump should be accommodated in an acid resistant bund capable of accommodating at least 110% of tank capacity.

Bunds should be regularly inspected for the build up of liquid and should be periodically emptied, by pumping (as there should be no outlet valve from the base of the bund), when required. The capacity of the bund should not be compromised by liquid retained in the bund from other sources. Drainage from bunded areas should be diverted for collection and safe disposal. The contents of a bund should only be discharged to a surface water drain where the sanitary authority is satisfied that there is no potential for pollution of the receiving waters from the discharge (e.g. the water should be tested for fluoride content prior to discharge).

All bunded areas should be integrity tested in accordance with BS8007 prior to commissioning and thereafter should be retested every 5 years in accordance with the guidelines set out in the EPA Publication "Storage and Transfer of Materials for Scheduled Activities".

## 6.4 Fluoride Dosing Pump

### 6.4.1 Location

The dosing pump will normally be sited adjacent to the day-tank and should be contained within the same bund. The pump should not be sited more than 1.2 metres above the lowest normal level of the contents of the day tank and should operate on suction lift.

### 6.4.2 Dosing Safeguards (Interlock / SCADA)

Flow-proportional dosing should be the normal practice at all plants i.e. the pulse rate of the dosing pump will be governed by an electrical signal which varies according to the water flow rate as measured by a flow meter. To prevent overdosing the dosing pump should incorporate some form of safeguard protection. This may vary depending on the size of treatment plant. The safeguard may be by interlock of the dosing pumps with the mains water pump or control by a SCADA system.

Dosing pumps should be hard wired in order to prevent by-pass of controls. Pumps should incorporate an audible alarm to indicate when the pump is operating in manual mode (the pumps have to be switched to manual mode for calibration - see 6.4.6 below) and the system should be locked to prevent mode switching by unauthorised personnel. At commissioning of new pumps, flow-meters, system components or a power cut a trial should be carried out to assess the effect on the dosing pump default setting.

### 6.4.3 Pump output and accuracy

The installations are to be capable, under unqualified guarantee, of operating within an accuracy of  $\pm 3\%$ . As dosing accuracy falls off when the pump is operating below 30% and above 70% capacity, consideration should be given to an automatic dose cut-off if, for any reason, plant output enters this range.

To optimise dosing accuracy and minimise the magnitude of any potential overfeed, the pump should be chosen so that, based on the typical range of the volume of water treated, it will not be expected to operate at speed / stroke settings of less than 50%, or greater than 70%, of maximum pump capacity (a pump delivering the optimal fluoride dose while operating at 70% pump capacity would deliver roughly one and a half times the optimal fluoride dose if it were, for any reason, to operate at maximum pump capacity treating the same volume of water).

### 6.4.4 Anti-siphonage and back-flow protection

The dosing system should in all cases be fitted with back pressure, anti-siphon and pressure relief valves.

### 6.4.5 Duty / standby dosing pumps

Duty / standby fluoride dosing pump arrangements should be provided at all plants to prevent a situation where underdosing / no dosing is carried out due to a pump malfunction.

It is important that system wiring should ensure that both pumps cannot be operated simultaneously as this could result in twice the intended dose of fluoride in the water.

### 6.4.6 Servicing and Calibration

There should be a documented programme of servicing & calibration of fluoride dosing pumps (at least annually, but more frequently if necessary e.g. after repairs, replacement, potential damage, dosing results outside specification with no apparent explanation). It is also recommended that monthly in-house calibration of dosing pumps is carried out. All dosing pumps must be switched to manual mode when being calibrated by service personnel where quantity of hydrofluosilicic acid pumped in a given time is measured, using a graduated tube and stopwatch, at different speed / stroke settings. It is important that the pump is restored to external mode by the service personnel once calibration has been completed.

Dosing pump suppliers, following service checks, should leave a documented record of checks carried out on site, including confirmation that the pump has been restored to external mode operation, following calibration. These checks should include the adequacy and functionality of anti-siphonage features as well as pump calibration.

It is recommended that all new pump installations should be fitted with burette type valved calibration gauges. Regular calibration (at least annually) of water flow-meters should also be carried out and documented. All calibration and servicing records should be retained on-site for inspection for the lifetime of the equipment.

## 6.5 Fluoride dosing system pipework

### 6.5.1 Accessibility for leak detection and identification

Pipework carrying hydrofluosilicic acid should, as far as possible, be readily accessible for visual inspection for leaks. All pipework carrying hydrofluosilicic acid should be clearly distinguishable, e.g. colour coded and labelled, from other plant pipework.

Underground piping should be enclosed in a sloped conduit with an inspection chamber downslope for detection of hydrofluosilicic leaks.

All pipework should be located to prevent accidental impact damage and with regard to electrical safety considerations.

Where more than one water supply source is being fluoridated at a water treatment plant, hydrofluosilicic acid pipework for each system should be readily distinguishable e.g. colour coding to prevent misconnection during commissioning /servicing / repair.

#### 6.5.2 Dosing point

In order to ensure adequate mixing, the injection point should normally be at a point where all of the water to be treated passes under constant positive pressure. The injection point should, where possible be located in the lower third of the pipe and the end of the injection line should extend one-third of the water pipe diameter.

### 6.6 Monitoring and Corrective Actions

#### 6.6.1 Automated on-line monitoring

In certain circumstances e.g. in treatment plants with a high level of automation and computerised process control, or for plants treating waters with significant variations in natural background fluoride levels (where 'feedback' trim dosing is advisable), the use of an automated on-line fluoride monitoring system may be advantageous. It is nevertheless recognised that many fluoridation plants using manual monitoring have achieved consistently excellent results over several years; hence the continued use of manual monitoring is deemed acceptable, providing the recommendations of 6.6.2 below are followed in full.

#### 6.6.2 Manual monitoring

In plants where there is no automated on-line monitoring there should be daily fluoride concentration measurement supplemented by 'volumetric' testing carried out by a member of the water treatment plant staff trained in the use of the testing methods

##### 6.6.2.1 Colorimetric testing

Colorimetric fluoride testing equipment at water treatment plants should be analogue or digital display specification, as this system is less subjective than visual comparison with standard colour discs. Allowance must be made for potential confounding interferences with analysis accuracy e.g. temperature differential between sample 'blank' and sample, presence of interfering substances such as Aluminium. The test equipment should be capable of measuring the typical concentrations of fluoride in treated drinking water with the trueness, precision and limit values set out in section 2 of part 3 of the schedule to the European Communities Drinking Water Regulations 2007 (S.I. No. 106 of 2007) or such other regulation that may apply.

It is of the greatest importance that steps, including provision of appropriate staffing resources, must be taken to ensure that daily colorimetric tests, using reliable test - methods, are carried out at all fluoridation plants as this, providing prompt subsequent corrective action is taken, can limit the length of time that consumers are exposed to a significant overdose or underdose of fluoride.

In addition to training on the specific test methodology, plant personnel should also receive training and information in relation to health and safety aspects of test procedures and reagents used and appropriate storage and disposal of reagents, samples etc.

#### 6.6.2.2 Daily weighing ('Volumetric testing')

As with colorimetric testing, it is strongly recommended that this be carried out at all plants on a daily basis. The day tank is weighed at the same time each day (both prior to refilling and following refilling) and the pre-fill weight subtracted from the previous day's post-fill weight to give the weight of hydrofluosilicic acid used. The following formula is then used to calculate the theoretical concentration of fluoride in the treated water:

$$\text{Fluoride conc. (mg/l)} = \frac{\text{kg acid} \times \text{strength of acid expressed as a fraction} \times 790}{\text{m}^3 \text{ water treated}}$$

This figure should be checked against the colorimetric test result and any discrepancy investigated. The weighing scales should be calibrated, at least annually, or at more frequent intervals if shown to be necessary.

#### 6.6.2.3 Monitoring of natural background fluoride levels

As some water supply sources can contain low levels of naturally occurring fluoride, which may need to be allowed for in dose calculations, a number of samples of source water should, where historical results are not available, be tested over the course of a year in the case of all supplies to obtain a profile of the background fluoride level. The test methodology for these samples should ideally be of sufficient sensitivity to detect levels as low as 0.05mg/l F.

The frequency of future source water background fluoride testing should be based on findings of the profiling samples and on the plant's consistency of compliance with fluoride levels in treated drinking water but it is suggested that it would be worth taking samples at least twice a year (at different times of the year) from all supply sources as a matter of routine.

### 6.6.3 Recording and reporting of monitoring results

#### 6.6.3.1 Testing at plant

All results should be recorded by the person carrying out the tests and forwarded to the local authority area engineer each calendar month. A copy of the results should be forwarded to a designated person (e.g. Principal Environmental Health Officer or Principal Dental Surgeon or both) at the Health Service Executive Local Health Office. Non-conforming results should be notified in accordance with the procedure, and within the timescale, outlined in table 2 in section 6.6.4 (see next page). Copies of all test results should be retained on site for inspection.

#### 6.6.3.2 Monthly monitoring and reporting

Each fluoridated water supply should be sampled monthly at consumers' taps at locations representative of the fluoridated supply by staff of the Health Service Executive for analysis by the Public Analyst. Abnormal results should be reported promptly to the relevant local authority and action taken in accordance with the protocol set out in table 2 below.

Results for each quarter of the year should be forwarded to the Department of Health & Children and the local Fluoridation Monitoring Committee. The local Fluoridation Monitoring Committee should review the results at every meeting held.

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6.6.4 Corrective actions

Immediate action should be taken to investigate the cause of abnormal results and institute appropriate corrective action. The protocol set out in table 2 below has been adapted from table 1. U.S. Centers for Disease Control and Prevention, Morbidity and Mortality Weekly Report Recommendations and Reports Engineering and Administrative recommendations for Water Fluoridation (1995) and has been modified to take account of: European Communities maximum parametric value (i.e. maximum acceptable limit for long-term exposure) for fluoride in drinking water (= 1.5 mg/l) as set out in Council Directive 98/83/EC or 3rd November 1998; World Health Organisation publication 'Fluoride in Drinking Water' (Fawell, J., Bailey, K., Chilton, J., Dahi, E., et al, 2006) and a literature review of fluoride concentrations in drinking water associated with acute toxic effects (Parle, 2001)

**Table 2 : Fluoridation Non-Conformance Protocol**

NOTES:

1. For any non-conforming result, the first step should be to retest immediately
2. All figures below are to the nearest decimal place e.g. 0.82 should be rounded down to 0.8; 1.06 should be rounded up to 1.1 and so forth.

Action level (mg/l F)	Action to be taken	Timescale
Less than 0.6 or greater than 0.8 and not greater than 1.0	<ol style="list-style-type: none"> <li>(1) Leave system on pending resolution of the problem; local authority to determine malfunction and repair and retest, notify details of incident, and corrective action taken, to Health Service Executive (Principal Environmental Health Officer and / or Principal Dental Surgeon) as soon as possible.</li> <li>(2) Health Service Executive to retest. If retest result &gt; 1 mg/l shut off fluoridation plant unless local authority can satisfy HSE that plant is back in conformance.</li> <li>(3) Where samples taken by Health Service Executive, local authority to be notified of unsatisfactory results.</li> </ol>	<ol style="list-style-type: none"> <li>(1) All results less than 0.6 or &gt; 0.8 ≤1.0 to be notified to Health Service Executive within 3 working days.</li> <li>(2) Within two weeks of receipt of notification (if &lt; 0.6) within one week of receipt of notification (if greater than 0.8 – less than or equal to 1.0).</li> <li>(3) Within 3 working days of receipt of result.</li> </ol>
Greater than 1.0 and not greater than 1.5	<ol style="list-style-type: none"> <li>(1) Leave system on for not more than 30 days pending resolution of the problem; local authority to determine malfunction and repair and retest, notify details of incident, and corrective action taken, to health service executive (Principal Environmental Health Officer / Principal Dental Surgeon) as soon as possible.</li> <li>(2) Health Service Executive to retest. If retest result &gt; 1 mg/l shut off fluoridation plant unless local authority can satisfy HSE that plant is back in conformance.</li> <li>(3) Where samples taken by Health Service Executive, local authority engineer with responsibility for water services to be notified of unsatisfactory results.</li> </ol>	<ol style="list-style-type: none"> <li>(1) All results greater than 1.0 and ≤1.5 to be notified to Health Service Executive within 3 working days.</li> <li>(2) Within one week of receipt of notification (if 1 – ≤1.5).</li> <li>(3) Within 24 hours of receipt of result.</li> </ol>

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Action level (mg/l F)	Action to be taken	Timescale
Greater than 1.5 and not greater than 2.0	<ol style="list-style-type: none"> <li>(1) Leave system on; local authority to determine malfunction and repair and retest; if problem cannot be rectified within 24 hours, local authority to shut off fluoridation plant until problem resolved.</li> <li>(2) local authority to notify details of incident, and corrective action taken, to Health Service Executive PEHO.</li> <li>(3) Local Authority to take and record fluoride tests at reservoir outlets and in distribution system.</li> <li>(4) Health Service Executive to retest. If follow-up sample still above 1.0mg/l shut off.</li> </ol>	<ol style="list-style-type: none"> <li>(1) All unsatisfactory results to be notified to Health Service Executive (or to local authority if result of test carried out by Health Service Executive) same day identified.</li> <li>(2) As soon as practicable but not more than 24 hours after identification of malfunction.</li> <li>(3) For the duration of the malfunction.</li> <li>(4) As soon as practicable but not more than three working days after receipt of notification.</li> </ol>
Greater than 2.0 and not greater than 10.0	<ol style="list-style-type: none"> <li>(1) Unless problem can be immediately identified and rectified immediately, local authority to shut off fluoridation plant.</li> <li>(2) local authority to notify incident and corrective action taken to Health Service Executive – PEHO and PDS.</li> <li>(3) Local Authority to take and record fluoride tests at reservoir outlets and in distribution system.</li> <li>(4) Health Service Executive to retest PEHO / PDS to notify PDS / PEHO, SMO (Community Health) and LHM. If follow-up sample still above 1.0mg/l shut down system until problem identified and resolved.</li> </ol>	<ol style="list-style-type: none"> <li>(1) Immediately on receipt of sample test result.</li> <li>(2) Immediately on receipt of sample test result.</li> <li>(3) For the duration of the malfunction.</li> <li>(4) Immediately on receipt of sample test result.</li> </ol>
Greater than 10	<p>Local authority to shut off fluoridation plant and notify Health Service Executive immediately; Local authority to take necessary steps to ensure that consumers do not drink the water e.g immediate notification that water must not be consumed / other steps considered necessary. Health Service Executive to satisfy itself that appropriate action has been taken.</p> <p>Fluoridation not to resume until Health service executive satisfied that cause of overdose has been determined and rectified.</p>	<p>Immediately on receipt of sample test result.</p>

## Abbreviations

mg/l F: milligrammes fluoride per litre of water

PEHO:	Principal Environmental Health Officer	(Health Service Executive)
PDS:	Principal Dental Surgeon	(Health Service Executive)
SMO:	Senior Medical Officer	(Health Service Executive)
LHM:	Local Health Manager	(Health Service Executive)

## 6.7 Audit programme

In addition to any programme of external audits, each fluoridation plant should be internally audited by either the local authority or the HSE on an annual basis to determine whether the plant is meeting the required standards as outlined in the Health (Fluoridation of Water Supplies) Act, 1960 or any other relevant legislation as well as the standards as outlined in this code or practice. The results of such audits and any recommendations arising therefrom shall be communicated to the relevant local authority and the fluoridation monitoring committee.

## 7. Commissioning (and re-commissioning) of fluoride dosing plants

Local authorities should agree acceptability criteria for the acceptance of new or refurbished fluoride dosing plants with the Health Services Executive (HSE). This will typically entail a test using undosed water (for new plants) followed by a surveillance period of at least 30 days during which daily water samples are submitted to an appropriate laboratory for verification. Where a significant component of the dosing system has been replaced or dosing has ceased for more than 30 consecutive days, the water undertaker should prepare an appropriate re-commissioning plan.

## 8. Decommissioning of fluoride dosing plants and equipment

The decommissioning and removal of fluoride dosing plants and equipment should take into consideration all relevant legal requirements, including those relating to Health and Safety, construction / demolition and waste disposal. Any decommissioning activity should include the preparation of a site specific assessment of the activities to be undertaken. This should be documented and agreed by both the local authority and the HSE.

## 8.1 Removal &amp; disposal of fluoridation chemicals

Prior to any removal of the fluoridation chemical off-site (except via existing bulk transfer arrangements that may be employed as part of normal fluoridation operations), water undertakers must ensure that the fluoridation chemical storage and dosing equipment is physically isolated from the treatment process / water supply.

Prior to decommissioning, the volume of fluoridation chemical present at the installation should be reduced to a minimum. The arrangements for the reduction in stored volumes of chemicals should form part of the documented site specific assessment, and but should consider the following options

## 8.1.1 Volume reduction via existing dosing arrangements

An assessment should be made of the viability of minimising the amount of bulk storage chemical to be disposed of off-site by continuing existing dosing in a controlled manner. Particular attention should be paid to the age, safety and reliability of equipment to be used and appropriate additional safeguards employed.

## 8.1.2 Transfer of chemicals to alternative sites

Where the reduction in stored chemicals via controlled dosing is not possible, a reduction in the stored volume may be possible via transfer to an alternative fluoride dosing installation. This is only likely to be possible where undertakers routinely utilise specialist equipment to transport fluoridation chemicals between sites. Careful consideration should be given to the health and safety implications of any non-routine chemical handling operations.

## 8.1.3 Disposal via an appropriate waste contractor

Where it is not possible to minimise the volume of fluoridation chemical by the above means, or where a residual amount remains after partial storage reduction, the fluoridation chemical should be disposed of via an appropriate licensed waste contractor. The potential long term effects of environmental exposure to the fluoridation chemical should be evaluated as part of the waste disposal options considered. Careful consideration of the waste classification will be required to ensure appropriate disposal control measures are employed.

This may involve the classification of fluoridation chemicals and/or materials that have been in contact with the fluoridation chemicals being considered as hazardous waste.

The waste should only be transported from the treatment plant by an authorized waste collector. In this regard the transporter of the waste must hold a Waste Collectors Permit in accordance with the Waste Management (Collection Permit) Regulations, 2001 (SI No. 402 of 2001). The permit must be valid for the period the waste is to be transported, must allow the permit holder to transport the waste type in question and must be valid for the area the waste is to be transported to/from. If in doubt the Waste Section of the relevant local authority should be contacted to verify the status of any potential waste collector. Once collected the waste must be transported to an EPA Licensed facility for disposal/recovery. The EPA licensed facility must be permitted to accept the waste type in question. Details of the license can be verified by examining the conditions of the license on the EPA website ([www.epa.ie](http://www.epa.ie)).

## 8.2 Removal of plant and equipment (tanks, pipework, pumps, monitoring equipment, etc)

All redundant material and equipment which has been subject to long term exposure to the fluoridation chemical should be removed and disposed of in an appropriate manner.

Equipment to be disposed of is likely to include (but is not limited to) the following:

- Chemical delivery pipework and equipment;
- Storage and holding tanks and associated equipment (including saturators for powder installations);
- Chemical transfer equipment and pipework;
- Pumps;
- Dosing lines and dosing point installations;

- Electrical equipment exposed to fluoridation chemicals or residues (including cable trays, ducts);
- Monitoring and telemetry installations associated with the fluoride dosing plant.

The equipment to be removed and disposed of should be agreed on a site-by-site basis between the local authority and the HSE.

Consideration should also be given to the future use of any buildings and land areas specifically associated with the fluoridation installation.

As with disposal of the chemical itself, the disposal of plant and equipment should be subject to an assessment of the potential long term effects of environmental exposure and careful consideration of the waste classification will be required to ensure appropriate disposal control measures are employed.

This may involve the classification of materials that have been in contact with the fluoridation chemicals being considered as hazardous waste.

### 8.3 Interaction with existing treatment processes / operations on site

Any decommissioning of fluoridation plant and equipment should include a documented assessment of the likely impact on continuing operational activities at the site concerned. This assessment should also include detail of the actions to be taken to safeguard the quality of treated water leaving the site during and after the decommissioning process.

This assessment should consider (but not be limited to):

- The impact of the cessation (temporary or permanent) on water quality, e.g. a reduction in the amount of pH depression as a result of stopping acid dosing;
- The impact of the cessation (temporary or permanent) on treatment processes employed at or near to the site, e.g. variation of other treatment processes, such as coagulation, pH correction;
- The impact on control loops, in particular where flow measurements are also used in the control of other dosing or control systems;
- The impact of changing carrier water flows and/or characteristics;
- The impact of changes to telemetry, alarms and electrical systems resulting from the isolation and/or removal of the fluoridation equipment.

## 9. Training of Personnel

Local authority employees involved in the operation and maintenance of fluoride dosing installations shall receive specific training in fluoridation issues. All fluoridation plant personnel (both temporary and full-time) shall, before commencing duties relating to water fluoridation, receive this appropriate training. It is recommended that personnel receive refresher training at defined intervals (e.g. every 5 years).

### 9.1 Training Programme Content

The training programme should as a minimum include instruction and the demonstration of competence in the following areas:

#### 9.1.1 Fluoridation - an overview

This would include the public health rationale for fluoridation e.g. the importance of dosing at optimal levels.

#### 9.1.2 Fluoridation Dosing process and practical aspects

A detailed examination of all parts of the process and the trainees role in this, in particular, chemicals used, procedures for delivery of acid to plant, transfer to day tank, operation and maintenance of dosing equipment; legal limits on fluoride content in fluoridated water test procedures (colorimetric / volumetric / automated monitoring) and their limitations.

#### 9.1.3 Corrective action procedures

It is imperative that those most likely to be the first to become aware of a dosing problem be fully conversant with the actions required to be taken and that lines of communication and contact details are brought to their attention during this training. This should also cover dealing with spillages.

#### 9.1.4 Safety Measures

It is essential that trainees are made fully aware of the hazards to their personal health and safety from hydrofluosilicic acid. A copy of the materials safety data sheet for hydrofluosilicic acid and chemical test reagents should be given to each trainee. Training should be given in safe work practices covering all aspects of the process, use of personal protective equipment, emergency procedures in the event of accidental contact with or ingestion of acid.

#### 9.1.5 Environmental Protection

Safe containment and disposal of spillages should be covered during training.

### 9.2 Training records

Local authorities should maintain records of all training and competence assessment of those employees operating fluoride dosing installations.

### 9.3 Plant personnel health and safety

The employer and the employee must comply with the Safety, Health and Welfare at Work Act 2005 and all other applicable legislation.

All employees including plant operators, plant engineers, Directors of Water Services and relief and holiday workers must receive health and safety training. Induction training must be completed before any new member of staff operates, adjusts or maintains the fluoridation system or receives deliveries of hydrofluosilicic acid. Refresher training for all staff must be carried out regularly or whenever a new hazard is introduced into the operation of the treatment plant. All training must be documented and signed off by the trainer and trainee.

## 10 Health and Safety Issues

**Disclaimer:** although compliance with the provisions of this section will reduce the risk of injury or ill-health for those working with hydrofluosilicic acid, this Code of Practice does not purport to be a guide to compliance with the Safety Health and Welfare at Work legislation in force in Ireland and should not be interpreted as such. The Health and Safety Authority has responsibility for the enforcement of such legislation and should be contacted with any queries.

### 10.1 Risk Assessment

A risk assessment is simply a careful examination of what, in your workplace, could cause harm to people, so that you can determine what precautions or controls are necessary to prevent harm. The aim is to prevent accidents or work-related ill-health in the workplace.

The five steps for carrying out a risk assessment are:

- Step 1 Look out for the hazards
- Step 2 Decide who might be harmed and how
- Step 3 Evaluate the risks and decide whether the existing precautions are adequate or whether more should be done
- Step 4 Record your findings
- Step 5 Review your assessment and revise it if necessary

'Hazard' means anything that can cause harm e.g. chemical

'Risk' is the chance, high or low, that somebody will be harmed by the hazard.

All employers and self-employed people have duties under health and safety law to assess risks in the workplace. The Safety, Health and Welfare at Work (Chemical Agents) Regulations, (S.I 619 of 2001) specifically obliges employers and self-employed persons to assess the risks arising from the use of, or presence of chemical agents in the workplace.

To comply with the Safety, Health & Welfare at Work (Chemical Agents) Regulations 1994 (S.I. no. 445 of 1994) (hereinafter referred to as 'the Chemical Agents Regulations'), a risk assessment of on-site reception, storage and use of hydrofluosilicic acid must be carried out at each location, including monitoring to ensure that the maximum airborne fluoride concentration does not exceed the Threshold Limit Value of 2.5 mg/m<sup>3</sup>. Testing during tank filling operations would probably be indicative of the maximum concentration likely to be encountered.

The risk assessment should also include an examination of testing procedures and reagents. The assessment should be documented and a copy retained on-site.

### 10.2 Training and information

All relevant plant personnel must, under the Chemical Agents Regulations, receive information and training in relation to all hazards associated with the storage and use of hydrofluosilicic acid and appropriate safe work

procedures. Materials safety data sheets for hydrofluosilicic acid and documented safe work procedures must be available at all plants. It is recommended that the documentation be prominently displayed in an easily readable format on durable material in the bulk storage area and day tank dosing rooms.

### 10.3 General Health and Safety Advice relating to Hydrofluosilicic Acid

This section provides general guidelines on occupational health and safety precautions to be taken in the use of hydrofluosilicic acid. It does not purport to be exhaustive or to discharge local authorities from the need to fulfil the requirements of clauses 10.1 and 10.2 above.

#### 10.3.1 General Principles

Treat hydrofluosilicic acid with respect. It is a highly corrosive liquid and will cause severe injury if splashed on the skin or in the eyes, or if taken internally.

When handling hydrofluosilicic acid:

1. Always wear acid-resisting clothing, goggles, PVC gloves and acid resistant footwear.
2. Always have a copious supply of water available.
3. Always keep an eyewash bottle ready.
4. Have foot/arm operated face wash and/or shower unit

#### 10.3.2 Personal Protective Equipment (PPE)

It is the duty of every employer to provide the use of personal protective equipment where required by his employees. The PPE must be suitable for its intended use and comply with relevant European Community Directives. A suitable storage area should be made available so that the PPE can be maintained in good working order and in a satisfactory hygienic condition. PPE provided should be normally confined to one employee, where it is necessary for an item of PPE to be worn by more than one employee, the employer shall ensure that such use does not create health or hygiene problems for any user. All employees must receive information, training and instruction on use of PPE.

PPE that is required to be worn when handling hydrofluosilicic acid:

**Eye protection:** in the form of goggles or full facemask, to protect the eyes from splashes.

**Skin protection:** in the form of protective clothing, PVC or rubber gloves, boots and an acid proof suit are essential.

**Respiratory Protection (RPE):** Not normally required. Breathing apparatus must be worn if levels exceed the recommended limit (occupational exposure limit is 2.5mg/m<sup>3</sup>)

**Ventilation Requirements:** Adequate ventilation is essential in buildings where the material is handled and stored.

#### 10.3.3 Emergency wash and decontamination facilities

It is important that emergency wash and eye-wash facilities be situated immediately adjacent to bulk storage tanks and day tank room. In this regard, the provision of mobile shower units would be worthy of consideration.

A first aid kit, containing antidote gel, should be provided at each site.

Although ingestion is the least probable exposure route, it is potentially the most damaging, a tin of evaporated milk / calcium gluconate or calcium lactate solution should be maintained in the first aid kit for such eventualities (ensure that an opening device for the can is also provided).

A foot/arm operated face wash and/or shower unit must be provided at each site.

See Appendix 1 for first aid procedure.

#### 10.3.4 Reporting of incidents under Safety, Health & Welfare at Work Legislation

All accidents or incidents that result in either personal injury or illness, and or damage to equipment, no matter how minor should be properly reported and investigated. Although accident/incident investigation is a reactive process, a comprehensive accident reporting and investigation process is a proactive measure that can effectively prevent or minimize future accidents/incidents.

It is essential that all accidents/incidents are properly reported in a timely manner and that all causes (direct and contributory) are thoroughly identified and that the appropriate corrective action is taken. All of these details must be recorded on an accident/incident report form.

Further details of reporting requirements can be found in Appendix 2

#### 10.3.5 Emergency communications

To effect rapid response to plant personnel injuries or significant fluoride overdoses, telephone / mobile phone facilities should be available at all times at all plants together with a list of emergency contacts.

#### 10.3.6 Environmental Protection - in the event of a spillage

Provisions relating to detection and containment of spills or leaks of hydrofluosilicic acid are contained in the following sections above: 3.1.1; 3.2.1; 3.2.2; 3.2.3; 3.3.1; 3.3.2; 3.3.6; 3.4.1; 3.5.1.

It is important that any plant drainage system, installed to contain or remove spillages contaminated with hydrofluosilicic acid, does not discharge to a watercourse.

A quantity of neutralising chemical, e.g. lime, should be maintained at each plant, or be readily available, in order to deal with any acid spillages that may occur. A quantity of dry earth or sand should also be available for absorption of spillages.

See Appendix 3 for details on dealing with hydrofluosilicic acid spillages.

Please refer to local major accidents plan where these apply to a hydrofluosilicic acid spillage.

#### 10.3.7 Storage of Reagents

Storage of reagents (used and unused) by the plant operator and/or Environmental Health Officer (the use of SPADNS test by some EHOs leaves ampoules to be disposed of) should comply with Health and Safety and protect against leakages or spillages until collection of used goods by licensed hazardous waste contractor.

## Glossary of Technical Terms

**Acid:** A substance that dissolves in water with the formation of hydrogen ions, contains hydrogen which may be replaced by metals to form salt, and/or is corrosive.

**Accuracy:** Closeness of a reading or indication of a measurement device to the actual value of the quantity being measured.

**ADR:** European Agreement concerning the International Carriage of Dangerous Goods by Road.

**Anti-siphonage valve:** a device that prevents back flow.

**Audit:** a systematic and independent examination to determine whether activities and related results comply with planned arrangements and whether these arrangements are implemented effectively and are suitable to achieve objectives.

**Bund:** A retention facility (including walls and base) built around an area where potentially polluting substances are handled, processed or stored, for the purposes of containing any unintended escape of material from that area until such time as remedial action can be taken.

**Calibration:** process of comparing an instrument's accuracy to known standards.

**Certificate of Analysis:** a document certifying results of analysis that was carried out.

**Cessation:** A stopping.

**Coagulation:** In water treatment, the use of chemicals to make suspended solids gather or group together into small flocs. The clumping together of solids so they can more easily be settled out or filtered out of water.

**Colorimetric testing:** a common method for testing how much of a substance is in the water is to run a colorimetric test. A colorimetric test is a test which forms a colour. The amount of the colour is then measured. In most tests the more colour formed, the more of the test substance there is in the water.

**Combustible:** a substance that is capable of igniting and burning.

**Conduit:** A conduit is a hollow tube, duct or pipe used for containing and protecting wires or pipes.

**Corrosive:** A liquid or solid that causes visible destruction or irreversible alterations in human skin tissue at the site of contact or is highly corrosive to steel.

**Demulcent:** substance that protects mucus membranes and prevents or lowers irritation.

**Dose Rate:** The dose delivered per litre of water.

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**Fluoridation:** A water treatment involving the addition of fluoride to drinking water to help prevent dental caries.

**Fluoride:** A mineral that is effective in preventing and reversing the early signs of dental caries. Fluoride occurs naturally and contains the element fluorine.

**Forum on Fluoridation:** The Forum on Fluoridation was a panel of some 18 persons with a very wide range of appropriate knowledge, experience and responsibilities. This panel was given the task of examining all aspects of fluoridation and its role in Ireland, and making recommendations as to whether its use should be continued and, if so, in what form. Its report was issued in 2002 and can be accessed on the DoHC website ([http://www.dohc.ie/publications/pdf/fluoridation\\_forum.pdf](http://www.dohc.ie/publications/pdf/fluoridation_forum.pdf))

**HACCP:** Hazard Analysis Critical Control Points. A system for risk management of a process, in widescale use in the food industry.

**Hazardous Waste:** Waste which, because of its quantity, concentration or characteristics, poses a present or potential hazard to human health or the environment when improperly treated, stored, transported, dispersed or otherwise managed.

**HSE:** Health Service Executive

**Hydrofluosilicic acid  $H_2SiF_6$**  (also known as hydrofluorosilicic acid; fluorosilicic acid; fluosilicic acid; hexafluorosilicic acid, HFSA): a chemical substance containing fluoride, used for fluoridation of drinking water.

**Indelible:** cannot be removed, washed away or erased.

**Inert:** Having little or no tendency to react chemically.

**Interlock:** An interlock is a safety device used to help prevent a machine from harming its operator or damaging itself by stopping the machine when tripped.

**Material Safety Data Sheet:** Printed material concerning a hazardous chemical, or Extremely Hazardous Substance, including its physical properties, hazards to personnel, fire and explosion potential, safe handling recommendations, health effects, fire fighting techniques, reactivity, and proper disposal. It is prepared by chemical manufacturers, importers and employers for hazardous chemicals.

**Methodology:** A documented approach for performing activities in a coherent, consistent, accountable, and repeatable manner.

**mg/l:** milligrammes per litre. It is the concentration of a substance expressed as its weight in a specified volume of liquid e.g. milligrammes of fluoride per litre of water. It is equivalent to parts per million.

**mg/m<sup>3</sup>:** milligrammes per cubic metre. It is the concentration of a substance expressed as its weight in a specified volume of a gas e.g. milligrammes of fluoride per cubic metre of air.

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**Natural Background Fluoride Levels:** The concentration of fluoride (mg/L) that is present in the water source from naturally occurring fluoride sources.

**Occupational Exposure Limit:** Measurement of personal exposure and effectiveness of control measures, using the appropriate measurement technique and standards.

**pH:** The pH of water is a scientific measurement that describes how acidic or alkaline (basic) a substance, e.g. water with a pH of 7 is neutral. It is expressed on a scale from 0 to 14. pH of less than 7 is acid and greater than 7 is alkaline.

**Precipitation:** Precipitation is the condensation of a solid from a solution during a chemical reaction. This occurs when the solution is supersaturated, whereupon the solid forms from the solute phase, and usually sinks to the bottom of the solution.

**Precision:** Is the closeness of agreement between the results obtained applying the method several times under prescribed conditions. The precision depends only on the distribution of random errors.

**Public Piped Water Supplies:** A system that provides piped water to the public for human consumption.

**Pungent:** A sharp or stinging sensation of an odour.

**SCADA:** Supervisory Control And Data Acquisition.

**Soda Ash:** The common name for sodium carbonate. It is a white powder that is used to increase the pH of acidic (below pH 7.0) water.

**Sodium Bicarbonate:** also known as baking soda and bicarbonate of soda. It is a white powder used to balance pH level and alkalinity.

**Source Water:** Untreated water (ie, raw water) used to produce drinking water.

**SPADNS:** Colorimetric test reagent.

**Standard Operating Procedure:** Standard operating procedures are written documents that describe in detail, step-by-step, how a procedure should be done.

**Telemetry Installation:** An electronic device which transmits specific data (measurements) to a remote site.

**Threshold Limit Value:** An exposure level under which most people can work consistently for 8 hours a day, day after day, with no harmful effects.

**Toxic:** Toxic means able to cause harmful health effects. Toxicity is the ability of a substance to cause harmful health effects. Descriptions of toxicity (eg low, moderate, severe, etc.) depend on the amount needed to cause

an effect or the severity of the effect.

**Turbulence:** Irregular motion or swirling agitation of water, air, gas, etc.

**Volumetric:** Of or relating to measurement by volume; "volumetric testing".

**Watercourse:** A definite channel with bed and banks within which concentrated water flows continuously, frequently or infrequently.

**Water treatment plant:** A plant where water is treated to make it fit for potable use.

## Appendix 1

### First Aid in the Event of Contact with Hydrofluosilicic Acid

Report to the certified first-aider and Health and Safety Officer

Refer to the Material Safety Data Sheet (MSDS) and seek medical attention.

The first-aid box should at all times contain adequate supplies of the following in specifically dealing with HFSA related incidents/accidents:

Calcium gluconate solution	Administer upon ingestion (or milk)
Sterile eyewash	Administer upon eye contact
Calcium gluconate gel	Administer to skin
Effervescent calcium pills (400mg calcium per pill)	Administer dissolved in water upon inhalation.

#### In contact with eyes:

Immediately irrigate with water for at least 10 minutes and continue to do so until medical aid is obtained.

#### Ingested:

Provided patient is conscious wash out mouth with water and give 5% Sodium Bicarbonate solution followed by a demulcent such as milk. Do NOT induce vomiting. Seek medical advice.

#### In contact with skin:

Remove contaminated clothing and wash affected area with copious amounts of water. Apply a dressing soaked in 20% Calcium Gluconate solution. Seek medical advice.

Refer to the MSDS Section 7 First Aid Measures for the use of the above.

**Always seek medical attention.**

## Appendix 2

### Reporting of Incidents, Involving Significant Injuries, Under Safety, Health & Welfare at Work Legislation

The following types of accidents must be reported to the Health and Safety Authority:

the death of any employed or self-employed person, which was caused by an accident during the course of their work.

an injury sustained in the course of their employment, which prevents any employed or self-employed person from performing the normal duties of their work for more than three calendar days, not including the date of the accident. Calendar days include Saturdays and Sundays. (For example, if an employee, who is injured on Wednesday, and does not normally work on Saturdays, Sundays and bank holidays, returns to work the following Monday, the accident is reportable.)

a death, or an injury that requires treatment by a registered medical practitioner, which does not occur while a person is at work, but is related to either a work activity or their place of work. Deaths or injuries caused by normal medical treatment (e.g. surgery or medication) do not need to be reported.

a road traffic accident that meets the criteria (a) and (b) above, excluding an accident that occurs while a person is commuting either to or from work.

a road traffic accident that meets the criteria (c) above as a result of construction work on or adjacent to a public road.

Reporting can be done either online at [www.hsa.ie](http://www.hsa.ie) or by filling out an IR1 Form.

Work place accidents must be reported promptly:

- Fatal or potentially fatal accidents must be reported immediately, by telephone in the first instance.
- Non-fatal accidents should be reported as soon as practicable, in most cases within two weeks of the occurrence of the accident.
- Major accidents notifiable under the major accident hazards regulations must be reported immediately, by telephone in the first instance.

## Appendix 3

### Procedure for Dealing with Spillages of Hydrofluosilicic Acid

In the event of a spill or leak eliminate all ignition sources (no smoking, flares, sparks or flames in immediate area) - although hydrofluosilicic acid is not combustible, it may decompose on heating to produce corrosive and/or toxic fumes. Runoff from fire control or dilution water may be corrosive and/ or toxic and cause pollution.

Do not touch damaged containers or spilled material unless wearing appropriate protective clothing and having received suitable training.

Stop the leak only if this can be done without risk. Prevent entry into waterways, sewers, basements or confined areas. In this regard it is essential that hydrofluosilicic acid spillage or leak containment facilities should not be constructed to drain to a watercourse. Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers. DO NOT GET WATER INSIDE CONTAINERS.

In the event of spillage from a delivery tanker, or leaking storage tank, please adhere to the following procedure.

PERSONAL PROTECTIVE CLOTHING MUST BE WORN, i.e. Full wet suit, PVC gloves, visor, helmet, wellington boots and gloves.

- In the event of a tanker spill, the driver should contact the suppliers of the chemical immediately (if this is not possible then the driver should ask a person present to contact them), treatment plant personnel should inform the Health, Safety and Environmental Coordinator. All spills should be recorded on an accident/dangerous occurrence form.
- Place "DANGER" signs/cones in the vicinity of the spill.
- The area should be cleared of all personnel not involved in clean-up operations.
- Personnel engaged in the clean-up operation, should always position themselves upwind and be fully protected.
- Treat as weak acid
- Swill away with copious amounts of water from a hose pipe - always directing the water jet to the outside of the spillage taking extreme care not to let it go down any drains or watercourses. NEVER DIRECT THE WATER HOSE TO THE CENTRE OF THE SPILLAGE.

#### Small Spillage:

#### Wash away with large quantities of water.

Wearing full protective clothing and working from the windward side wash down immediately with copious supply of water, directing the water jet to the outside of the spillage and carefully working towards the centre.

**Large Spillage:** If fumes are evolved wear respiratory protection. Bund large spillages with sand, earth etc. and pump away, neutralise with soda ash then dilute with water (spray) and flush away with large amounts of water after neutralisation. Inform the local water authority if product has entered public drains or waterways.

**Personal Precautions:** Wear full protective clothing.

**Neutralising Chemicals:** Hydrated lime or soda ash.

#### UTILISE SPILL KIT:

- Try to stop the flow of liquid product. Use earth or sand as boom if possible to try to contain liquid, gradually shovel this onto the spillage working from outside in.
- Neutralise contaminated boom for disposal with soda ash. Gradually shovel this onto the spillage working from outside in.
- In the event of a major spill contact the local authority, the EPA, the Local Fisheries Board and the Health and Safety Authority (if required).

#### PERSONAL CONTAMINATION:

- Treat as weak acid.
- Wash out eyes and rinse skin with copious amounts of water
- Seek medical attention

Consult the "ADR Written Instructions" for further instructions  
Do not leave the area unattended, if possible.

#### HAZARDOUS WASTE:

Any hazardous waste resulting from spillages (including sand and boom) or otherwise should be retained in appropriate waste storage containers that are clearly labelled as hazardous waste and have the correct chemical label on them. The waste should only be disposed of by a licensed hazardous waste contractor (refer to section 8.1.3) Details of the waste should be logged into the Hazardous Waste Logbook:

Drum No  
Type of waste (name of chemical)  
Quantity per ton  
EWC Code  
Company responsible for transport and disposal of the waste  
Destination of waste  
C1 Form received from waste contractor

## Appendix 4

### Sample Daily Checklist for Fluoridation Plant

- (1) **PLANT PERIMETER AND BUILDINGS:** check integrity of fences, gates, door locks and bolts. Look for evidence of unauthorised entry to site or interference with facilities or equipment.
- (2) **BULK TANK AND BUND AREA:** check tank surfaces and bund for evidence of leaks. View tank contents level indicator - check for evidence of abnormal change in contents level. Assess need to re-order supply of acid.
- (3) **PIPEWORK:** examine all visible pipework, joints and valves for evidence of damage, leaks, or failure.
- (4) **DAY TANK AND BUND AREA:** assess level of tank contents for any abnormal change in level. Check for evidence of leaks. Carry out weighing of contents to calculate quantity of acid used since previous weighing. Ensure contents level, following refill, does not exceed maximum recommended capacity.
- (5) **DOSING PUMPS AND BUND AREA:** check for evidence of leaks or pump malfunction; check that pump is operating in 'external' mode. Ensure that back-up pump is not plugged in or operating simultaneously.
- (6) **MONITORING OF FLUORIDE CONCENTRATION:** where automated on-line monitoring is not in operation, carry out a colorimetric test in accordance with correct procedures and record result. Compare with theoretical concentration obtained from calculation of quantity of acid used (see 4 above).

N.B. please note that the above checklist does not purport to be a comprehensive assessment of the requirements of this code of practice but suggests those items that need to be assessed at least daily.

## Appendix 5

### Draft Protocol for the Independent Testing of HFSA

#### 1. Introduction

This Protocol refers to the independent testing of Hydrofluosilicic Acid (HFSA) which is used for the fluoridation of water intended for human consumption (Chemicals used for treatment of water intended for human consumption, Hydrofluosilicic acid, ISEN 12175:2001)

The specification for HFSA is as follows:

- 10.9% by weight of HFSA, subject to a tolerance of  $\pm 0.3\%$
- See limits for Heavy Metals in Table 1
- Shall contain no other soluble mineral or other organic substance in quantities capable of a deleterious or injurious effect upon health.

Each batch of HFSA 10.9% that is produced by the supplier has a representative sample analysed (not every batch is tested for Heavy Metals by the supplier, however it is carried out by the original manufacturer and the results are included on their Certificate of Analysis) and a Certificate of Analysis is produced stating the actual test results. This Certificate of Analysis must accompany each delivery of HFSA to the different water treatment plants (one tanker of HFSA may not necessarily deliver to a single plant). A sample is also taken from each tanker before it leaves the suppliers site and this is retained in the event of any queries on the quality of the material.

Methods for testing HFSA should be capable of serving their intended purpose: to quantify HFSA with adequate precision and accuracy.

It is essential that any laboratory carrying out Independent testing of HFSA according to this guidance must have appropriate quality systems in place.

Non-conforming results can sometimes be due to testing errors

The sources of error that affect testing methods are:

- sampling error - the error due to the taking of subsamples
- systematic error - the error inherent in the method used
- random laboratory error - the error that is particular to a laboratory or analyst

In an attempt to reduce the effects of the last two errors to a minimum it is essential that laboratories use external reference in the form of appropriate use of reference materials and take part in recognised external quality assessment schemes.

In addition, a quality assurance programme must be in place and documented in the quality manual used.

#### 2. Purpose

The purpose of this protocol is to clearly identify the guidelines required for the independent testing of hydrofluosilicic acid (HFSA), to meet the requirements of the National Fluoridation Programme.

#### 3. Scope

This document describes the procedure for the Independent Testing of HFSA. A protocol gives detailed instructions, including the collection of samples, and recommends the frequency of sampling. The protocol applies to all personnel involved in the independent testing and subsequent reporting of results of HFSA.

#### 4. Responsibility

It is the responsibility of the Health Service Executive to ensure that the independent testing of HFSA is carried out.

It is the responsibility of the Health Service Executive to ensure that timely reporting of the results from the independent testing of the HFSA is carried out.

It is the responsibility of the supplier to facilitate the awarding authority in the independent testing of samples for analysis of the HFSA and all its concentrations, independently of the supplier.

#### 5. Procedure

- 5.0 Approximately 300 tankers are delivered to the various water treatment plants around the country. Thirty grab samples per annum should be taken at random for independent testing. This sampling frequency may be reduced for a given year if all sample results for the supplier for the previous year are satisfactory. In such circumstances the minimum frequency of sampling should be not less than 12 grab samples per annum.

*At random locations (a) from the supplier's tanker before it leaves for delivery to treatment plants (b) from an appropriate location at the water treatment plant.*

- 5.1 A schedule should be drawn up on an annual basis highlighting when and where the random sampling for independent testing is carried out to ensure that sampling is representative and at the correct frequency.
- 5.2 The container to be used for sampling must be of suitable acid resistant material (not glass), clean, free of contamination and should have a tamper evident cap on it. The sample container should be labelled and have the following information clearly visible on it:

Name of sample: i.e. HFSA 10.9%  
 Sample number\*:  
 Date  
 Sample taken by:  
 Name of treatment plant:

\* This sample number should be a unique identifier so that duplication is not possible.

- 5.3 Personnel sampling the HFSA must ensure that they are compliant with The Safety, Health and Welfare Act 2005 by using the correct personnel protective equipment (PPE) including safety goggles, rubber gloves, protective clothing. (Refer to Code of Practice on fluoridation of public water supplies). The sample must be collected in a safe manner. If it is not possible to obtain the sample safely, personnel should not proceed with the task and must report to the person responsible for Health and Safety.
- 5.4 A sample of 200ml should be taken for sampling and testing. Before sampling approximately 200ml should be run off into a clean and contamination free container to ensure a representative sample is obtained. The run-off can then be put back into the storage tank, thereby reducing the amount of waste generated.
- 5.5 The labelled sample is to be then sent to the contract laboratory concerned for testing. Transport of the sample must comply with the Carriage of Dangerous Goods by Road Regulations 2004. These regulations apply to the carriage, in tanks, in bulk and in packages, of dangerous goods by road; including the packing, loading, filling and unloading of the dangerous goods in relation to their carriage.
- The Regulations impose duties on the various participants associated with the carriage of the dangerous goods. They contain requirements for the vehicles, tanks, tank containers, receptacles and packages containing the dangerous goods during their carriage. They require that the drivers and others, involved in the carriage of the dangerous goods by road (including their packing/loading /filling/transport/unloading) be adequately trained and, in the case of drivers, hold certificates of such.
- 5.6 All of the sample details (as outlined in 5.2) must be logged into the relevant Laboratory Testing Logbook, to be maintained by the Independent sampling body.
- 5.7 The method of testing that should be adopted is based on the performance characteristics that are required to be met for the measurement of fluoride. (See Note 1)  
 The sample must be tested for fluoride content as well as heavy metals.

European Standard IS.EN 12175:2001

**Table 1**  
**Parameters for Heavy Metals\***

Parameter	Limit mg/kg HFSA (at 100% active ingredient)
Antimony (Sb) max.	80
Arsenic (As) max.	400
Cadmium (Cd) max.	40
Chromium (Cr) max.	400
Lead (Pb) max.	400
Mercury (Hg) max.	10
Nickel (Ni) max.	400
Selenium (Se) max.	80

**Note:** Other chemical parameters and indicator parameters – as listed in EU Directive 98/83/EEC (see [1]- are not relevant in hydrofluosilicic acid because the raw materials used in the manufacturing process are free of them.

\* specification was previously referenced as  $\leq 0.06\%$  by weight “heavy metals” expressed as lead (Pb) in the tender document for HFSA and is no longer applicable.

- 5.8 If a non-compliant result is obtained by the laboratory, the sample is to be retested. If a second non-compliant result is obtained, then re-sampling from the treatment plant involved is to be carried out.

## 6.0 Action to be taken in the event of a non-compliance

- 6.1 If the result is discovered at the supplier’s premises it may not be necessary to shut off any fluoridation plant as the fluoride may not have been delivered to any plants.
- 6.2 If the fluoride has been delivered to treatment plants it will be necessary to trace back the delivery to the original batch. Even though one tanker may be non-compliant it may have been caused by the supplier having the wrong strength batch at the suppliers premises and thus several deliveries could have gone out in several tankers to several plants.

In the case of a non-compliant result being determined, if the test finds the HFSA at greater than 12.4%\*, and if it is the case that the non-compliance is related to the batch, then all of the plants to which the non-compliant batch was delivered would need to be informed and fluoridation should be suspended.

There is no justification for suspending fluoridation where the HFSA is under-strength as it will still give a dental health benefit (albeit slightly reduced) while complying fully with drinking water regulations fluoride limit values.

Once the actual strength of the non-compliant fluoride is determined some plants may be able to adjust their dosing regime to allow for this and can continue fluoridation. Where this cannot be reliably done, fluoridation should be suspended pending removal of the non-compliant batch from the treatment plant.

**The Health Service Executive and the Local Authority concerned are to be informed immediately and at all times of any non-conformances.**

\* At a dosing rate giving a final fluoride concentration in the treated water of 0.7mg/l (i.e. at the midpoint of the statutory range) and using hydrofluosilicic acid of correct concentration (i.e. 10.9%), the same dosing rate, would only result in a final fluoride concentration greater than 0.8 mg/l (i.e. exceeding the statutory range) if the hydrofluosilicic acid concentration exceeded 12.4% (12.456 % to be exact). This has been calculated as follows: divide 0.8 by 0.7 and multiply the answer by 10.9.

## References

- 6.0 User-Guide for supply and delivery of chemicals used for treatment of water intended for human consumption, Hydrofluosilicic acid - Health Service Executive, Shared Services-Eastern Region.
- 6.1 The Safety, Health and Welfare Act 2005
- 6.2 Protocol on comparison of methods for drinking water bacteriology – cultural techniques – January 2000. Drinking Water Inspectorate (DWI)
- 6.3 Chemicals used for treatment of water intended for human consumption, Hydrofluosilicic acid, ISEN 12175:2001
- 6.4 Correspondence on Analytical Methods for fluoride in water – Dr Michael O’Sullivan, Public Analyst Laboratory Dublin.
- 6.5 Carriage of Dangerous Goods by Road Regulations 2004
- 6.6 McLoughlin J., Clarkson J., Connolly F., Hargaden J. An Evaluation of the Delivery and Monitoring of Water Fluoridation in Ireland. A report conducted by the Department of Public and Child Dental Health, Dublin Dental School & Hospital. 2005. Dublin:Department of Health and Children.

## Note 1

### Re: Analytical Methods for fluoride in water

There are a number of methods for measuring fluoride in drinking water. These include ion-selective electrode, ion chromatography, and colorimetric methods.

It is not possible or appropriate to recommend a ‘standard method’ for the measurement of fluoride in drinking water. The approach that should be adopted is based on the performance characteristics that are required to be met for the measurement of fluoride. Appropriate performance characteristics are those specified in European Communities (Drinking Water) Regulations 2007 (S.I. No. 106 of 2007) which came into force on the 8th March 2007. The Performance Characteristics stipulated for fluoride are:

Trueness (Accuracy) % of parametric value	Precision % of parametric value	Limit of detection (LOD) % of parametric value
10	10	10

This means that the current fluoride EU Parametric Value of 0.8 mg/l (800 µg) would require Trueness, Precision and LOD of 0.08 mg/l (80 µg). Both the ion-selective electrode and ion chromatography techniques can achieve this. These methods can achieve commensurate Performance Characteristics for the current fluoride levels under the Fluoridation Act and any future revised fluoride level, down to about 0.5 mg/l.

## References

*This list is for reference purposes only, it is not a comprehensive appendix.*

The development of this code of practice has been informed by a number of sources which include the following:

Centers for Disease Control and Prevention. , (1995), Morbidity and Mortality Weekly Report Recommendations and Reports Engineering and Administrative recommendations for Water Fluoridation, September 29, 1995, Volume 44, No. RR-13 U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention (CDC), Atlanta, Georgia 30333, U.S.A.

Drinking Water Inspectorate (2005), Code of Practice on technical aspects of fluoridation of water supplies, 2005 Ashdown House, 123 Victoria Street, London SW1E 6DE.

Queensland Government, Queensland Health (2000), Code of Practice for the Fluoridation of Public Water Supplies. Oral Health Unit, Public Health Services, Queensland Health, GPO Box 48, Brisbane, Queensland 4001, Australia. ISBN 1 876532 31 9

Parle, Redmond, (2001) Risk Management of Drinking Water Fluoridation Systems in the South-East of Ireland, M.Sc. Thesis, School of Food Science and Environmental Health, Faculty of Tourism and Food, Dublin Institute of Technology

McLoughlin J., Clarkson J., Connolly F., Hargaden J. An Evaluation of the Delivery and Monitoring of Water Fluoridation in Ireland. A report conducted by the Department of Public and Child Dental Health, Dublin Dental School & Hospital. 2005. Dublin:Department of Health and Children.

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Notes

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