

Irish Water

DESIGN SPECIFICATION: FLUORIDATION

Document No: IW-TEC-900-06-1



RECORD OF CHANGES

This specification shall be reviewed on an annual basis by the document owner. Updates, if necessary, shall be completed following this review and shall take into consideration all stakeholder comments and recommendations received in the intervening period.

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TABLE OF CONTENTS

1	PURPOSE.....	10
1.1	DWSP APPROACH TO THE FLUORIDATION OF DRINKING WATER	10
1.2	BACKGROUND TO FLUORIDATION OF DRINKING WATER	11
1.3	APPLICATION OF THIS SPECIFICATION	11
1.4	ASSOCIATED SPECIFICATIONS	12
2	FLUORIDATION OF DRINKING WATER	13
2.1	HYDROFLUOSILICIC ACID	13
2.2	CHEMICAL STABILITY AND REACTIVITY	13
3	HAZARD MITIGATION AND RISK MANAGEMENT	14
3.1	GENERAL PRINCIPLES OF PREVENTION	14
3.2	GENERAL RISK ASSESSMENT	15
3.3	SCOPE OF GENERAL RISK ASSESSMENT	15
3.3.1	<i>Replacement of Individual System Components</i>	<i>16</i>
3.3.2	<i>Upgrades or New Developments</i>	<i>16</i>
3.4	MANAGEMENT OF RESIDUAL RISK (HACCP)	17
3.5	SIMPLICITY OF DESIGN	18
4	HEALTH AND SAFETY MEASURES	19
4.1	PERSONAL PROTECTIVE EQUIPMENT	20
4.2	EMERGENCY PROCEDURES	20
4.3	FIRST AID KIT	21
4.4	EMERGENCY WASHING FACILITIES	21
4.5	CHEMICAL DELIVERY, STORAGE AND DOSING.....	22
5	PROCESS DESIGN OF FLUORIDATION SYSTEMS	24
5.1	OVERVIEW OF DESIGN REQUIREMENTS	24
5.2	PROCESS DESIGN SCHEMATIC	29
6	CONTROL OF FLUORIDATION SYSTEMS	30
6.1	FLOURIDE DOSE MONITORING	30
6.1.1	<i>Total Fluoride Monitoring (Inline Analyser)</i>	<i>30</i>
6.1.2	<i>Added Fluoride Monitoring (Manual Monitoring)</i>	<i>30</i>
6.2	CONTROL PANEL LAYOUT	31
6.3	PLC & HMI FUNCTIONALITY	32
6.4	AUTOMATIC CHANGEOVER OF DOSING PUMPS	34
6.5	SECURITY OF SYSTEM CONTROL.....	34
6.6	REMOTE ASSET MANAGEMENT (RAM).....	35
7	INSTALLATION AND GENERAL LAYOUTS.....	36

7.1	GENERAL DESIGN FEATURES	36
7.2	INDICATIVE FLUORIDATION LAYOUT (OUTDOOR BULK STORAGE TANK)	39
7.3	INDICATIVE FLUORIDATION LAYOUT (INDOOR BULK STORAGE TANK)	40
8	EQUIPMENT AND MATERIALS SPECIFICATION.....	42
8.1	BULK STORAGE TANKS AND FILL LINES FOR HYDROFLUOSILICIC ACID.....	42
8.2	DAY TANKS FOR HYDROFLUOSILICIC ACID	44
8.3	DOSING PUMPS	44
8.4	TRANSFER PUMPS	46
8.5	ELECTRONIC SCALES	46
8.6	HANDWASHING FACILITIES	46
8.7	EMERGENCY SHOWER AND EYEWASH	47
8.8	CONTROL PANEL, HMI AND PLC	48
8.9	INSTRUMENTATION	49
9	HYDROFLUOSILICIC ACID CHEMICAL DELIVERY	52
10	PROCESS ALARMS AND AUTOMATIC SHUTDOWN	53
11	TESTS ON COMPLETION	54
11.1	SITE ACCEPTANCE TEST	54
11.2	PRE-QUALIFICATION TESTS.....	55
11.3	DOSE OPTIMISATION AND PROCESS PROVING PERIOD	55
12	OPERATION AND MAINTENANCE.....	57
12.1	OPERATION AND MAINTENANCE MANUALS	57
13	DECOMMISSIONING OF FLUORIDE DOSING PLANTS.....	60
13.1	REMOVAL AND DISPOSAL OF FLUORIDATION CHEMICALS.....	60
13.2	VOLUME REDUCTION VIA EXISTING DOSING	60
13.3	TRANSFER OF CHEMICALS TO ALTERNATIVE SITES	60
13.4	DISPOSAL VIA WASTE CONTRACTOR	60
13.5	REMOVAL OF PLANT AND EQUIPMENT	61
13.6	INTERACTION WITH EXISTING PROCESSES	61

LIST OF TABLES

Table 1	Identified DWSP Hazards Associated with Fluoridation Processes
Table 2	Irish Water Plant Categorisation by Hydraulic Capacity
Table 3	Example of Initial Stages of HACCP Development for Fluoridation of Drinking Water
Table 4	Day Tank Storage Requirements.
Table 5	Specific Requirements for Hydrofluosilicic Acid Dosing Pumps
Table 6	Delivery and Storage Requirements for Hydrofluosilicic Acid
Table 7	Examples of Alarm and Shutdown Criteria for Hydrofluosilicic Acid Systems

LIST OF DIAGRAMS

Diagram 1:	General Design Schematic for all Irish Water Fluoridation Systems.
Diagram 2:	MCC Layout for Independently Controlled Fluoridation Systems
Diagram 3:	HMI Screen Hierarchy for Fluoridation Systems
Diagram 4:	Indicative Layout of Outdoor BST Installation (DEFAULT)
Diagram 5:	Indicative Layout of Indoor BST Installation (IW APPROVAL REQUIRED)

LIST OF APPLICABLE STANDARDS

ANSI/ASHRAE	Standard 62.1 – Ventilation for Acceptable Indoor Air Quality
ANSI-Z358.1	American National Standard for Emergency Eyewash and Shower Equipment
BS EN 166	Personal eye protection
BS EN 374	Protective gloves against chemicals and micro-organisms
BS EN 1992-3	Eurocode 2 - Design of concrete structures (liquid retaining & containing structures)
BS EN 12175	Chemicals used for treatment of water intended for human consumption (H_2SiF_6)
BS EN 12573	Welded static non-pressurised thermoplastic tanks
BS EN 13034	Protective clothing against liquid chemicals
BS EN 13121	GRP tanks and vessels for aboveground use
BS EN 13575	Static thermoplastic tanks for the aboveground storage of chemicals
BS EN 13923	Filament wound FRP pressure vessels. Materials, design manufacturing & testing
ISO 3864 – 1	Graphical Symbols – Safety Colours and Safety Signs
WIMES 3.01	Low Voltage Switchgear and Control Gear Assemblies

WIMES 8.02	Chemical Dosing Equipment (General Requirements)
IW-TEC-900-05	Irish Water Design Specification: Chemical Storage
IW-RAM-SPEC-5000-001	Irish Water Signal Provision Standard (General)
IW-RAM-SPEC-5020-009	Irish Water Signal Provision Standard (Fluoridation)
IW-XXX-SOP-XXX	Guidance Note on Prioritisation of Emergency Shower and Eyewash Station

LIST OF APPLICABLE REGULATIONS

SI No.122 of 2014	European Union (Drinking Water) Regulations 2014
SI No.42 of 2007	Fluoridation of Water Supplies Regulations 2007
SI No.299 of 2007	Safety, Health and Welfare at Work (General Application) Regulations 2016
SI No.36 of 2016	Safety, Health and Welfare at Work (General Application) (Amendment) 2016
SI No.619 of 2001	Safety, Health and Welfare at Work (Chemical Agents) Regulations 2001
SI No.623 of 2015	Safety, Health and Welfare at Work (Chemical Agents) (Amendment) 2015
SI No.349 of 2011	European Communities (Carriage of Dangerous Goods by Road and Use of Transportable Pressure Equipment) Regulations 2013
SI No.238 of 2013	European Communities (Carriage of Dangerous Goods by Road and Use of Transportable Pressure Equipment) (Amendment) Regulations 2013
	European Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR)
SI No.402 of 2001	Waste Management (Collection Permit) Regulations 2001

ABBREVIATIONS AND ACRONYMS

BS	British Standards
CCP	Critical Control Points
CEN	European Committee for Standardization
DWSP	Drinking Water Safety Plan
EPA	Environmental Protection Agency
GPP	General Principles of Prevention
GPRS	General Packet Radio Service
GRA	General Risk Assessment
GRP	Glass Reinforced Plastic
HACCP	Hazard Analysis and Critical Control Points
HAZOP	Hazard and Operability Study
HSA	Health and Safety Authority
HSQE	Health Safety Quality and Environment
HSE	Health Service Executive
h	Height
Hz	Hertz
HDPE	High Density Polyethylene
HMI	Human Machine Interface
I/O	Input/Output
IP	International Protection Marking
IW	Irish Water
kg	Kilogram
L	Litre
MLD	Mega-litres Per Day
m	Metres
µm	Micrometre
mg	Milligram
mm	Millimetres

MCC	Motor Control Centre
O&M	Operation and Maintenance
OEL	Operational Exposure Limit
ppm	Parts per Million
PPE	Personal Protective Equipment
PE	Polyethylene
PP	Polypropylene
PVC	Polyvinyl Chloride
PLC	Programmable Logic Controller
PSCS	Project Supervisor Construction Stage
PSDP	Project Supervisor Design Process
RDT	Random Daytime Testing
RPE	Respiratory Protection Equipment
SCADA	Supervisory Control and Data Acquisition
SDS	Safety Datasheet
SI	Statutory Instrument
SMS	Short Message Service
STEL	Short Term Exposure Limit
UV	Ultra Violet
UPS	Uninterruptible Power Supply
UK	United Kingdom
UN	United Nations
uPVC	Un-Plasticised Polyvinyl Chloride
V	Volts
WHO	World Health Organization
WIMES	Water Industry Mechanical and Electrical Specifications
w/w	Weight/Weight

1 PURPOSE

Under the current *Drinking Water Regulations (S.I. 122 of 2014)*, Irish Water has the responsibility to provide potable water to all public supply users in Ireland. The Regulations prescribe the quality standards to be applied, the relevant supervision required and the enforcement procedures in relation to the supply of drinking water, including sampling frequency requirements, methods of analysis, compliance monitoring points and the provision of information to consumers.

This specification describes the minimum requirements for fluoridation dosing systems and comprises Irish Water's policies towards process control and automation techniques, as well as equipment specifications, chemical storage specifications, critical alarms and critical control points. While the specification is provided as a standard to describe Irish Water's baseline requirements, specialist Contractors who may be appointed to:

- complete the replacement of individual system components,
- complete full or partial upgrades to existing systems, or
- develop new fluoridation systems,

shall retain the role of detailed system Designer for the specified works, and each design shall be carried out on a site specific basis, accounting for all constraints and restrictions therein. It should be noted that the application of this, and every other specification within the 'building block' structure must also give paramount consideration to Health and Safety, operability and TOTEX of each proposed design and installation.

1.1 DWSP APPROACH TO THE FLUORIDATION OF DRINKING WATER

The World Health Organisation (WHO) has promoted a risk based approach known as the Drinking Water Safety Plan (DWSP) to provide an integrated framework for the effective design, operation and management of water supply systems. This approach, which has been adopted by Irish Water, involves an assessment of how particular hazards can affect the quality, safety and security of water supplies, and how the associated risk can be effectively managed from source to tap. Each Irish Water fluoridation system, or part thereof, that is upgraded under the guidance of this specification must address the associated DWSP hazards. While only one of the potential hazards identified by the DWSP relates directly to fluoridation systems [TO220], many are indirectly related and must therefore be considered in the design and operation of such systems. The hazards associated with fluoridation processes under Irish Water's DWSP are outlined in Table 1 below.

Hazard Code	Hazard Description
TO010	Unapproved treatment chemicals / materials causing contamination
TO020	Ineffective chemicals causing inadequate final water
TO030	Chemicals delivered to incorrect storage vessel causing inadequate final water
TO040	Malfunction / failure of chemical dosing point causing inadequate final water
TO050	Loss of power supply
TO090	Instrumentation failure – loss of control
TO180	Poor process control causing chemical overdose
TO190	Risk of running out of key treatment chemicals causing inadequate final water quality
TO210	Critical pump failure leading to loss of supply
TO220	Risk of fluorine overdose in treated water
TO230	Key equipment not coming back online after power failure causing inadequate final water

Table 1: Identified DWSP Hazards associated with fluoridation processes.

1.2 BACKGROUND TO FLUORIDATION OF DRINKING WATER

Irish Water is committed to fluoridating water supplies as required and funded by the Health Service Executive (HSE), whilst simultaneously meeting the requirements of the drinking water regulations with regard to the parametric limitations for fluoride. The requirements for fluoridating public water supplies are set out in the *Health (Fluoridation of Water Supplies) Act 1960* and the *Fluoridation of Water Supplies Regulations 2007 (S.I. No. 42 of 2007)*. Following the commencement of the Water Services (No. 2) Act 2013, fluoridation of public drinking water supplies is undertaken by Irish Water, acting as an agent for the HSE. Irish Water will work with the HSE to implement State policy on fluoridation and will install and operate fluoridation systems at all public water supplies as required and funded by the HSE.

Under *S.I. No. 122 of 2014 (European Union Drinking Water Regulations)* the limits for fluoride in water are 0.80 mg/L in artificially fluoridated supplies, and 1.5 mg/L in supplies containing naturally occurring fluoride. Fluoridation in Ireland is typically carried out by the addition of hydrofluosilicic acid (H_2SiF_6) to potable water following completion of clarification, filtration and disinfection processes. Hydrofluosilicic acid is a compound derived from the raw mineral fluor spar (calcium fluoride - CaF_2) through a purification process which must conform to tightly controlled specifications under the requirements of CEN standard BS EN 12175:2013. The Health Service Executive ensures that independent testing is regularly carried out on commercial hydrofluosilicic acid to ensure it conforms to regulations.

1.3 APPLICATION OF THIS SPECIFICATION

This specification forms part of a series of standard 'building block' specifications which are to be used when compiling project designs. The document is intended to guide the Designer in establishing engineered solutions that deliver robust, reliable and repeatable performance that meet the fluoridation objectives for treated water produced by plants under Irish Water's control. It should be read in conjunction with each project's Work Order Requirements (or alternatively, a fluoridation system Risk Assessment) which shall set out Irish Water's site specific requirements for each particular upgrade.

The specification shall be applied to all future upgrade works associated with fluoridation systems, across all Irish Water plant classes (see Table 2 overleaf for plant classification). These works will primarily consist of:

- **Replacement** of individual fluoridation system components (i.e. pumps, storage tanks, showers, etc.)
- **Upgrade** (partial to full) of existing fluoridation systems
- **Development** of new build fluoridation systems (on greenfield or extended sites)

The user shall note however that the full magnitude of the specification may not require implementation in every case. For example, for the development of new build fluoridation systems, this specification sets out the minimum baseline requirements, and all systems as described herein shall be implemented.

But where the Work Order Requirements (or fluoridation Risk Assessment) identifies that only the replacement of an individual component is required, then only this individual component shall require compliance with the specification. Similarly, if a partial upgrade is specified, or identified under the fluoridation Risk Assessment, then only the elements that are replaced shall require to be compliant.

Plant Class	MLD	m ³ /day
A	< 1	< 1,000
B	1 – 5	1,000 – 5,000
C	5 – 10	5,000 – 10,000
D	10 – 20	10,000 – 20,000
E	≥ 20	≥ 20,000

Table2: Irish Water plant categorisation by hydraulic capacity

All Designers shall therefore study the site specific Work Order Requirements / fluoridation Risk Assessment in order to fully appreciate the scope of works required at each site, and shall then ensure that the specified works are carried out in full compliance with this specification and associated documents.

1.4 ASSOCIATED SPECIFICATIONS

Where appropriate, this Fluoridation Specification makes reference to other Irish Water Design Specifications, contract documents and to the relevant Water Industry Mechanical and Electrical Specifications (WIMES), which have also been adopted by Irish Water in a bid to ensure a baseline quality standard of system design and installation across all categories of water treatment plant.

In order to apply the Fluoridation Specification effectively, the user should, at the very least, also make reference to the following:

- **IW-RAM-SPEC-5000-001** Irish Water Signal Provision Standard (General)
- **IW-RAM-SPEC-5020-009** Irish Water Signal Provision Standard (Fluoridation)
- **IW-XXX-SOP-XXX** Guidance Note on Prioritisation of Emergency Shower and Eyewash Station
- **IW-TEC-900-13** Irish Water Design Specification: Chemical Storage
- **WIMES 8.02** Chemical Dosing Equipment (General Requirements)
- **WIMES 3.01** Low Voltage Switchgear and Controlgear Assemblies
- **IW WOR** The site specific Work Order Requirements
- **IW FRA** The site specific fluoridation risk assessment (may identify the scope of works in Place of the WOR for smaller / one off projects)

The above documents outline the detailed scope of works, and shall also form the basis of equipment selection, material selection, installation and testing for all fluoridation systems and, in tandem with this document, should be used as a reference point by the Designer to ensure compliance with Irish Water requirements.

If situations arise where compliance with this specification, WIMES, or Water Treatment Strategy documents is not possible and an alternative solution is proposed, then the designer shall require prior approval from Irish Water Asset Strategy (Water Treatment) before proceeding with detailed design and installation.

2 FLUORIDATION OF DRINKING WATER

2.1 HYDROFLUOSILICICACID

Hydrofluosilicicacid (H_2SiF_6) is the only chemical permitted by Irish Water and the Health Service Executive for fluoridation of public drinking water supplies. The chemical must be stored, transferred and dosed at 10.9 % w/w concentration, and will not be acceptable for use on Irish Water treatment facilities at any other concentration. Hydrofluosilicicacid (also known as fluorosilicic acid, hexafluorosilicic acid or dihydrogen hexafluorosilicate) is an inorganic colourless liquid compound, free of precipitation, with a pungent odour. It is a strong acid with a pH typically <1. At 10.9% concentration, it has a melting point of -10°C and a boiling point of 110°C . The density of hydrofluosilicicacid at 10.9% w/w is 1009 kg/m^3 and it is miscible in water. It is corrosive, and can cause severe skin burns and eye damage. Appropriate caution must be observed when in close proximity to the chemical, as outlined in Section 3, and appropriate PPE must be worn at all times. The Health Service Executive ensures that regular independent testing is carried out on the final supplied chemical to ensure it meets all Health, Safety, Quality and Environmental (HSQE) requirements.

2.2 CHEMICAL STABILITY AND REACTIVITY

Hydrofluosilicicacid is only stable in an aqueous solution and should only be stored under manufacturer recommended conditions. It remains stable over long periods of time, thus can be stored in bulk on site. It is a strong acid, and must be handled with due care. It cannot be mixed with other chemicals, and all indoor storage areas (bulk tanks and day tanks) must have dedicated forced ventilation facilities to prevent the accumulation of fluoride fumes which are corrosive and pose a significant health and safety hazard. It reacts violently with strong alkaline substances, and may also react with reducing agents. On contact with concentrated acids, it has the potential to form the toxic compound hydrogen fluoride.

Materials must be carefully assessed before being used to store or convey hydrofluosilicicacid, as hydrogen gas can form as a by-product of contact with metals. Contact with unalloyed steel or galvanised surfaces should be avoided. Fumes are also toxic and corrosive (can etch glass, corrode electrical equipment and irritate skin), so must be treated with due caution and vented to the atmosphere. Storage systems must strictly adhere to the requirements set out in this Specification. The design of fluoridation equipment should only be undertaken by competent designers, and all operation and maintenance activities which risk contact with the chemical shall only be carried out by competent staff that have received specific training in how to handle hydrofluosilicicacid and are aware of the hazards and risk mitigation precautions to be taken.

Designers and operational staff should consult the Safety Data Sheet (SDS) for 10.9% hydrofluosilicicacid for Health and Safety hazard data, recommended PPE, spillage containment and recommended emergency first aid procedures. Designers shall review their proposals with respect to the choice of materials which may come into contact with hydrofluosilicicacid from the bulk storage filling point to its dosing point. The Designer shall undertake a risk assessment and submit same to Irish Water to demonstrate that no consequent corrosive or hazardous environment results from their design. Following installation and commissioning of the equipment, the O&M Contractor shall post a copy of the relevant SDS adjacent to all storage, conveyance and dosing equipment, and include a copy of the risk assessment in the Operation and Maintenance Manual.

3 HAZARD MITIGATION AND RISK MANAGEMENT

The delivery, transfer, storage and administration of hydrofluosilicic acid presents a significant occupational health and safety hazard, and the wellbeing of all operational employees, site visitors and the general public is Irish Water's primary concern. In its raw state, hydrofluosilicic acid is a strong, corrosive acid, which also produces airborne vapours of a corrosive nature. Due to the aggressive properties of hydrofluosilicic acid, occupational health and safety must be of paramount concern to all personnel involved in the design, construction and operation of a fluoridation system.

System Designers shall be fully cognisant of their obligations to design and implement a safe working environment for all operational personnel, and if required by project specific conditions, take part in a HAZOP study to eliminate or mitigate against possible hazards. Due to the occupational health and safety hazards posed by fluoridation systems it is essential that all facilities are designed in accordance with current Health and Safety Legislation. Designers shall ensure that all facilities used for the storage and dosing of chemicals maintain compliance with the standards set out in the following regulations:

- *Safety, Health and Welfare at Work Act (Chemical Agent Regulations) 2001 (S.I. No. 619 of 2001),*
- *Safety, Health and Welfare at Work (Chemical Agents) (Amendment) Regulations 2015 (S.I. No. 623 of 2015),* and associated amendment documents,
- *Safety, Health and Welfare at Work (General Application) Regulations 2007 (S.I. No. 299 of 2007),*
- *Safety, Health and Welfare at Work (General Application) (Amendment) Regulations 2016 (S.I. No. 36 of 2016)* and as amended.

At a minimum, the requirements outlined in the following sections shall be complied with for all installations. Operational personnel must be made fully aware of hazards associated with hydrofluosilicic acid and given appropriate training to mitigate risks when working in close proximity to the chemical. An up-to-date copy of the SDS shall be posted in every fluoridation room, every plant control room and available in all fluoridation O&M manuals.

3.1 GENERAL PRINCIPLES OF PREVENTION

Designers can directly influence safety, and must take into account the General Principles of Prevention when preparing system designs. The GPP promotes the elimination of risk by implementing engineering controls such as containment, ventilation, monitoring systems, etc. Following the 'designing out' of risk, Designers shall then, via the General Risk Assessment, identify the residual risks and establish suitable control measures to mitigate against same. The General Principles of Prevention (GPP) are set out in descending order of preference as follows:

- Avoid risks
- Evaluate unavoidable risks
- Combat risks at source
- Adapt work to the individual, especially the design of places of work
- Adapt the place of work to technical progress

- Replace dangerous systems of work by non-dangerous systems
- Use collective protective measures over individual measures
- Develop an adequate prevention policy
- Give appropriate training and instruction to employees

3.2 GENERAL RISK ASSESSMENT

The Designer shall prepare a detailed General Risk Assessment (GRA) for all works proposed at hydrofluosilicic acid dosing facilities which shall identify all associated hazards from a health, safety, quality and environmental (HSQE) perspective. In considering each hazard, if it cannot be eliminated entirely through design, then the risk posed by the hazard must be assessed and discounted, or mitigated/controlled by some further action as outlined under the GPP (Section 3.1). Completion of the General Risk Assessment may also illustrate if certain risks are low enough as to be acceptable, thereby allowing the Designer to omit certain unnecessary items from the system design.

All discernible hazards shall be included within these risk assessments, and quantified numerically. The Designer shall take all reasonable measures necessary to ensure that final risk ratings for each particular identified hazard are 5 or less, and present concise descriptions of the hazard relief and mitigation methodologies proposed to ensure minimisation of risk ratings. Each Risk Assessment shall be completed on a site specific basis by a competent chemical safety professional, and designs / procedures resulting from the exercise shall be implemented throughout the installation. The basis of the GRA for each facility shall consider the following:

- What are the hazards associated with the facility?
- What is an identified hazard's *likelihood of occurrence*? – Quantifiable (scored out of 5)
- What is the *hazard severity* if the identified hazard does occur? – Quantifiable (scored out of 5)
- What is the overall risk score? – Quantifiable (scored out of 25, product of likelihood and severity)
- What can be done to reduce the probability of the hazard occurring?
- What can be done to mitigate the consequences of the hazard occurring?

The GRA for each facility shall be prepared at the outset of each project and submitted to Irish Water or their representative in order to obtain approval for design, as well as for procurement of the equipment proposed. No construction or procurement shall proceed until Irish Water approval of each GRA has been granted. Following completion of any upgrade, the GRA shall be updated to reflect the impact of the works carried out, and to identify if / where further GPPs must be applied (i.e. training) to mitigate against residual risks.

3.3 SCOPE OF GENERAL RISK ASSESSMENT

The scope of the General Risk Assessment shall be determined by the site specific Work Order Requirements, and its extent will depend on whether the specified works consist of:

- **Replacement** of individual fluoridation system components (i.e. pumps, storage tanks, showers, etc.)
- **Upgrade** (partial to full) of existing fluoridation systems

- **Development** of new build fluoridation systems (on greenfield or extended sites)

3.3.1 REPLACEMENT OF INDIVIDUAL SYSTEM COMPONENTS

For the replacement of individual fluoridation system components, an initial GRA shall have been carried out by Irish Water (or their representative). This initial GRA shall detail the system components that have been identified for replacement on the basis of an unacceptable risk score (i.e. dosing pump, BST, etc.), and shall be submitted to the Designer in advance of the works. The Designer will update the initial GRA during the design process to illustrate how the risk scores for the identified hazards will be reduced by the replacement works proposed. The Designer shall also update the initial GRA to show the expected risk score once the works have been completed. No construction or procurement shall proceed without Irish Water approval of the updated GRA. The Designer shall also notify the client or the client's representative of any further hazards identified during the works, which may have been overlooked / unapparent during development of the initial GRA.

3.3.2 UPGRADES OR NEW DEVELOPMENTS

For upgrades (partial or full) of existing facilities, or for the development of new build fluoridation systems, the Designer shall complete the initial GRA which shall address all aspects of the installation, from the delivery of the chemical to site, to the injection of chemical to the process water, and everything between, including peripheral operational, monitoring and control systems. The scope for the development of the initial GRA for upgrades (partial or full) or new developments, shall include, at a minimum:

- **Delivery Hazards** – all hazards, initial risk scores, mitigation measures and final risk scores associated with the delivery of H_2SiF_6 between the WTP boundary and the BST fill line
- **Storage Hazards** – all hazards, initial risk scores, mitigation measures and final risk scores associated with the storage of H_2SiF_6 , including its proximity to other chemicals stored on site
- **Transfer Hazards** – all hazards, initial risk scores, mitigation measures and final risk scores associated with the manually operated transfer of H_2SiF_6 from bulk storage tank to day tank storage
- **Dosing Hazards** – all hazards, initial risk scores, mitigation measures and final risk scores associated with the dosing of H_2SiF_6 to process water or carrier waterlines
- **Exposure Hazards** – all hazards, initial risk scores, mitigation measures and final risk scores associated with the exposure of operational staff / visitors to H_2SiF_6 liquid or vapour

The Designer will update the initial GRA during the design process to illustrate how the risk scores for the identified hazards will be reduced by the upgrade / new development works proposed. The Designer shall also update the initial GRA to show the expected risk score once the works have been completed. No construction or procurement shall proceed without Irish Water approval of the updated GRA. The Designer shall also notify the client or the client's representative of any further hazards identified during the works, which may have been overlooked / unapparent during development of their initial GRA.

3.4 MANAGEMENT OF RESIDUAL RISK (HACCP)

The Irish Expert Body on Fluorides and Health (Code of Practice on the Fluoridation of Drinking Water 2016) recommends the use of the Hazard Analysis Critical Control Points (HACCP) risk management tool to ensure product safety. The HACCP management system is commonly used in the food industry and strives to maintain food standards and laws, while upholding cost-effectiveness and efficiency. As fluoridated water is a product for human consumption, with a defined fluoride concentration limit, the Designer shall apply the HACCP management tool for residual hazards which cannot be fully eliminated during the detailed design process.

There are 7 principles of HACCP, and an example of the initial stages of development of a HACCP for fluoridation of drinking water is presented in Table 3 below.

- i. Identify the hazards
- ii. Determine critical control points (CCPs) and establish a system to monitor CCPs
- iii. Establish critical limits
- iv. Establishing and implementing effective monitoring procedures at CCPs
- v. Establish the corrective action to be taken when monitoring indicates that a particular CCP is breached
- vi. Establish and maintain procedures for verification to confirm the HACCP system is working effectively
- vii. Establish documentation describing all procedures required to maintain an effective HACCP, and develop a recording system appropriate to these principles and their application.

HAZ No.1	Variability in strength of chemical upon delivery to treatment plant	Source of Hazard	Failure of quality control during chemical manufacturing
		Critical Control Point(s)	Good manufacturing practice to ensure 10.9% ± 0.3%, Certificate of Compliance from supplier(s), regular independent monitoring
		Critical Limits	10.6 – 11.2% w/w strength hydrofluosilicic acid
		Corrective Actions	Notify supplier, notify HSE, adjust dosing concentration at plant to allow for variation in strength of acid
HAZ No.2	Variation in fluoride concentration of raw water source	Source of Hazard	Natural background fluoride fluctuation, contamination by chemical spillage/leakage from treatment plant
		Critical Control Point(s)	Monitor, make provision for dose calculation adjustment, maintain plant security, ensure tanks, pipes, equipment are fit for purpose, leak detection, secondary containment of leaks/spillages, suitable fill valves
		Critical Limits	0.80 mg/L F in water supplied to consumer
		Corrective Actions	Follow corrective actions as per protocol (see Section 12)
HAZ No.3	Fluoride overdose / underdose	Source of Hazard	Dose rate incorrectly set, pump failure, siphoning of storage tank, malfunction of control systems
		Critical Control Point(s)	Training, instrument calibration, pump maintenance, automatic duty changeover of pumps, anti-siphon valves, regular monitoring of F concentrations in treated water
		Critical Limits	0.60 – 0.80 mg/L in treated drinking water
		Corrective Actions	Follow corrective actions as per protocol (see Section 12)
HAZ No.4	Inhalation of chemical vapour or liquid contact with skin / eyes	Source of Hazard	Tank filling, connecting pipes, tanks and pumps, general works in the vicinity of chemical storage systems
		Critical Control Point(s)	Appropriate equipment design and installation, training, ventilation, PPE, safe systems of work procedures
		Critical Limits	Airborne concentration max 2.5 mg/m ³ F
		Corrective Actions	Follow emergency procedures (see Section 12)

Table 3: Example of the initial stages of development of a HACCP for fluoridation of drinking water.

The Designer shall summarise the residual risks that remain following design approval and completion of the post upgrade revision of the GRA, and shall apply the HACCP tool as described above to establish the CCPs, critical limits, and SOPs (monitoring, corrective action, etc.) necessary to mitigate against such residual risks.

3.5 SIMPLICITY OF DESIGN

As risk of infrastructural failure is reduced as system simplification is increased, the Designer shall strive to keep the design of the entire chemical delivery, transfer, storage and administration system as simple as possible, whilst remaining within the constraints of this specification, and associated documentation as referenced. The designer shall maintain a design simplicity approach throughout the development process so that potential for system failure is minimised at all times. Pipe runs (fill lines, dosing lines, vent pipework, etc.) shall be kept as short as possible, with minimal connections or joints where leakages are likely to occur. Dosing pipework and valves shall be positioned within the bunded area, or alternatively within an enclosure or outer pipe which will contain any leakages and drain back to the bunded area. Connections on each storage tank shall be kept to a minimum, whilst remaining compliant with this specification and associated documents (WIMES, best practice documents, etc.). All dosing pumps shall be mounted so that they are accessible from outside the bunded area, whilst also allowing spillages to drain back to the bunded area. Routine maintenance to equipment and instruments shall be capable of being completed without requiring access to the bund, as

should all chemical replenishment. Access to the bund shall only be required in exceptional circumstances or for non-routine maintenance activities.

4 HEALTH AND SAFETY MEASURES

Due to the occupational health and safety hazards posed by fluoridation systems it is essential that all fluoridation facilities are compliant with current Health and Safety Legislation. Designers shall ensure that all facilities used for the storage and dosing of chemicals maintain compliance with the standards set out in the following regulations:

- *Safety, Health and Welfare at Work Act (Chemical Agent Regulations) 2001 (S.I. No. 619 of 2001),*
- *Safety, Health and Welfare at Work (Chemical Agents) (Amendment) Regulations 2015 (S.I. No. 623 of 2015),* and associated amendment documents,
- *Safety, Health and Welfare at Work (General Application) Regulations 2007 (S.I. No. 299 of 2007),*
- *Safety, Health and Welfare at Work (General Application) (Amendment) Regulations 2016 (S.I. No. 36 of 2016)* and as amended.

At a minimum, the requirements outlined in the following sections shall be complied with for all installations. Operational personnel must be made fully aware of hazards associated with hydrofluosilicic acid and given appropriate training to mitigate risks when working in close proximity to the chemical. An up-to-date copy of the SDS shall be posted in every fluoridation room, every plant control room and available in all fluoridation O&M manuals.

4.1 PERSONAL PROTECTIVE EQUIPMENT

The *Safety, Health and Welfare at Work Act 2005* and *Safety, Health and Welfare at Work (General Application) Regulations 2007* enforce laws for the provision of PPE in the workplace. Irish Water establish that only PPE with the CE mark is suitable for chemical storage and handling purposes. The following PPE shall always be available and maintained on all sites where there is a possibility of contact with hydrofluosilicic acid:

- Eye Protection (BS EN166): to be used for all chemical proximate activities
- Skin Protection (BS EN374): to be used for all chemical proximate activities
- Protective Clothing (BS EN13034): to be used for chemical proximate activities which carry an increased risk of contact (i.e. disconnection of pumps /pipework, chemical replenishment, etc.)
- Respiratory Protection Equipment: to be used if vapour levels in fluoridation rooms exceed the recommended STEL or OEL limits

The site specific General Risk Assessment, shall determine if further PPE, beyond that listed above, needs to be maintained on each site. In the case of acid storage facilities, a number of factors shall be considered in the establishment of which items of PPE are suitable for each storage facility, and the PPE material of manufacture shall be suitable as a means of protection for hydrofluosilicic acid. Material resistance should be considered in terms of degradation, penetration, chemical compatibility and permeation when in contact with the chemical. Consideration should be taken on the following issues:

- Practicality of PPE for the task intended
- Consultation of the Safety Data Sheets in choosing appropriate PPE material
- Extent of exposure
- Available training for personnel
- Seeking of Advice from relevant bodies where appropriate

Further information can be found in the HSA Document: *A Guide to Non-Respiratory Personal Protective Equipment (PPE) for use with Chemical Agents in the Workplace*.

4.2 EMERGENCY PROCEDURES

Emergency procedures shall be established to mitigate against all residual risks that could not be practicably 'designed out' and which have been identified by the completion of the General Risk Assessment and HACCP. Emergency procedures shall be made known to all operational and supervisory personnel and shall be available in the operation and maintenance documentation provided by the PSDP / PSCS for the project. Training in the specific emergency procedures may be necessary in certain situations and, if deemed required by Irish Water or their representative, should be completed by a competent chemical safety professional. In terms of hydrofluosilicic acid systems, operators and personnel should typically be aware of the following:

- General emergency procedures in terms of contact with hydrofluosilicic acid or evacuation requirements
- Location of emergency facilities such as washing facilities, fire extinguishers etc.
- Emergency contact numbers in the occurrence of a crisis situation
- Location of information and data sheets specific to hydrofluosilicic acid
- Emergency decontamination measures
- Emergency spill protection measures

4.3 FIRST AID KIT

A first aid kit, containing antidote gel, should be provided at all sites which incorporate a hydrofluosilicic acid dosing installation. 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 a can opener is also provided). Calcium pills should be provided for administration dissolved in water upon inhalation. Dressings soaked in 20% Calcium Gluconate solution can be applied in the instance of skin contact. Medical attention should always be sought in case of contact with hydrofluosilicic acid.

4.4 EMERGENCY WASHING FACILITIES

Emergency shower and eyewash facilities shall be installed in accordance with the following documents, and shall also be compliant with the equipment specifications as laid out in Section 8.7 of this document:

- IW Guidance Note on Prioritisation of Emergency Shower and Eyewash Installations
- ANSI Z358.1 – American Standard for Plumbed in Emergency Shower and Eyewash Equipment

Under the *IW Guidance Note on Prioritisation of Emergency Shower and Eyewash Installations*, the hazard statement for hydrofluosilicic acid is 'H314 - Causes severe skin burns and eye burns'. As such, the chemical is classified as **Priority 1** for both **Emergency Showers** and **Emergency Eyewash** installations, meaning that both must be provided in appropriate locations for every hydrofluosilicic acid dosing installation.

For all washing facilities that are classified as Priority 1, the '10 second rule' shall apply, which means that any individual who comes into contact with the associated chemical shall be able to reach the shower / eyewash in no more than 10 seconds from any location where there is a risk of contact. Taking the physical and emotional state of the individual into account, the '10 second rule' should practically translate to a distance of no more than 10 metres from the hazard.

Precise locations for emergency showers and eyewash facilities on each site shall be established during the development of the GRA and HACCP as outlined in Sections 3.2 and 3.4. In determining the optimum number of showers, and appropriate locations for those showers, Designers shall consider the following when completing the Exposure Hazards element of the Risk Assessments:

- Volumes of the chemicals utilised on-site
- Site map identifying the location of the chemicals
- Method of delivery of the chemicals and location of delivery fill point

- Existing emergency washing facilities at the site
- Proposed emergency shower locations
- Recommendations for improvement.

The location of each emergency shower or eyewash station should be identified with a highly visible sign. The sign should be in the form of a symbol that does not require workers to have language skills to understand it, and location of the emergency shower or eyewash station should be well lit, making use of a timer or photocell to illuminate the shower when dark. Further design requirements include:

- Emergency washing facility shall not be separated by a partition from the hazardous work area.
- Emergency washing facility shall be located on an unobstructed path between the wash station and the hazard. (Workers should not have to pass through doorways or weave through machinery or other obstacles to reach them.)
- Emergency washing facility shall be located where workers can easily see them - preferably in a normal traffic pattern.
- Emergency washing facilities shall be on the same floor as the hazard (no stairs to travel between the workstation and the emergency equipment)
- Emergency washing facilities shall be located near an emergency exit where possible so that any responding emergency response personnel can reach the victim easily.
- Emergency washing facilities shall be located in an area where further contamination will not occur
- A suitable drainage system for excess water shall be provided, and the Designer shall implement all appropriate measures required to prevent the discharge of spilled hydrofluosilicic acid via emergency shower drainage systems. Note that the wash water, if contaminated, may be considered a hazardous waste and special regulations may apply.
- Wash water shall not come into contact with any electrical equipment that may become a hazard when wet.
- Facilities shall be protected from freezing when installed outdoors (self-draining showers).

4.5 CHEMICAL DELIVERY, STORAGE AND DOSING

The Designer shall take cognisance of the end user of the facility when completing their designs, and ensure that the layout of the facility is such that it minimises risk to all personnel or visitors who may be in the vicinity of the installation. In addition, all necessary infrastructure shall be provided to permit safe access to all aspects of the facility which require service, maintenance and inspection, as well as all necessary equipment required for the completion of routine operational tasks. Health and Safety good practice should be maintained throughout the lifetime of operations occurring at the site and it is critical that the initial design of the delivery, storage and dosing facilities are adequate in this regard.

Minimum requirements are highlighted in the non-exhaustive list below:

- All operational areas shall be clearly identified in compliance with current health and safety legislation. Signage will be incorporated at appropriate locations as identified in the General Risk Assessment.
- Chemical type, safety data sheets, procedures and working capacity of storage systems shall be clearly displayed at relevant locations.
- In accordance with WIMES 8.02, access to all non-weather shrouded bunded areas (where permitted) shall be via a GRP open mesh platform and access ladder
- A minimum of 450mm should be provided between all bulk tanks and non-weather shrouded bunded areas to minimise risk of chemical jetting from the bulk tank. This distance shall increase depending on the height and volume of the bulk storage vessel. Where space is unavailable for adequate distance between the bulk storage tank and the bund, hydrofluosilicic resistant clear screens shall protect against chemical jetting.
- All storage accessories and equipment such as pipes, pumps, valves etc. shall be suitable for use with hydrofluosilicic acid.
- A copy of the section of the O&M manual dedicated to chemical delivery, transfer, handling, storage and administration shall be kept in a polycarbonate file holder mounted in a prominent location which is maintained dry and warm. This shall also include details of all emergency procedures.
- The designer shall implement an intelligent design layout whereby operational staff need not access the bund for routine equipment maintenance procedures, as far as is reasonably practicable.
- For all chemical handling equipment for which secondary containment is unavailable (e.g. larger dosing / transfer pumps which cannot be housed in a dosing cabinet), the Contractor shall implement protection measures to minimise the risk of chemical spray out (e.g. hydrofluosilicic resistant clear screens).

5 PROCESS DESIGN OF FLUORIDATION SYSTEMS

While the appointed Designer shall retain the responsibility for the detailed design of fluoridation systems on a site specific basis, minimum Irish Water requirements must be met for all such installations. The following sections describe the minimum process requirements in relation to equipment, instrumentation and the type of control and validation systems to be used for each fluoridation system. The Designer shall ensure that each installation is completed in accordance with the details outlined herein. While Irish Water accepts that certain site variations may apply with regard to pipework routes, electricity supplies, access, etc., the basic process and control systems described in the *General Design* should not be altered without receipt of prior approval from Asset Strategy (Water Treatment).

5.1 OVERVIEW OF DESIGN REQUIREMENTS

All installations proposed shall be carried out in accordance with the *General Design* schematic as presented in Diagram 1, which outlines Irish Water's minimum requirements for fluoridation systems. Critical features of the *General Design* for fluoridation systems are briefly described below, and in further detail in subsequent sections of this specification.

- **Chemical Concentration:** All fluoridation systems, across all plant classes, shall utilise hydrofluosilicic acid at a concentration of 10.9% w/w as the fluoridation chemical. The use of hydrofluosilicic acid at concentrations in excess of 10.9% w/w will not be permitted at any Irish Water treatment facility. As such, all equipment which may come into contact with the chemical in its liquid or vapourised form (i.e. bulk tanks, day tanks, fill/transfer/dosing pipework, pump internals, instrumentation, etc.) shall have a high corrosion resistance to hydrofluosilicic acid at 10.9% w/w.
- **Day Tank:** All fluoridation systems shall utilise a day tank, to act as a buffer between the bulk storage tank and the point of chemical injection to the process water pipe. This arrangement shall be specifically designed to mitigate against the risk of discharge of the entire contents of the bulk storage tank to the water supply. The day tank and associated transfer pump and dosing pump arrangements shall be designed in order to reduce the potential for overdose from the effects of siphoning or dosing pump malfunction. The day tank shall be situated within the dedicated Fluoridation Room, and shall contain the volume required for a 24 hour supply of fluoride at the correct concentration (or maximum 3 days where a plant is not visited on a daily basis – see Table 4 for details). All day tanks shall be of translucent material which will allow observation of volume of chemical within the tank, and shall be provided complete with graduations to allow assessment of tank volume.
- **Day Tank Volume:** Unless stated otherwise in the project specific Work Order Requirements, the minimum required volume of the day tank shall be calculated by the Designer to ensure the storage times outlined in Table 4 overleaf. All day tank volume calculations shall be based on the design throughput of the plant, and the maximum chemical usage expected to maintain a fluoride concentration of 0.60 – 0.80 mg/L. Day tanks shall be replenished by transfer pumps which abstract from the bulk storage tank(s) and discharge to the day tank. Note that initiation of transfer pumps shall not be automated, and replenishment of the day tank shall require the manual intervention and the continuous presence of the

plant operator. Day tanks in excess of 1000 litres in volume will not be permissible by Irish Water without prior written consent from Asset Strategy.

Plant Class	MLD	m ³ /day	Day Tank Storage
A	< 1	< 1,000	3 days
B	1 – 5	1,000 – 5,000	2 days
C	5 – 10	5,000 – 10,000	1 day
D	10 – 20	10,000 – 20,000	1 day
E	≥ 20	≥ 20,000	1 day

Table 4:Day tank storage requirements. Class A& B plants may not be visited daily by operational personnel therefore increased storage required.

- **Fluoridation Room Segregation:** A dedicated, fully segregated, and adequately ventilated fluoridation room shall be provided to house the fluoride day tank, dosing pumps, industrial electronic weighing scales, control panel (when not incorporated into a larger centralised panel) and associated instrumentation. No other processes shall be permitted within the fluoridation room.
- **Fluoridation Room Bund:**For fluoridation rooms which house day tanks ≤ 250 litres in volume, the day tank, the electronic weighing scales, the dosing pumps and all valves may be contained in a suitably lined cast in situ concrete bund, or alternatively, in a 'tray' type bund, manufactured from reinforced polyethylene, polypropylene or uPVC lined GRP. For installations where day tank storage volume is in excess of 250 litres, the day tank, the electronic weighing scales, the dosing pumps and all valves shall always be installed in a suitably lined cast in situ concrete bund. All concrete that may come into contact with hydrofluosilicic acid shall therefore be of an acid resistant grade. Leak detection level indicators (LI005) shall be provided in all bunds, as shown in Diagram 1, and shall be of probe (conductivity probes, capacitance probes, etc.) or float type instruments. All bunds are to have the capacity to hold 110% of the volume of one of the bulk tanks. Ultrasonic level probes will not be permitted for use as leak detection as they may return a loss of echo signal during normal operation.
- **Electronic Scales:** All day tanks shall sit on an appropriately sized electronic weighing scales which shall allow the plant operator to determine precisely how much chemical has been used since the previous assessment. The weight of chemical used shall be compared to the volume of water discharged in the same time period, and allow the fluoride dose to be manually calculated by the plant operator (see Section 5.1.2). The scales shall be provided with a local digital readout which shall be mounted adjacent to the door of the fluoridation room. An analogue signal representing the weight reading shall also be relayed to the system PLC, where, in conjunction with the flow reading, the fluoride dose will be automatically calculated and displayed on the HMI.
- **Handwash Sink:** A handwash sink shall be provided in the fluoridation room for hygiene purposes. It shall be located close to the door of the fluoridation room and be easily accessible to operational staff entering or leaving the premises. A hot and cold water supply shall be available at the sink, and a soap dispenser and electric hand drier shall be wall mounted nearby.
- **Bulk Storage Tank Volume:** Unless stated otherwise in the project specific Work Order Requirements, the minimum required bulk storage shall be calculated by the designer to ensure 90 days storage. All bulk

tank volume calculations shall be based on the design throughput of the plant, and the maximum chemical usage expected to maintain a fluoride concentration of 0.60 – 0.80 mg/L. The required storage volume will determine whether a single tank or dual tank installation will be required. Where total bulk storage volume exceeds 500 litres, the volume shall be split evenly in a dual tank installation (i.e. proposed storage volume = 2000 litres, tank size & configuration = 2 x 1000 litre tanks). Bulk storage tanks shall not normally be filled above 90% capacity.

- **Bulk Storage Tank Installation:** Unless stated otherwise in the project specific Work Order Requirements, or following a written departure from Irish Water (Asset Strategy), all bulk tanks storing hydrofluosilicic acid shall be installed outdoors. Bulk tank installations shall be fully segregated from all other processes, and also fully segregated from the dedicated fluoridation room. To avoid crystallisation of the acid in storage, the temperature of chemical in the Bulk Storage Tank shall be maintained above 5°C at all times.
- **Bulk Storage Tank Bund:** All outdoor bunds shall be polymeric weather shrouded bunds which are integrated to the bulk storage tank structure. Each integrated weather shrouded polymeric bund shall have the capacity to hold 110% of its associated tanks volume. In the event that indoor storage is permitted by IW Asset Strategy, the following shall apply:
 - Single bulk storage tanks, installed indoors and which have capacities ≤ 250 litres, may be placed in their own individual plastic bunds
 - Single bulk storage tanks, installed indoors and which have capacities > 250 litres must be contained within a suitably lined cast in situ concrete bund, or alternatively be provided with an integrated polymeric weather shrouded bund.
 - All dual bulk storage tanks, installed indoors shall be contained within a common suitably lined cast in situ concrete bund., or alternatively each be provided with an integrated polymeric weather shrouded bund

All bund concrete that may come into contact with hydrofluosilicic acid shall be of an acid resistant grade. Leak detection level indicators (LI003) shall be provided in all bunds, as shown in Diagram 1, and shall be of probe (conductivity probes, capacitance probes, etc.) or float type instruments. Ultrasonic level probes will not be permitted for use as leak detection as they may return a loss of echo signal during normal operation. All bunds are to have the capacity to hold 110% of the volume of one of the bulk tanks.

- **Dosing Pumps:** Unless specified otherwise in the project specific Work Order Requirements, the Designer shall ensure that all dosing pumps shown in Diagram 1 are provided in the quantities and configurations as indicated. Full duty / standby configurations, complete with automatic changeover, are required of all pumping systems to provide adequate redundancy in the event of failure or maintenance. Dosing pumps may be installed within 'tray' type bunds provided they can be safely accessed without entering the bund. For larger concrete bunds, or integrated weather shrouded bunds, dosing pumps shall be installed in dedicated pump cabinets, mounted externally to the bund. All concrete that may come into contact with hydrofluosilicic acid shall be of an acid resistant grade.

- **Transfer Pumps:** Unless specified otherwise in the project specific Work Order Requirements, the Designer shall ensure that all transfer pumps shown in Diagram 1 are provided in the quantities and configurations as indicated. Full duty / standby configurations are required of all pumping system to provide adequate redundancy in the event of failure or maintenance. Note that initiation of the transfer pumps shall not be automated, and replenishment of the day tank shall require the manual intervention and continuous presence of the plant operator (i.e. a 'dead man's switch' - the plant operator shall be required to hold the transfer pump 'Run' button / switch in place in order to replenish the day tank – once the button / switch is released, transfer pumping shall cease). The dead man's switch for activation of the transfer pump should be installed in a location that allows full and unobstructed viewing of the translucent day tank, to permit the plant operator to observe the day tank as it fills.

- **Pump Cabinets:** Where high walled cast in situ concrete bunds are used, or where integrated weather shrouded polymeric bunds are used, dosing pumps and/or transfer pumps shall be installed in a fully enclosed and sealed dosing pump cabinet, which shall be mounted adjacent to the bund. The dosing cabinet shall incorporate a transparent polycarbonate door to allow viewing of the pumps without opening the cabinet, and it shall also act as a spill tray which incorporates a drainage pipe at its base to ensure that all spillages are returned to the bunded area. Pump cabinets shall be mounted at chest height to allow ease of viewing and inspection.

- **Dosing Pump Pipework:** Each dosing pump is to have its own independent suction pipework as shown in Diagram 1. As an added mitigation against uncontrolled discharge to the processwater supply, an actuated valve system shall isolate the standby pump while it is not in operation. Changeover between duty and standby pumps shall be completed automatically on a scheduled rotation to ensure equal usage. Similarly, each pump should have its own delivery pipework and injection fitting to the process water pipe. This is to ensure continued dosing in the event of pipework failure. Each injection fitting is to include an isolation valve and be installed in an accessible area, mounted vertically and perpendicular to the processwater pipe. Below ground injection points are to be provided with adequate access to allow routine or preventative maintenance to be carried out. The dosing lines shall be enclosed in an outer pipe which drains back to the bunded area, to mitigate against fluorine leakages from cracked dosing lines. Flow meters (FI002 & FI003) shall be required where proposed pumps do not incorporate a digital display showing instantaneous and totalised flow rates.

- **Transfer Pump Pipework:** Each transfer pump is to have its own independent suction pipework and, in the case of dual tank installations, each pump should be capable of taking its supply from either of the 2 No. bulk tanks, as shown in the Diagram 1 schematic. Transfer pumps shall not permit gravity flow from the Bulk Storage Tank to the day tank, and as an added measure to protect against uncontrolled discharge, all pipework between the Bulk Storage Tank and the day tank shall be arranged in such a way that makes gravity discharge impossible (i.e. the delivery pipework should rise vertically to a level higher than the highest fill point of the Bulk Storage Tank – see Diagram 1 overleaf). The Designer shall ensure the presence of foot valves on suction pipework to prevent air locking and maintain prime on the suction pipework. An actuated valve system shall facilitate the changeover from the duty to standby source tank, and shall be controlled by the bulk tank level ultrasonic level sensors. Changeover between source tanks

shall only be done once the chemical levels within the duty tank are low and a sufficient supply is held within the standby tank.

Note that transfer pumps shall always take their supply from the same tank, i.e. when the source tank is changed, it shall be changed for both duty and standby pumps. For transfer pumps, a common delivery line to the day tank is sufficient.

- **Fill Lines:** All fill lines for bulk storage tanks shall be manufactured from uPVC, adequately sized (minimum 50 mm internal diameter) and adequately supported to withstand mechanical vibration / impact during filling. The point of connection between the fill line and the chemical tanker delivery pipework shall be located to provide full and unobstructed viewing of the bulk storage tank, so that chemical delivery personnel / operational staff are not reliant on instrumentation alone during filling operations. Venting shall be a minimum 150 mm diameter and sized to prevent pressurisation of the tank during fill. The fill lines shall be located within the bunded area or above a suitable drip tray that drains to the bunded area.
- **Overflow Pipework:** Overflow pipework shall be minimum 100 mm internal diameter or double the inlet size, located on the opposite side of the tank to the inlet. The overflow pipe shall extend down the side of the tank and discharge into the bund above bund flood level at a height that will not cause excessive splashing. Overflow take off pipework shall be clamped securely to a low level. As a minimum a clamp shall be required at the base and mid-point of the overflow. Where the distance between these clamps exceeds 900 mm additional clamps shall be required.
- **Instrumentation:** In addition to the electronic weighing scales, the Designer shall ensure that all level, flow and process (i.e. fluoride monitoring) instrumentation as shown in Diagram 1 is provided with each installation.

For dosing control, Designers are referred to Section 5 below. Dose optimisation and process proving following functional commissioning of the process elements shall be undertaken, in accordance with Section 10 of this Specification.

5.2 PROCESS DESIGN SCHEMATIC

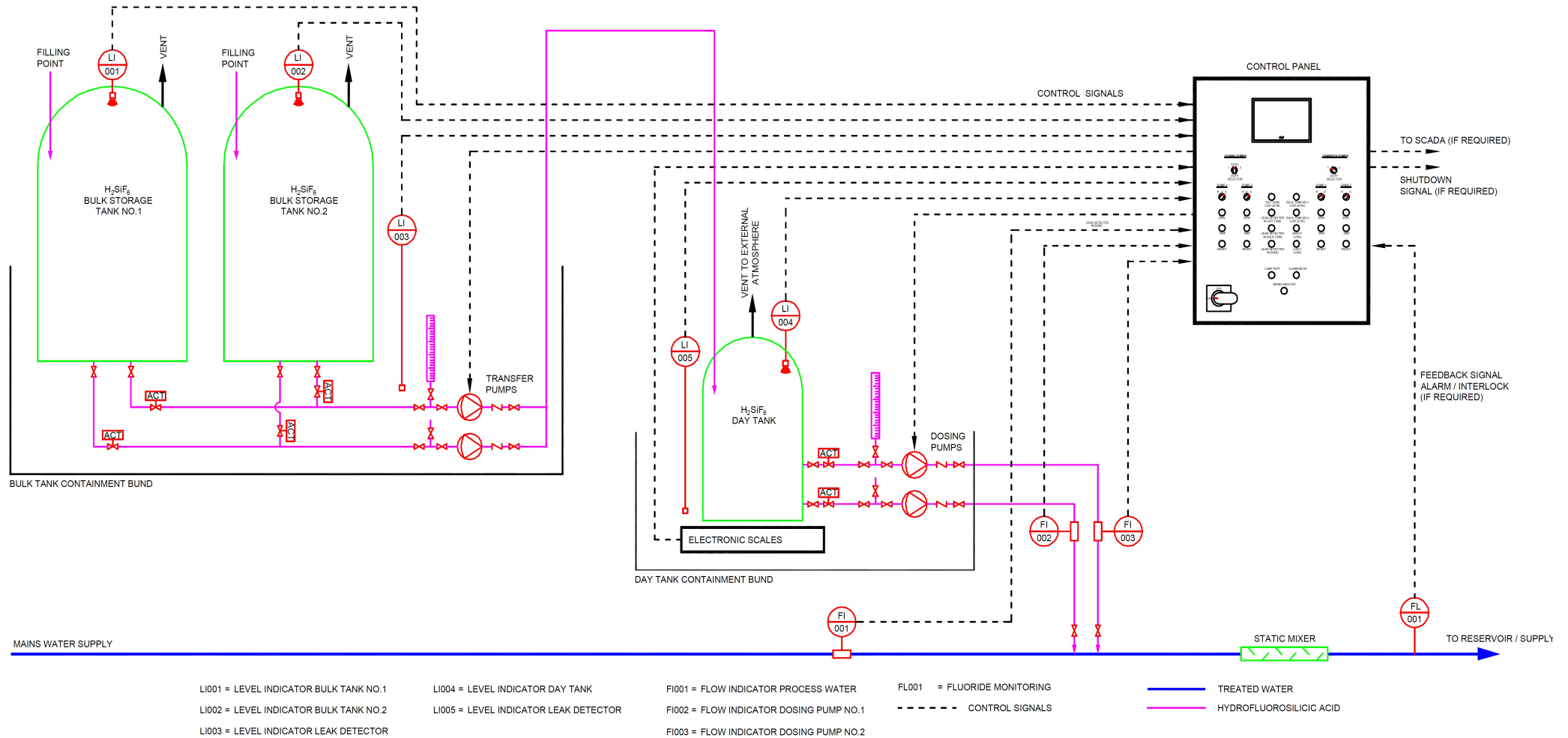


Diagram 1: General design schematic outlining the minimum requirement for all Irish Water fluoridation systems.

6 CONTROL OF FLUORIDATION SYSTEMS

It is a requirement that daily measurement of the fluoride content of the treated water takes place at the treatment plant (*S.I. 42 of 2007*). Dosing of hydrofluosilicic acid to process water shall be controlled on a flow proportional basis only, with an appropriate dose rate per cubic metre of process water established during process commissioning. Fluoride measuring methods shall be utilised for monitoring purposes only, and shall not provide any dose control or dose trimming functionality. All chemical dosing shall cease if the detected process water flowrate is zero in order to prevent the creation of a high fluoride 'slug' within the process water pipeline during interruptions to the water supply. All fluoride dosing shall take place downstream of disinfection processes (chlorination and UV), and upstream of final water pH correction systems.

6.1 FLOURIDE DOSE MONITORING

As fluoride can occur naturally in raw water sources, two methods of monitoring fluorine content of the final water shall be required to ensure that concentrations are maintained within the required 0.6 – 0.8 mg/L range:

- a. Total Fluoride Monitoring (i.e. natural fluoride + added fluoride) by an electronic instrument
- b. Added Fluoride Monitoring by manual scales and calculation

6.1.1 TOTAL FLUORIDE MONITORING (INLINE ANALYSER)

The Designer shall install an inline fluorine analyser downstream of the dosing point, at a distance of 40 times the diameter of the process water pipework, or if space within the site boundary is limited, an appropriate distance downstream of a static mixer. This is to ensure that the hydrofluosilicic acid has sufficiently mixed with the process water prior to fluoride concentration measurement. The purpose of the inline analyser is to monitor total fluoride concentrations (i.e. background fluoride concentrations plus fluoride added as part of the treatment process) in water entering the distribution network. As such, the inline analyser shall not provide any control of the fluoride dose. The dose shall be determined on a flow proportional basis only, with the rate of chemical addition per cubic meter of water established during process commissioning.

The analogue signal from the fluoride analyser monitor shall be relayed to the system PLC and be used to generate alarms in the event of the fluoride concentration falling outside of the required 0.60 – 0.80 mg/L range (see Section 9 for alarm thresholds). Where specifically required by Irish Water, the installation may also incorporate a facility to shut off hydrofluosilicic acid dosing based on a set-point fluoride level detected by the downstream monitor. In such circumstances, the Designer's commissioning staff shall set the initial interlock point as 2 mg/L F⁻. The plant operator shall have the ability to adjust the interlock set point in response to site specific water quality / system conditions.

6.1.2 ADDED FLUORIDE MONITORING (MANUAL MONITORING)

In order to monitor the process water fluoride concentrations which are a direct result of artificial fluoridation, the Designer shall implement an electronic weight measurement system as shown in Diagram 1 which shall allow operational staff complete daily *Gravimetric Testing*. For all installations, a handheld colorimeter shall also

be provided to permit daily (or upon each site visit) completion of *Colorimetric Testing* for fluoride concentrations.

Gravimetric Testing

This process allows the fluoride concentration that has been artificially added by the treatment process to be assessed by comparing the weight of hydrofluosilicic acid against the volume of water that has passed through the treatment process in a given period. At as close to the same time as possible on each day (or on each site visit), the measured weight of the day tank shall be recorded (both prior to refilling and following refilling) and the pre-fill weight subtracted from the previous day's post-fill weight to give the precise weight of hydrofluosilicic acid used in the intervening period. The following formula is then used to calculate the theoretical concentration of added fluoride in the process water:

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

The constant 790 represents the available fluoride ion for hydrofluosilicic acid, and the *strength of acid* shall be 0.109 to represent the 10.9% concentration of supplied hydrofluosilicic acid. The resultant fluoride concentration shall be checked against the *Colorimetric Test* result and any discrepancy investigated. The weighing scales shall be constructed of materials resistant to corrosion by hydrofluosilicic acid at 10.9% and be calibrated at least annually.

Colorimetric Testing

Daily (or upon each site visit) colorimetric (reagent based) testing for fluoride shall also be completed using a handheld colorimeter, with results logged and assessed against both the theoretical *Gravimetric Test* result and the reading from the inline analyser. The *Gravimetric* and *Colorimetric* test results should generally align, with the result yielded by the inline analyser being equal or slightly higher. If this is not the case, the discrepancy shall be investigated.

It is imperative that steps must be taken to ensure that daily colorimetric tests, using reliable test methods, are carried out at all fluoridation plants, as this can limit the length of time that consumers are exposed to a significant overdose or under dose of fluoride, providing prompt subsequent corrective action is taken. Contractors shall also ensure that plant operational personnel 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

6.2 CONTROL PANEL LAYOUT

For all independent hydrofluosilicic acid installations, the MCC panels shall take the forms shown in Diagram 2. If a SCADA system is present on site, all signals shall be relayed and mimicked on the main control interface which shall replicate the functionality of the localised hydrofluosilicic acid dosing HMI. Additional pumps, instrumentation etc. may be added as required on a site specific basis. For newly designed treatment plants, green-field builds, or facilities which are undergoing major upgrades which incorporate replacement of MCC facilities, the panel shown shall be incorporated into a common centralised control panel.

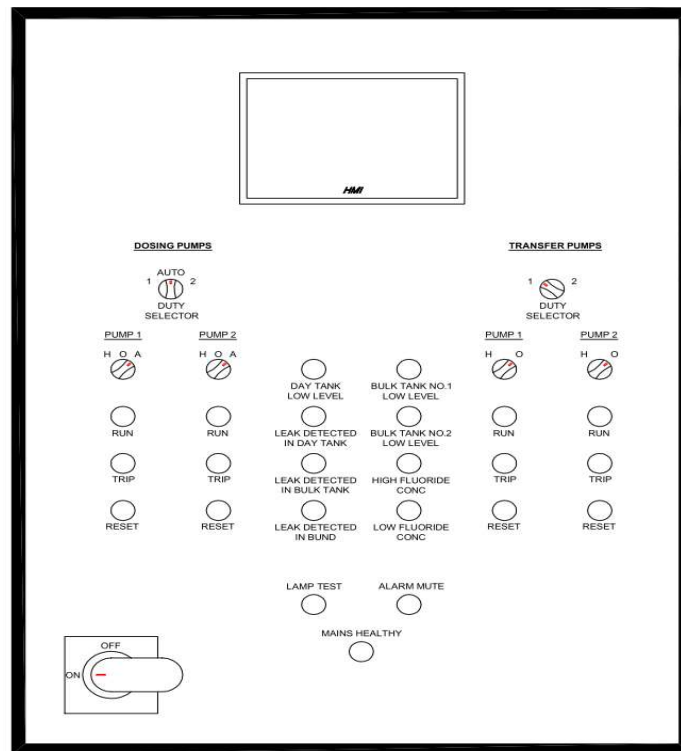


Diagram 2: MCC

Layout for independent

H_2SiF_6 dosing systems

6.3 PLC & HMIFUNCTIONALITY

The Designer shall ensure that the installed fluoridation system has the capability to operate in a fully automated fashion in accordance with Irish Water's requirements, and be capable of maintaining fluoride concentrations in the supply network within the required 0.60 – 0.80 mg/L range as determined during dose optimisation and process commissioning. The system shall be designed to minimise the DWSP hazards listed in Section 1 and to ensure consistent and reliable performance under normal and abnormal operating conditions (i.e. variations in flow, pump failure, etc.). A HMI touchscreen shall provide the plant operator with a visual mimic representation of the installation and will also allow process adjustments to be made in order to optimise the operation of the system. The HMI screen will take the following structure:

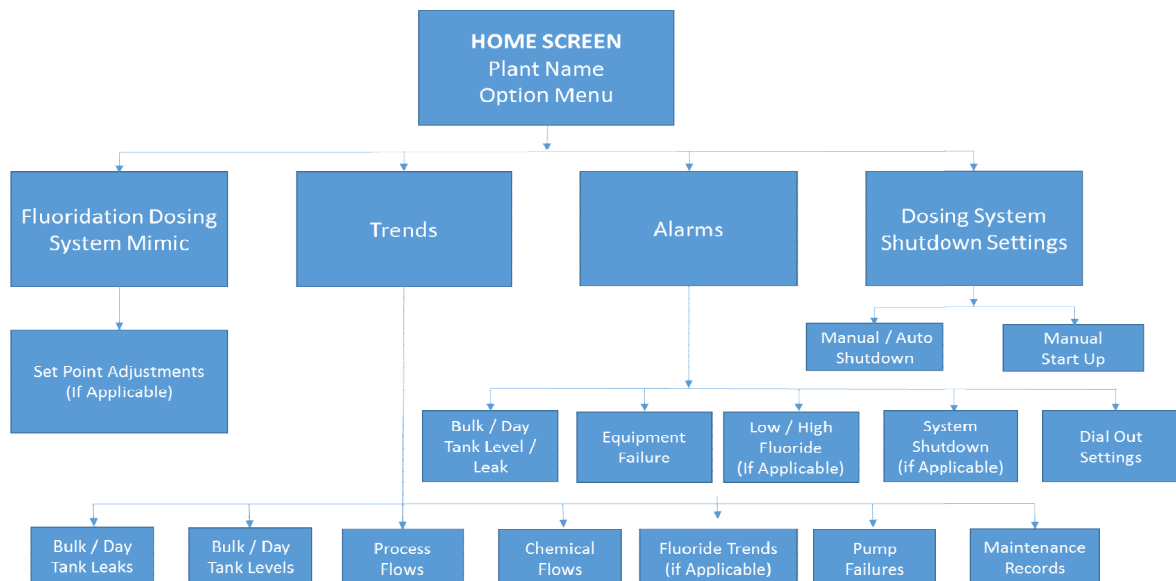


Diagram 3: HMI screen hierarchy for fluoridation system.

Home Screen

The home screen of the HMI shall show the name of the plant and include four icons allowing the plant operator to select which screen he / she wishes to view. The icons shall be labelled as shown above and as follows; Fluoridation System Mimic, Trends, Alarms and Dosing System Shutdown Settings.

Fluoridation System Mimic

The Fluoridation System Mimic will show a precise representation of the site specific design that has been implemented. It should be used as an overview screen which shall allow the operator to both view and make control adjustments to the fluoridation process. Each element of the process shall be represented (bulk tanks, day tanks, bunds, dosing pumps, transfer pumps, actuated valves, instruments and pipework) and signals from each instrument shall be used to allow the current measurement be displayed on the mimic (i.e. the level of hydrofluosilicicacid in each bulk tank shall be displayed in real time beside the bulk tank mimic, the process water flow shall be displayed beside the process water flowmeter mimic, etc.).

The unique tag number for each tank, pump, instrument and item of plant shall also be displayed on the screen beside the mimic of that particular item. If an item of plant has an element of functionality adjustment, then touching its mimic shall introduce a schedule of options which will allow the operator to make adjustments. For example, touching the dosing pump mimic shall open another screen which will allow the operator toggle the duty/standby pumps or adjust the flow proportionality ratio. The mimic of operational pumps should be presented in green, and the standby pump mimic should be presented in black. If a fault signal is returned by one of the pumps or instruments then its onscreen mimic should flash between red and black, allowing the operator to see where a fault has occurred.

Every page on the HMI hierarchy should also incorporate a 'Home' button which will return the user to the Home screen, and a 'Back' button which will return the user to the previously visited page. On pages that allow functionality adjustment, an 'Apply' button should appear if any changes or adjustments are made to the current settings. New settings will not be saved until the operator presses the 'Apply' button, at which point the user will be returned to the previously visited page.

Trends

The Trends page will allow the operator to view historical readings and graphs for the previous 30 days for each of the instruments used on the hydrofluosilicicacid system. This page will also allow the operator to view historical records of pump, instrument and plant failures and enter details of maintenance procedures completed (maintenance dates, type of work that was carried out, date of last delivery). As per previous pages, the trend screen will incorporate a 'Home' button which will return the user to the Home screen, and a 'Back' button which will return the user to the previously visited page.

Alarms

The Alarms page will allow the plant operator to view a historical record of generated alarms for a period of up to 30 days prior to the date of access. This page shall also allow the operator to view the alarm generation set points, but shall not allow their adjustment. The record of generated alarms will show the type of alarm generated and give the date and time that the alarm was raised and inhibited. The alarm screen will

incorporate a 'Home' button which will return the user to the Home screen, and a 'Back' button which will return the user to the previously visited page.

Dosing System Shutdown

The Dosing System Shutdown Settings shall allow the operator to adjust the set points at which an automatic shutdown of the hydrofluosilicic acid pump occurs. Automatic shutdown of the dosing system will also occur upon a 'no-flow' detection from the process water flowmeter or on detection of high fluoride levels (if the latter capability is specified by Irish Water). The HMI screen shall also allow the operator to initiate a manual shutdown if required, and incorporate a function for restarting the system after a manual *or* automatic shutdown has been initiated.

6.4 AUTOMATIC CHANGEOVER OF DOSING PUMPS

The PLC shall be capable of initiating an automatic rotation policy between the duty and standby dosing pumps as well as an automatic changeover in the event of pump or process failure. Pumps shall be wired such that simultaneous operation cannot occur. The same functionality shall apply for all duty / standby transfer pump installations. The rotation policy shall ensure that the pumping workload is distributed over both pumps, and each of the pumps should be capable of operating as the duty or standby unit. Changeover shall take place when one of the following applies;

- On a scheduled time basis (in auto mode) with default 30-day rotation (operator adjustable on the HMI)
- If a fault signal is registered on the duty pump, the standby unit will start and act as a replacement for the failed pump, operating on the same flow proportional basis
- No flow signal generated from one of the chemical flowmeters (if corresponding pump is running)

6.5 SECURITY OF SYSTEM CONTROL

To ensure that precise operational control of the fluoridation system is maintained, a password hierarchy shall be implemented on the HMI screen. There shall be 3 levels of security, as follows:

- Level 1: No password required. Access permitted for all.
- Level 2: Password required. Access permitted for operators and service personnel.
- Level 3: Password required. Access permitted for process commissioners only.

Level 1

Level 1 functions shall be available to all HMI users. Functions shall include display of all settings, mimics, current instrument readings, set-points, alarms and trends, however no adjustment or alterations shall be allowable under Level 1 access.

Level 2

Level 2 functions shall require the HMI user to enter a password to gain access, and should be available to the plant operator and service personnel. All Level 1 functions will be available, but the plant operator and service personnel shall also have access to make changes to certain control functions and set points, including;

- Adjust control of flow proportionality
- Toggle duty pumps, adjust automatic toggle frequency between duty and standby, inhibit one dosing pump to allow for maintenance or replacement

- Adjust target fluoride set-points (if applicable) only as far as the maximum and minimum values as set under Level 3 access
- Adjust cut-in / cut-out level control parameters for transfer pumps (if applicable)
- Adjust bulk tank / day tank high and low level alarm set points (but only within the maximum and minimum range as set under Level 3 access)
- Adjust alarm set points and shut down limits (but only within the maximum and minimum range as set under Level 3 access)
- Select active dial out phone number, or add / change dial out phone numbers to allow alarms to be sent to a number of different caretakers. Also allow for a hierarchy of alarm SMS – i.e. no acknowledgement from active caretaker after (adjustable) time period, then SMS issued to next number on the hierarchy

Level 3

Level 3 functions shall require the HMI user to enter a password to gain access and should be available to the plant initial commissioning personnel. All Level 1 and Level 2 functions will be available, but the commissioning staff shall also have access to make changes to certain control functions and set points, including:

- Adjust dosing pump control (adjust stroke length, stroke frequency and stroke speed)
- Setting of maximum and minimum limits for fluoride target set-points (if required by Irish Water at specific sites)
- Setting of maximum and minimum limits for adjustment of flow proportional control
- Setting of maximum and minimum ranges for bulk tank / day tank level alarms
- Setting of maximum and minimum ranges for all alarm set-points and emergency shutdown triggers

6.6 REMOTE ASSET MANAGEMENT (RAM)

IW has a range of Remote Asset Management(RAM) Policies for a wide range of assets which outline:

- The responses to be taken on foot of an alarm and the associated response time
- An asset management approach to performance monitoring

To facilitate Irish Water's RAM Policy, Designers and Contractors shall ensure that for each fluoridation asset, telemetry systems shall be configured to permit each of the signals outlined in the **IW Signal Provision Standard** (IW-RAM-SPEC-5000-001) to be relayed to the indicated Irish Water monitoring location. IW-RAM-SPEC-5000-001 summarises the signals required in each of the individual RAM policy documents.

7 INSTALLATION AND GENERAL LAYOUTS

Diagrams 4 and 5 included in this section of the document show indicative layouts for outdoor and indoor bulk storage tank fluoridation installations. However the Designer shall note that the outdoor Bulk Storage Tank installations (Section 6.2, Diagram 4) shall be the default layout, with indoor Bulk Storage Tank installations (Section 6.3, Diagram 5) only permissible in certain situations and upon receipt of written approval from Irish Water. Both layouts shall incorporate the General Design features as described in Section 6.1 below.

7.1 GENERAL DESIGN FEATURES

For all installations, the *Fluoridation Room* shall be a fully segregated facility containing no other processes. Only equipment associated with the day storage and administration of hydrofluosilicic acid (i.e. day tank, scales, dosing pumps, instruments, control panel, etc.) shall be permitted for installation in the dedicated *Fluoridation Room*. Each Fluoridation Room shall contain a day tank, electronic weighing scales, dosing pumps, instrumentation and control panel (unless the panel is integrated into a larger centralised MCC).

The *Fluoridation Room* shall incorporate a forced ventilation system which shall operate at all times, and ensure an exhaust rate of 7.5 L/s m^{-2} (as per ANSI/ASHRAE standard 62.1-2004), or alternatively the maintenance of an airborne fluoride concentration below the maximum permissible value of 2.5 mg/m^3 (as a time weighted average over an 8 hour reference period). The fluoridation room shall be equipped with a fluoride gas monitor and the Contractor shall outline to Irish Water at design stage the:

- i. Set points at which 'High Fluoride Gas' alarm is generated [to account for Short Term Exposure Limit (STEL)]. Entry to fluoridation room without respiratory apparatus and appropriate PPE shall be forbidden while a 'High Fluorine Gas' alarm is active
- ii. Maximum time in each 24 hour period that a plant operator can spend in the fluoridation room when fluoride vapours are within acceptable concentrations [to account for an Operational Exposure Limit (OEL)]

The fluoride monitor shall be linked to a flashing red light outside the room, which shall be activated if unsafe gas levels are reached, indicating that it is forbidden to enter the room. It shall also generate an alarm on the system HMI which shall be relayed to the overall plant monitoring system as well as by SMS to a hierarchy of plant operators. There shall be an external override to allow the ventilation rate to be increased to make the room safe to enter following a hazardous occurrence (i.e. elevated gas levels).

Day tanks and valved fill stations should be clearly labelled with its chemical name, its 4 digit UN number and its chemical formula. An emergency shower and eyewash shall be provided at a suitable location as identified by the design risk assessment. The Designer shall ensure that all indoor areas, which contain installations associated with fluoridation systems shall be dry environments that can be maintained at a minimum temperature of 10°C , in all climatic conditions down to a minimum external air temperature of -18°C . This is to be achieved by the installation of a thermostatically controlled heating system.

Bulk storage of hydrofluosilicic acid shall be facilitated in a dedicated and fully segregated outdoor area. Indoor bulk storage of hydrofluosilicic acid shall only be permissible in certain installations with written approval from

Irish Water Asset Strategy. Indoor bulk storage may be permissible where new tank installations (i.e. replacing existing indoor bulk tanks) are required in existing facilities, provided the new tanks safely fit in the existing location. If approved, the *Bulk Storage Room* shall also incorporate a forced ventilation system which shall operate at all times to ensure an exhaust rate of 7.5 L/s m⁻² (as per ANSI/ASHRAE standard 62.1-2004), or the maintenance of an airborne concentration below the maximum permissible value of 2.5 mg/m³ (as a time weighted average over an 8 hour reference period). Indoor Bulk Storage Rooms shall also be equipped with a fluoride gas monitor and, as per day tank storage rooms, the Contractor shall outline to Irish Water at design stage the alarm limits and acceptable OEL times. Each tank will also be vented to the atmosphere to minimise the risk of fluoride vapour build up. The bulk storage volume for the acid chemical shall be determined by the Designer and based on a minimum of 90 day usage as per Section 4.1.

All buildings / rooms which house hydrofluosilicic acid bulk storage facilities shall be fully lockable, with keys provided to site operational staff only. No access to indoor chemical storage facilities shall be permitted without the presence of competent operational staff. This includes access for chemical replenishment deliveries. All indoor storage rooms shall be actively ventilated. 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. As all chemical filling points for indoor installations shall be located within the chemical storage room, all chemical deliveries will require the supervisory presence of the plant caretaker to permit access. Fill points should be located directly over bunded containment areas to capture spillages and provision should be also made for a lockable ball shut off valve to prevent backflow of chemical when the supply hose is disconnected, and to guard against any unauthorized filling without the presence of appropriate site personnel.

An audible and visual alarm activated by the ultrasonic level sensor mounted in each bulk tank shall allow the chemical delivery operator to determine when the tank is full without monitoring the levels on the HMI screen. The visual element of this alarm shall take the form of a traffic light system mounted over each of the bulk tanks in the storage room/area (one traffic light for each bulk tank). When the bulk tank is at 20% of its capacity, the red light shall be activated. When the tank is above 20% and below 40% of its capacity, the amber light shall be activated to show that the tank is filling. When the tank is above 40% of its capacity, a blinking green light shall be activated. Once the tank is at 90% of its capacity, the green light shall activate indicating that filling should cease. Once the green light is activated, the audible alarm will also activate and remain on until muted at the control panel. The traffic light system can remain active over each of the bulk tanks during normal operations as a means to notify the plant operator that chemical replenishment is required. 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. Designs shall be completed in such a way to ensure direct line of sight between the fill point and the destination tanks to ensure operational staff / delivery personnel can observe the tank while filling.

Transfer pumps may be installed within the day tank bund or within the bulk storage tank bund, but clear and reasonable access to the pumps shall be maintained for servicing and maintenance operations. Transfer pipework shall, at some point on its route, extend above the maximum possible liquid level in the Bulk Storage Tank to render gravity discharge to the day tank impossible. Note that initiation of the transfer pumps shall not

be automated, and replenishment of the day tank shall require the manual intervention and continuous presence of the plant operator (i.e. a 'dead man's switch' - the plant operator shall be required to hold the transfer pump 'Run' button / switch in place in order to replenish the day tank – once the button / switch is released, transfer pumping shall cease). The "dead man's switch" for activation of the transfer pump should be installed in a location that allows full and unobstructed viewing of the translucent day tank, to permit the plant operator to observe the day tank as it fills. All pipework connections to the day tank shall allow for vertical movement on the weighing scales.

If the designer proposes that the fluoridation system is to be installed in existing rooms / buildings, then they shall demonstrate the suitability of that building for use, i.e. show how all other processes will be removed from the building and adequately relocated, demonstrate that the building is large enough to accommodate the proposed fluoridation system and show how the design will be implemented within the existing structure in accordance with the indicative layout Diagrams 4 and 5. The designer shall also ensure direct and unobstructed access to the bulk tanks for chemical replenishment is available at all times, with transfer distances kept to a minimum and lines of sight between fill points and destination tanks kept clear.

In their proposal to convert an existing building, the designer shall allow for all such modifications to ensure that the building is exclusively used for the purposes of fluoridation and should also allow for any remedial works which may be required to ensure the building has adequate heat insulation, security against unauthorised access, forced air ventilation to the outside of the building, lighting, power supply, water supply and is structurally sound. Existing blockwork walls will not be permitted to act as bunded containment – all concrete bunds proposed shall be purpose built, of cast in-situ construction, and in accordance with BS EN 1992-3 Design of Concrete Structures for Containing and Retaining Liquid, even if proposed within existing rooms or buildings.

The containment bund shall be constructed without drains, and shall be protected against spillage of hydrofluosilicic acid by a suitable concrete surface protection coating (two part epoxy coating, neoprene or other suitable chemical resistant lining), applied in accordance with manufacturer's instructions. Leak detection level indicators shall be provided in all bunds, and shall be of probe type (conductivity probes, capacitance probes, etc.) or float type instruments. Ultrasonic level probes will not be permitted for use as leak detection as they may return a loss of echo signal during normal operation. Irish Water will reserve the right to reject any proposed layout design that does not meet the above criteria.

Unless proposed in a polymeric 'tray' type bund (only applicable to day tanks ≤ 250 litres), dosing pumps shall be installed in an enclosed cabinet in an accessible position outside of the day tank bund. All pumping accessories such as flow meters and calibration tubes should be contained within this cabinet, which shall be installed at chest height on an adjacent wall. Note that the dosing cabinet may not be supported by the bund wall surrounding the storage tanks. If the specified pumps are too large to fit in the dosing cabinet, then they shall be enclosed in a dedicated bund (separate to the bund containing the day tanks).

Each of the flowmeters shall be capable of being isolated by upstream and downstream valves so that they can be safely and easily removed if calibration, maintenance or replacement is required. All suction pipework should also be provided with foot valves and ceramic weights so that the dosing pumps prime is maintained at

all times and all pipe routing is to be designed to minimise gas locks and should be in accordance with WIMES 8.02. All valves throughout the system should be easily accessible by the plant operator. Outdoor actuated valves shall be insulated and heat traced to operate effectively in external temperatures as low as -18°C. Similarly, isolation valves for the dosing pumps and chemical flowmeters should be contained within the dosing cabinet enclosure.

All injection fittings are to include an isolation valve and shall be mounted vertically and perpendicular to the process water pipeline. Below ground injection points for 10.9% hydrofluosilicic acid shall be permitted, and if proposed, a below ground chamber with sufficient space provided to allow routine or preventative maintenance to be carried out shall be provided. Underground piping should be enclosed in a sloped conduit with an inspection chamber downslope for detection of hydrofluosilicic acid leaks. Flow meters shall be required where proposed pumps do not incorporate a digital display showing instantaneous and totalised flow rates.

The installation location of equipment should not interfere with the day to day operational duties of the plant, and shall not cause an obstruction to routine operational duties. Handwash facilities shall be located at an accessible location close to the door of the fluoridation room. For all fluoridation system layouts proposed, the Designer shall ensure that direct and unobstructed access to the bulk acid tanks, day tank, pumping systems, control systems, instruments, dosing points, etc. is available at all times to allow completion of routine operational duties.

7.2 INDICATIVE FLUORIDATION LAYOUT (OUTDOOR BULK STORAGE TANK)

Diagram 4 overleaf shows an indicative layout of an outdoor fluoridation installation, with externally mounted bulk storage tanks. Outdoor installation of hydrofluosilicic acid bulk storage tanks is the default Irish Water requirement, and shall be provided at all new builds and new installations on existing sites. Indoor installation of hydrofluosilicic acid bulk storage tanks shall only be permissible upon receipt of a written agreement from Irish Water Asset Strategy. All outdoor bulk storage tanks shall be supplied with an integrated and weather shrouded polymeric bund, each with a leak detection level instrument. Open topped concrete bunds will not be permitted on outdoor bulk storage tank installations. All outdoor bulk storage tanks shall incorporate a heating system which shall be thermostatically controlled to automatically maintain the temperature of the hydrofluosilicic acid above 5°C during all climatic conditions in which external air temperatures fall to -18°C. The freezing point of 10.9% hydrofluosilicic acid is -16°C but crystallisation of the acid can occur at -10°C.

The dedicated *Fluoridation Room* is to be temperature regulated and adequately ventilated. No other chemicals or processes shall be accommodated in the *Fluoridation Room*. The diagram overleaf omits the emergency shower, as its precise installation location will be determined by the completion of the General Risk Assessment as described in Section 3. In the indicative case outlined below, an external and climatically protected emergency shower and eyewash may be the most appropriate solution, as it could be installed at a location where it serves both the *Fluoridation Room* and the *Bulk Storage Area*, provided it is within the maximum distance of 10m from a potentially hazardous area.

In the diagram overleaf, installation of the emergency shower and eyewash within the *Fluoridation Room* would not be permissible, as access to the emergency washing facilities could be inhibited if the *Fluoridation Room* door was locked during the occurrence of a hazardous incident in, or adjacent to, the *Bulk Storage Area*.

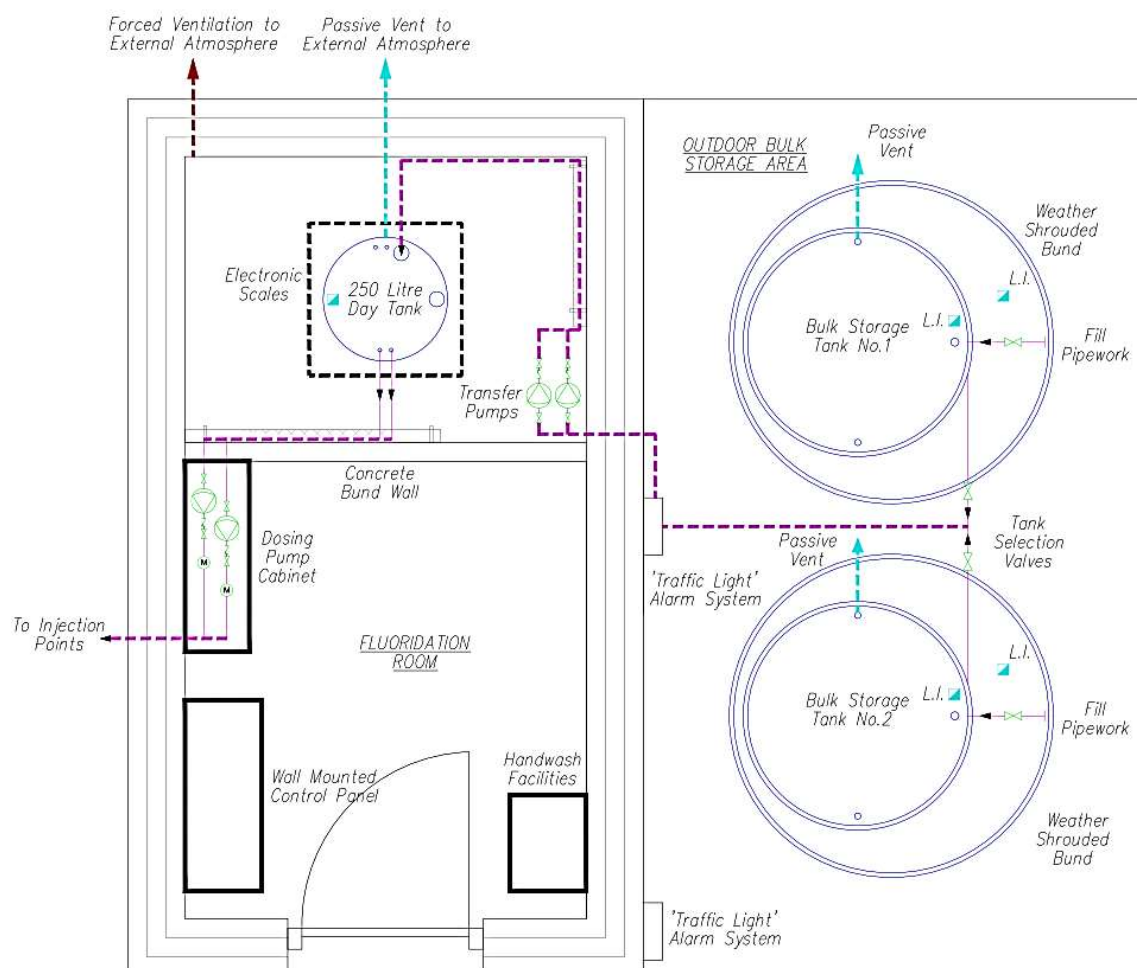


Diagram 4: Indicative layout of outdoor fluoridation BST installation (outdoor Bulk Storage Tank installation with fully segregated Fluoridation Room).

7.3 INDICATIVE FLUORIDATION LAYOUT (INDOOR BULK STORAGE TANK)

Diagram 5 overleaf shows an indicative layout of an indoor Bulk Storage Tank installation. Indoor bulk storage of hydrofluosilicic acid shall only be permissible in certain situations, and upon receipt of a written agreement from Irish Water Asset Strategy. One such situation may be where existing bulk storage tanks that are housed in an existing bulk storage room are scheduled for replacement. In such cases, direct replacement of BSTs within the bulk storage room shall only be permissible when tanks will safely fit within existing facilities.

Where approved by Irish Water, indoor installation of hydrofluosilicic acid bulk storage tanks shall be facilitated in a dedicated and fully segregated *Bulk Storage Room*, separate from the dedicated and segregated *Fluoridation Room*. Both rooms are to be temperature regulated and adequately ventilated. No other chemicals or processes shall be accommodated in either the *Fluoridation Room* or *Bulk Storage Room*.

Diagram 5 overleaf omits the emergency shower, as its precise installation location will be determined by the completion of the General Risk Assessment as described in Section 3. In the indicative case outlined overleaf,

an external and climatically protected emergency shower and eyewash may be the most appropriate solution, as it could be installed at a location where it serves both the *Fluoridation Room* and the *Bulk Storage Room*, provided it is within the maximum distance of 10m from a potentially hazardous area.

In Diagram 5 below, installation of the emergency shower and eyewash within the *Fluoridation Room* would not be permissible, as access to the emergency washing facilities could be inhibited if the *Fluoridation Room* door was locked during the occurrence of a hazardous incident in, or adjacent to, the *Bulk Storage Room*.

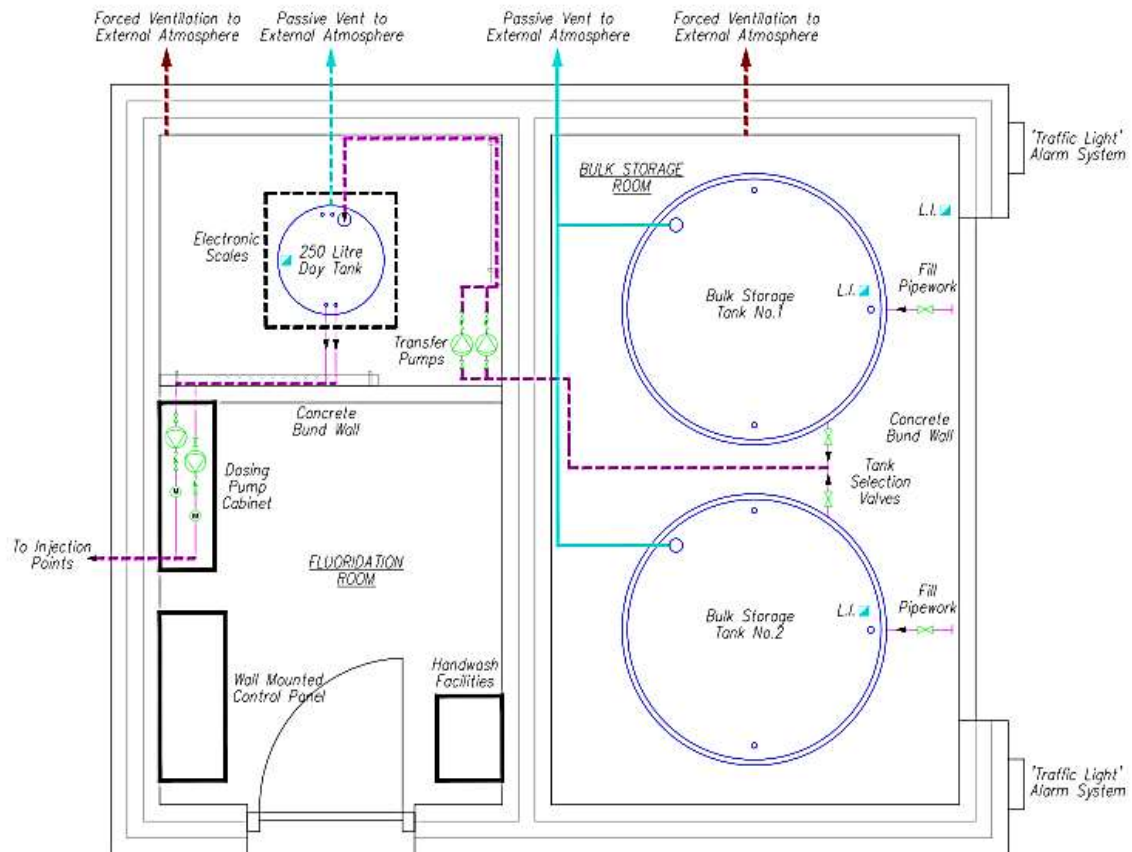


Diagram 5: Indicative layout of indoor fluoridation BST installation (indoor Bulk Storage Tank storage with fully segregated Fluoridation Room and Bulk Storage Room)

8 EQUIPMENT AND MATERIALS SPECIFICATION

The Designer shall ensure that all equipment proposed for installation as part of replacement works, upgrade works (full or partial), or development of new build fluoridation systems shall be in accordance with the following industry specifications:

- **IW-TEC-900-13** Irish Water Design Specification: Chemical Storage
- **WIMES 8.02** Chemical Dosing Equipment (General Requirements)
- **WIMES 3.01** Low Voltage Switchgear and Controlgear Assemblies

The above documents, in tandem with this specification, shall form the basis of equipment selection, material selection, installation and testing for all hydrofluosilicic acid dosing systems and, be used as a reference point by Designers to ensure compliance with Irish Water requirements.

In addition to the particulars outlined in the aforementioned documents, Irish Water has a range of specific requirements for each major equipment item, which are outlined in the following sections. Note that where an Irish Water requirement contradicts a WIMES clause, the Irish Water requirement shall take precedence.

8.1 BULK STORAGE TANKS AND FILL LINES FOR HYDROFLUOSILICIC ACID

All bulk storage tanks (and integrated polymeric bunds) proposed for containment of 10.9% hydrofluosilicic acid shall be designed to facilitate liquid deliveries made in accordance with Section 6.2 of WIMES 8.02. All bulk storage tanks shall be specifically designed to store liquid with a minimum specific gravity of 1009 kg/m³ (i.e. the density of 10.9% hydrofluosilicic acid) plus a minimum factor of safety of 20%. They shall have a minimum design life of 20 years (or 1000 cycles, if it corresponds to longer than 20 years). They shall be stored on a continuous, horizontal smooth flat surface such as a load bearing concrete pad. All concrete that may come into contact with hydrofluosilicic acid shall therefore be of an acid resistant grade, or alternatively, be coated with an appropriate acid resistant protective lining.

Bulk storage tanks and day tanks for hydrofluosilicic acid shall conform to the following standards where applicable:

- BS EN 12573 Welded static non-pressurised thermoplastic tanks
- BS EN 13121 GRP tanks and vessels for use above ground
- BS EN 13575 Static thermoplastic tanks for the aboveground storage of chemicals
- BS EN 13923 Filament wound FRP pressure vessels. Materials, design manufacturing & testing
- UK Health and Safety Executive advice to users – GRP vessels and tanks
- UK Health and Safety Executive advice to users – thermoplastic tanks

Manufacturer's advice shall always be sought prior to purchase, and certification of the tank shall always be required. Bulk storage tanks shall be constructed from one of the following materials:

- High Density polyethylene (HDPE) (tanks < 1000L)

- Polypropylene (PP) (tanks < 1000L)
- uPVC or PP lined GRP (tanks > 1000L)
- Rubber coated steel (tanks > 1000L)

All rigidfill lines shall be manufactured from uPVC and shall be adequately supported to withstand mechanical vibration / impact during filling. Associated valves shall be constructed from Hastelloy, uPVC, PP or PE. Thermoplastic valves may be used on smaller tanks (<1000L). Moisture traps and meshed covers shall be fitted at all venting / overflow pipework to prevent moisture / vermin ingress. The prevention of moisture ingress is necessary to prevent altering of the acid concentration within the bulk storage tank, which may affect fluoride concentrations within the process water supply. All tanks shall have a dedicated fill pipe with non-return valve, with the filling connection accessible at low level for connection to the delivery tanker hoses. Drip / spill containment is required if it is not possible to install the filling connection over an unobstructed area. Vent(s) shall be provided on all bulk tanks and should be sized at 100-150% of fill pipe diameter to prevent excess pressures or vacuums during filling. Vents shall be terminated at a suitable external location, remote from air intakes, doors, windows, and parked vehicles, with a fine corrosion resistant mesh to prevent contamination.

Bulk storage tanks, day tanks and valved fill stations should be clearly labelled in accordance with the *Safety Health and Welfare at Work (General Application) Regulations 2007*, Chapter 1, Part 7: Safety Signage. The chemical name, its 4 digit UN number and its chemical formula shall be clearly displayed on all such labels. The tank placard shall also contain the manufacturer, date of commissioning, design life, nominal/max delivery temperatures and the tank material. In order to ensure that the correct bulk tank is being replenished, and that chemical delivery personnel cannot access the fill point without the presence of the plant operator (thereby minimising risk of incorrect chemical being delivered), all outdoor located fill points shall be located within locked covers and all indoor storage tank fill points shall be located within a locked chemical dosing area. The draw-off point from the bulk tank to the day tank should be situated close to the base of the tank, otherwise the effective capacity of the tank will be reduced. Tanks should be located where all parts of the outer tank surface are accessible for visual inspection of leaks.

BST installation in open outdoor concrete bunds shall not be permitted. All outdoor tanks proposed shall incorporate an integrated polymeric weather shrouded bund. Each self-contained bund shall also incorporate a leak detection system to alert the operator of a bulk tank failure. Self-contained bund capacity shall be 110% of the storage capacity of the bulk tank. At the time of installation and commissioning of the tank, the expected working lifetime of the tank shall be ascertained and recorded, with a view to having a replacement schedule in place. All concrete bunded areas should be integrity tested in accordance with BS EN 1992-3 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". Drainage from bunded areas should be diverted for collection and safe disposal.

Hydrofluosilicic acid is extremely corrosive to many base metals, including aluminium, copper and iron, and should not be allowed to come into contact with unalloyed steel or galvanised surfaces. The chemical is also extremely corrosive to concrete, and may cause rapid disintegration if in contact. All concrete that may come into contact with hydrofluosilicic acid shall therefore be of an acid resistant grade, or alternatively suitably

lined with a dual layer of epoxy undercoat and urethane topcoat. The designer shall consult with a lining specialist for all concrete plinths, bunds, and other concrete infrastructure proposed for use with hydrofluosilicic acid storage and dosing facilities.

8.2 DAY TANKS FOR HYDROFLUOSILICIC ACID

All storage tanks shall be specifically designed to store liquid with a minimum specific gravity of 1009 kg/m³ (i.e. the density of 10.9% hydrofluosilicic acid) plus a minimum factor of safety of 20%. The maximum capacity of the day tank must be as close to sufficient to treat one day's maximum water output for the plant as practicable, but the level cannot become too low as to cause an air-lock in the dosing system. Where existing day tanks have capacities in excess of 3 days usage, a clearly identifiable maximum fill line should be affixed to the tank, and a procedure implemented to ensure that filling above this line does not take place. Each day tank shall be provided with level measurement instrument, and the bund will incorporate a leak detection system which will also take the form of a point level measurement device. The day tank shall be installed on an industrial electronic weighing scales, to allow for daily monitoring of fluoride consumption, and thus expected fluoride levels in the drinking water. The day tank shall be replenished daily (or on the occasion of each operational visit) by the manual activation of the transfer pumps. This shall only be completed by appropriately trained plant personnel.

All day tanks, and where applicable, polymeric bunds proposed for containment of 10.9% hydrofluosilicic acid, shall be constructed from one of the materials listed below.

- High Density Polyethylene (HDPE) (tanks < 1000L)
- Polypropylene (PP) (tanks < 1000L)

They shall have a minimum design life of 20 years (or 1000 cycles, if it corresponds to longer than 20 years). Note that day tanks in excess of 1000 litres shall not be permitted without prior approval from IW Asset Strategy. The material of manufacture of the day tank should be translucent, with an easy readable graduated volume scale on the tank exterior, or have a suitable alternative contents volume indication system. This is to allow visual assessment of the level of acid in the tank. 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.

All transfer pipework shall be manufactured from uPVC. Note that uPVC pipework shall be adequately supported to withstand mechanical vibration / impact during chemical transfer. Associated valves shall be constructed from Hastelloy, uPVC, PP or PE. Moisture traps shall be fitted to prevent moisture ingress into venting / overflow pipework. This is to prevent altering of the acid concentration within the bulk storage tank.

All concrete bunded areas should be integrity tested in accordance with BS EN 1992-3 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" and shall have level sensors.

8.3 DOSING PUMPS

Unless specified by the site specific work order requirements, a minimum of two dosing pumps operating in a duty / standby configuration, shall be provided for each fluoridation installation. Upon failure of the duty

pump, the standby pump shall be automatically initiated and an appropriate alarm raised. All pumps shall be mounted adjacent to the day tank, in a dedicated dosing pump cabinet manufactured from materials in accordance with WIMES 8.02. Fluoridation dosing pumps shall operate on flow proportional control only. Each dosing pump proposed should comply with Section 6.5 of WIMES, with the exception of Irish Water's specific dosing pump requirements, as outlined in Table 5. As hydrofluosilicic acid generates fumes while in storage, all dosing pumps shall incorporate degassing valves which will enable their continued reliable operation.

Description	Criteria	Notes
Pump Type	Electronic diaphragm type – adjustable stroke length and frequency	Required for precision flow proportional and dosing at low flows
Pump Turn Down Ratio	Minimum of 1:800	Required for precision flow proportional and dosing at low flows
Dosing Control	mg/L, flow pulse or 4-20mA	Input from process water flowmeter and system shutdown facility based on a target fluoride level as measured by fluoride analyser (where specified by Irish Water)
Fault Detection	Over/under pressure protection, no flow, trip	Built in digital I/O for fault signal generation to PLC.
User Display	mg/L, ppm, l/h, totaliser, fault	-
PLC / SCADA Interface	Fieldbus	-

Table 5: Specific requirements for hydrofluosilicic acid dosing pumps.
All additional requirements as per WIMES 8.02

All parts (dosing head, suction/pressure connectors, ball seats, seals, etc.) in contact with the dosed chemical are to be made of materials suitable for use with 10.9% hydrofluosilicic acid (hastelloy, PVC, PP, and PE). Diaphragms shall be constructed of PP or CSM Rubber (Hypalon), and valve seals shall be constructed of Viton.

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. Each pump is to be suitable for use with a 220V – 230V, 50 Hz, single phase power supply and shall remain operational within permissible ambient temperatures of -10°C to +45°C. Each proposed pump shall also have an ingress protection rating of IP65, and an insulation class F. Dosing pumps should be hard-wired to prevent by-pass of controls. System wiring shall ensure that both pumps cannot be operated simultaneously as this could result in twice the intended dose of fluoride in the water.

When installed, the suction line for each pump shall incorporate a strainer and a foot valve in order to keep each pump primed and prevent air-locking throughout the duty cycle of the day tank (i.e. varying chemical levels within the tank). The pump should not be sited more than 1.2 metres above the lowest normal level of the contents of the day tank. Strainers, valves, pipework, etc. with high corrosive resistance to 10.9% hydrofluosilicic acid shall only be proposed for each installation. To prevent overdosing, all fluoride dosing shall be inhibited upon receipt of a 'no flow' signal from the controlling process water flowmeter. The dosing system in all cases shall be fitted with back pressure, anti-siphon, pressure relief and degassing valves.

8.4 TRANSFER PUMPS

Transfer of hydrofluosilicic acid between bulk storage and day tanks shall be facilitated by controlled centrifugal pumping, by a duty / standby set of transfer pumps sized to fill the day tank within 5 – 10 minutes of operation. All wetted parts of transfer pumps are to be made of materials suitable for use with 10.9% hydrofluosilicic acid (hastelloy, PVC, PP, and PE). Transfer pumps are to be installed within the day tank bund or within the bulk storage tank bund, but also retain the ability to be inspected without accessing the bund. As hydrofluosilicic acid generates fumes while in storage, all transfer pumps shall be supplied with degassing valves to enable their continued and reliable operation and to prevent the air-locking of the chemical transfer system.

The transfer pump shall incorporate a non-return valve arrangement to prevent backflow and an anti-siphon device to prevent uncontrolled discharge to the day tank. Transfer pumps shall not permit gravity flow from the Bulk Storage Tank to the day tank, and as an added measure to protect against uncontrolled discharge, all pipework between the Bulk Storage Tank and the day tank shall be arranged in such a way that makes gravity discharge impossible (i.e. the delivery pipework should rise vertically to a level higher than the highest fill point of the Bulk Storage Tank – see Diagram 1).

Note that initiation of the transfer pumps shall not be automated, and replenishment of the day tank shall require the manual intervention and continuous presence of the plant operator (i.e. a ‘dead man’s switch’ - the plant operator shall be required to hold the transfer pump ‘Run’ button / switch in place in order to replenish the day tank – once the button / switch is released, transfer pumping shall cease). The control panel for activation of the transfer pump should be installed in a location that allows full and unobstructed viewing of the translucent day tank, to permit the plant operator to observe the day tank as it fills.

8.5 ELECTRONIC SCALES

The day tank shall sit on a floor mounted industrial electronic weighing scales that shall be used to record the daily usage of fluoride. The scales shall be appropriately sized to ensure the recorded weight is within calibration up to 105% of the weight of the full day tank. The scales shall be of material which is resistant to corrosion from 10.9% hydrofluosilicic acid, and shall be installed within the day tank containment bund. A digital display mounted on the wall of the fluoridation room shall accurately display the weight in kg, accurate to 2 decimal places, of hydrofluosilicic acid currently held in the day tank, and shall also relay such readings to the control system PLC. This reading will be used to perform the volumetric tests as outlined in Section 5.1.2. If required by the site specific work order requirements, an algorithm shall be included in the fluoridation system control programme to automatically calculate the theoretical fluoride concentration using the formula outlined in Section 5.1.2.

8.6 HANDWASHING FACILITIES

Handwash facilities for hygiene practices shall be located close to the door of the fluoridation room, and be easily accessible to operational staff entering or leaving the premises. A hot and cold water supply shall be available at the sink, and a soap dispenser and electric hand drier shall be wall mounted nearby. All

equipment, pipework and fittings shall be of material which is resistant to corrosion from 10.9% hydrofluosilicic acid.

8.7 EMERGENCY SHOWER AND EYEWASH

Emergency showers and eyewash stations shall be 'plumbed-in' systems in accordance with ANSI-Z358.1 American National Standard for Emergency Eyewash and Shower Equipment. Emergency washing facilities shall provide an adequate flow of flushing fluid, dispersed in a pattern as to maximize rinsing of the body / eyes for a minimum of 15 minutes (or higher if specified in the SDS). Delivery of the wash water shall come from overhead, and provide sufficient body coverage at the minimum height and dimensional requirements detailed below.

The shower and eyewash shall have both a hand and foot pedal operating system that shall continue to be operated until the valve is manually closed by the operator. Wash-stations shall have a header tank with a minimum volume of 1200 L which ensures sufficient pressure and capacity in the event that two showers are operating simultaneously. Header tanks shall be mains fed and fitted with 2 No. ballcocks, and the inlet pipe shall allow for a maximum 30 minute replenishment of tank during periods of no discharge.

All showers and eye washing facilities shall be self-draining, therefore eliminating the need for heat tracing, but shall take no longer than 3 seconds to fully re-pressurise following activation. Pipework system design for the emergency shower and eyewash station shall ensure that all pipework is flushed during normal maintenance and shall avoid where possible the creation of dead legs. A facility for manual drainage shall be provided from all units and provision shall be made for drainage of header tanks for testing and maintenance.

Shower frames shall be of rigid construction, and the complete shower and pipework installation shall be of corrosion resistant material coated where necessary to provide low maintenance and reliable long term operation. Eyewash stations shall be mounted adjacent to the shower or on the rear of the stand-pipe. Indoor units shall include a shower cubicle constructed in galvanised and painted steel frame, and green panelling for high visibility.

The following equipment and installation specifications shall apply for all emergency shower and eyewash installations:

- Shower head:
 - Positioned 208 – 244 cm from floor
 - Spray pattern will have a minimum diameter of 50 – 153 cm above the floor
 - The centre of the spray pattern shall be located at least 50 cm from any obstruction
 - Delivers conical deluge of water
- Valves:
 - Activate in 1 second or less
 - Stay-open valve (no use of hands)
 - Valve remains on until the user shuts it off
- Flow rates:
 - Shower/body wash: 76 l/min

- Facewash: 12 l/min
- Hand held eyebath: 4.5 l/min
- Materials must be corrosion resistant:
 - Pipework: galvanised carbon steel/stainless steel encased in a PVC-U jacket and insulated with polyurethane and/or polystyrene
 - Shower heads: anodised cast aluminium
 - Facewash bowls: stainless steel or ABS plastic

As hydrofluosilicic acid requires Priority 1 installation of emergency showers and eyewashes, site telemetry systems must be capable of issuing the below alarms when the shower or eyewash is activated. The system shall also permit the disablement of the alarm during testing procedures:

- Emergency Shower activated signal (local alarm and possibly remote alarm via telemetry)
- Emergency Eyewash station activated signal (local alarm and possibly remote alarm via telemetry)
- High water temperature signal (local alarm only)
- Low water temperature signal (local alarm only)
- High water level signal (local alarm only)
- Low water level signal (local alarm only)
- Local temperature gauge

Designers, Contractors and operators shall note that there is a requirement to regularly test the Emergency Shower and Eyewash Facilities. Plumbed emergency showers shall be activated weekly to verify correct operation. All showers shall be inspected annually to ensure compliance with the relevant standards. Where the Risk Assessment has shown a need for remote monitoring a facility adjacent to the shower to disable the telemetry alarm while testing is being carried out shall be provided to prevent false alarms being transmitted. The telemetry signal shall have an automatic re-enable function to ensure that alarms cannot be left disabled when testing is completed.

Emergency Shower and Eyewash Station signs shall be clearly displayed in colours associated with this equipment to design standard ISO 3864 – 1: 2011. This standard establishes the safety identification colours and design principles for safety signs and safety markings to be used in workplaces. Location signs shall also be provided such that Emergency Showers and Eyewash Stations are easily located during all periods when the works is manned.

8.8 CONTROL PANEL, HMI AND PLC

For fluoridation installations that are part of the design of an entirely new treatment facility, or that are being completed in conjunction with a major upgrade of a treatment plant's entire control system, the control equipment may be incorporated into a centralised panel which may be installed in a dedicated control room, in a location remote from the fluoride dosing room. The fluoride dosing panel shall take the form of the panel into which it is being incorporated.

Control panels that are installed as part of a stand-alone system may be of Form 2 construction and shall be laid out as per the general arrangement shown in Diagram 2. Panels for this type of installation shall be wall mounted and shall incorporate both power distribution and signal terminations for all items of plant and instrumentation, as well as all necessary breakers, transformers, starters and ancillary equipment required for a fully functional control system. The panel should be constructed of 1.5mm thick high grade sheet steel and have a powdered and baked enamel finish to RAL7032, 50µm in depth. Cable entry may be top or bottom, whichever best suits the individual installation. The door to each panel should be hinge mounted and when shut shall provide an ingress protection rating of IP65. Where the panel is at risk of water ingress from an adjacent emergency washing facility, the ingress protection rating shall increase to IP66.

As well as all required control panel functions, it shall also incorporate 2 No. 220 volt domestic outlets, accessible by opening the panel door. The panel shall be constructed in accordance with WIMES 3.01 – Low Voltage Switchgear and Controlgear Assemblies and shall incorporate lightning protection systems and uninterruptible power supplies (UPS) in order to protect and maintain all instruments in the event of power surges or losses.

The PLC provided shall have sufficient digital and analogue I/O to accommodate all functionalities required by the fluoridation system as described in this document, and also be capable of expansion should additional I/O signals need to be incorporated. The unit shall also incorporate an SD card port to allow logging, backup and cloning of the PLC code. An Ethernet port shall be provided on the PLC and to enable connection to an external GPRS device to issue and receive signals by radio transmission. All information shall be made available via Modbus/TCP for relay to the plant telemetry system. The HMI screen shall have a minimum diagonal dimension of 175 mm and shall have full ‘touch screen’ capability, allowing all control functions as described in Section 5.3 of this document. Touch properties should be capable of being applied to all text and graphical on-screen elements and a HMI troubleshooting function should be available to eradicate the requirement for an onsite PC. Combined PLC and HMI units are acceptable to Irish Water.

The control system should also incorporate a dial out facility which is capable of issuing text message or e-mail alarms to plant operators, with a function on the HMI screen that will enable a range of mobile phone numbers to be inputted on the touch screen. A hierarchy of contacts shall also be programmable via the HMI, with text based alarms being sent to the primary contact number.

The dial out should wait for an acknowledgement response for a pre-set adjustable period of time until the text alarm is then issued to the secondary contact number. Once a text acknowledgement is received by the dial out, the text alarm shall no longer be sent, however visual alarms shall remain displayed on the HMI and, if applicable, SCADA screen.

8.9 INSTRUMENTATION

The instrumentation required to provide a fully automated and reliable hydrofluosilicic acid system is detailed in Irish Water’s Remote Asset Management Policy (IW-RAM-SPEC-5020-0009). All instruments shall be in accordance with WIMES 8.02 Section 6.10, and associated guidance text. All light and fan switches should not be located within the fluoride room.

Ultrasonic Level Indicators

All ultrasonic level sensors used in this installation shall be suitable for use with hydrofluosilicic acid at 10.9%, and be capable of issuing two 4-20mA analogue signals to within $\pm 1\%$ accuracy of range and a minimum of 3 relay signals. Sensors and controllers shall be rated to IP68 and shall have a measurement range of 0.3 to 6.0 metres. Controllers shall be wall mounted and installed adjacent to the hydrofluosilicic acid control panel, or within the instrumentation/control room if the control panel has been incorporated into a centralised MCC.

Point Level Indicator (Leak Detection)

All point level indicators used in this installation shall be suitable for use with hydrofluosilicic acid and be capable of issuing a digital signal to the system PLC. Point level indicators may only be used as leak detection instruments and are not permitted for installation as stock level management instruments.

Process Water Flowmeters

Process water flow measurement is to be achieved by the use of electromagnetic flowmeters, lined internally. The external casing of the flow meter shall be epoxy coated carbon steel and rated for a pressure of up to 16 bar, with PN16 oriented flanges. Flow meter controllers shall be wall mounted and capable of issuing a 4-20mA analogue (live measurement) and a digital signal (bulk measurement) to the control PLC to within 1% accuracy of range, with a minimum flow velocity of 5 metres/second.

Chemical Flowmeters

Chemical flow measurement is to be achieved by the use of wall mounted ultrasonic flowmeters, to best accommodate pulsing flows generated by diaphragm or stepper motor driven metering pumps. All internal or wetted parts are to be resistance to corrosion by contact with hydrofluosilicic acid, using chemically resistant parts manufactured from hastelloy, PVC, PP, PE or similar. The flowmeter should be capable of issuing a 4-20mA output signal and generate a flow measurement of $< 2\%$ accuracy of range. Connections should be available to accommodate a range of hose sizes and the instrument should be rated for a maximum operating pressure of 16 bar.

Fluoride Monitors

Constant monitoring to ensure that the fluoride concentration in public piped water supplies is maintained within the correct limits is essential. Fluoride monitors shall be on-line colorimetric analysers, which shall be mounted internally and continuously supplied with sample(s) from water downstream of the reservoir, complete with support tray for reagents and deionised water. The Designer shall ensure that sufficient contact time has been allowed for the fluoride chemical to mix with the process water before the point of sample take off (i.e. a distance of 40 times the process water carrier pipe diameter, or immediately downstream of a static mixer). The fluoride monitor itself shall be suitable for the continuous measurement of fluoride in aqueous solutions utilising fluoride ion electrode measurement technique.

The monitor shall be of robust construction, suitable for use in an industrial application, with an undiluted fluoride measurement (as F⁻) range from 0.05 -10 mg/L -at an accuracy of ± 0.01 mg/L and an automatic cleaning process. The monitor shall be capable of automatic calibration with the option for manual calibration and shall have a colour HMI display, embedded web server and text message/e-mail notification capability. The monitoring instrument shall be provided with an approved controller, which shall be capable of issuing a 4 -

20mA signal to the main system PLC, which represents the fluoride measurement of the final process water. The probe and support tray shall be installed indoors, and shall have an operating range of 1°C to 35°C.

Pipework, Valves, Fittings & Accessories

All necessary hoses, pipework, fittings and control valves shall be of materials which have a high resistance to degradation by hydrofluosilicic acid solutions at the concentrations specified (10.9%). If proposed as part of the installation, all of the following peripherals associated with a hydrofluosilicic acid based system shall be manufactured from materials in accordance with WIMES 8.02. Piston-type injection fittings may be used to ensure build-up of hydrofluosilicic acid does not occur.

- | | | |
|--------------------------------------|-----------------------|----------------------|
| ▪ Suction & Delivery Pipework | ▪ Loading Valves | ▪ Suction Strainers |
| ▪ Isolation & Non Return Valves | ▪ Foot Valves | ▪ Pulsation Dampers |
| ▪ Static Mixers | ▪ Weights | ▪ Fill Lines |
| ▪ Pressure Relief / Degassing Valves | ▪ Calibration Vessels | ▪ Injection Fittings |

All pipework carrying hydrofluosilicic acid should be readily accessible for visual inspection for leaks, where possible. Pipework 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.

9 HYDROFLUOSILICIC ACID CHEMICAL DELIVERY

Hydrofluosilicic acid solutions that are delivered to site must comply with the relevant up to date European Standard (BS EN 12175), and manufacturers / suppliers of the product shall provide a copy of the certificate and testing report from approved certification bodies. Chemical transportation, and the design and structural integrity of all vehicles used for chemical transportation shall be in accordance with the following regulations:

- the *European Communities Carriage of Dangerous Goods by Road and Use of Transportable Pressure Equipment Regulations (S.I no 238 of 2013)*
- *European Agreement on the International Carriage of Dangerous Goods by Road (ADR) 2015* (or any subsequent amendments to these).

Description	Criteria	Notes
Allowable Concentrations	10.9%	-
Minimum / Maximum Storage Temperature	Min 10°C, Max 25°C	Extract fans & heaters to be installed in chemical storage room. External tanks to be heated to maintain hydrofluosilicic acid temperature >5°C
Minimum Liquid Temperature	5°C	Outdoor storage tanks to incorporate automated heating system to maintain acid temperature above 5°C, to prevent crystallisation. The temperature of internally stored tanks to be regulated by provision of space heating
Delivery Method	Bulk liquid	Pumped to bulk storage from delivery tanker
Bulk Storage Volume	90 days minimum @max dose rate and design daily production as per Section 5	Bulk tank volume to be selected to achieve this target
Day Tank Storage volume	1 day (up to max of 3 days where plants are not visited on a daily basis)	Day tank volume to be selected to achieve this target
Bulk / Day Tank Bund Volume	Minimum 110% of volume of 1 tank	-
Dosing Room Ventilation	Forced Ventilation. Directly to atmosphere external to building	Required to prevent build-up of hydrofluosilicic acid gases within dosing rooms. Minimum exhaust rate of 7.5 L/s m ⁻² (as per ANSI/ASHRAE standard 62.1-2004).

Table 6: Delivery and storage requirements for H₂SiF₆

The chemical shall be delivered in bulk liquid form and pumped directly to the bulk storage tank(s). For all installations, fill lines shall be located at ground level, slightly higher than the top wall level of bunds. A standard operating procedure delivery of hydrofluosilicic acid shall be developed and posted in a protective shop envelope on the wall of the dosing room for use by the operating personnel. A chemical inventory shall be maintained to monitor the stock levels stored on site.

In order to ensure the health and safety of all staff, onsite personnel and visitors all activities which incur a risk of contact with hydrofluosilicic acid (i.e. chemical delivery / replenishment) shall only be carried out by suitably trained operators. Clear and concise labelling of storage tanks and fill lines in accordance with Section 7.1 of this document shall also minimise the risk of chemical delivery to incorrect storage vessels. Delivery and storage of chemical stocks shall be in accordance with the details outlined in Table 6 above.

All access manways, filling valves, etc. shall also be lockable to prevent tampering by visitors or unauthorised personnel. Keys for these items shall be provided to site operational staff only. Opening of fill lines for chemical replenishment deliveries shall therefore only be possible in the presence of the plant caretaker.

10 PROCESS ALARMS AND AUTOMATIC SHUTDOWN

Alarms associated with installations shall take the form of text messages to plant operators, audible alarms on site, flashing beacons on the external wall of the dosing buildings and flashing messages or mimics on HMI/SCADA screens. Irish Water's Remote Asset Management Policy (IW-RAM-SPEC-5020-009) outlines the Alarm Generation and Plant Shutdown criteria for fluoridation systems, and specifies the type of alarm that each occurrence should generate. At a minimum, each fluoridation system shall be capable of generating the following alarms:

Alarm & Automatic Shutdown Criteria	Minimum Target Criteria (Alarm)	Exceedance of a Critical Limit (Dosing System Shutdown)
Fluoride Range in treated water (where specifically required by Irish Water)	Fluoride <0.6 mg/L Fluoride > 0.8 mg/L	Fluoride >2mg/L as F ⁻
Low Hydrofluosilicic Acid Stock	≤ 10% of total bulk storage capacity	-
Leak Detection	Positive level in bund	-
Pump Fault / Trip	One Chemical Dosing Pump Trips One Chemical Transfer Pump Trips	-
Chemical Flowmeter (while positive flow from process water flowmeter)	No flow signal from one chemical flow meter (if associated pump is running)	-
Process Water Flowmeter (while positive flow from chemical flowmeter)	No flow signal from process water flowmeter while chemical pumps are running	Inhibit all dosing pumps (Prevent creation of fluoride 'slug')
Activation of Emergency Washing Facilities	See Section 8.7	-

Table 7: Examples of alarm and shutdown criteria for hydrofluosilicic acid systems.

Any exceedance of a Critical Limit shown in the right hand column of the above table will result in the immediate shutdown of the dosing system.

11 TESTS ON COMPLETION

Following installation of the fluoridation plant, the Contractor shall ensure that the works have been fully commissioned in advance of the Tests on Completion. Following completion of the Commissioning Checks, the Contractor shall submit to the Employer's Representative a written Commissioning Check declaration confirming that the works have been suitably inspected, are fully operational in accordance with the Control Philosophy and are ready to commence Tests on Completion. The Contractor shall also submit signed and commissioning sheets for each item of plant and instrumentation installed. Tests on Completion shall not commence until the above documentation has been received, reviewed and approved by the Employer's Representative.

Tests on Completion shall be carried out in three distinct stages, which shall be completed in the following sequence:

- a) Site Acceptance Test
- b) Pre-Qualification Tests
- c) Process Proving Period

The Contractor shall require a written instruction to proceed from the Employer or the Employer's Representative prior to commencing each stage of the Tests on Completion. The Contractor shall provide all necessary test equipment and human resources required for completion of the tests. Copies of current test/calibration certificates for all reference instruments used as part of the tests shall be made available to the Employer or the Employer's Representative in advance of commencement of testing.

11.1 SITE ACCEPTANCE TEST

The Site Acceptance Test (SAT) shall demonstrate to the satisfaction of the Employer's Representative that all fluoridation equipment required to achieve the project goals is satisfactorily installed, fully operational, fully automated in accordance with the Control Philosophy, operating as required by the legislation and this Specification, and represented on the HMI mimic in compliance with the Purchaser's and Contractor's specifications.

In advance of the Site Acceptance Test, the Contractor shall submit to the Employer or the Employer's Representative a detailed and comprehensive SAT Schedule which shall include details of all tests to be carried out on each item of equipment, as well as each alarm and alarm response to be tested. The SAT Schedule shall detail all Low Priority and High Priority alarm thresholds which will be used during the test, and the methodology to be used to simulate generation of each alarm. The SAT Schedule shall also include a sign-off section for each proposed test to be carried out, which shall ultimately be signed by both the Employer/Employer's Representative and the Contractor upon satisfactory completion of the test. The SAT Schedule shall be submitted to the Employer's Representative no later than two weeks prior to the proposed date for the SAT.

The Contractor shall allow for all consumables which may be required for the completion of the SAT and shall allow sufficient time to rectify any defects which may occur on the day of the test, and subsequently any

retesting if necessary. The Contractor shall be liable for all expenses incurred on the Employer or their Representative should the SAT be interrupted and consequently rescheduled due to the Contractor's failure to comply with their previously submitted Commissioning Check declaration. The Contractor shall also allow for the attendance of all specialist staff (electricians, commissioning engineers, control system programmers, project managers) who may be required on site for the successful completion of the SAT (i.e. to make minor process alterations, to force signals, to adjust alarm thresholds, etc.).

The Site Acceptance Test will incorporate a full visual inspection of all aspects of the fluoridation system, and shall include but not be limited to:

- A visual check of all works to verify installation is in accordance with this specification and submitted design proposals
- A visual check to ensure all equipment is safe to operate and all necessary guards, bunds, emergency showers, etc. are in place
- A visual check of all connections, pipework, valves, controls, etc. installed as part of the works
- A visual check of all online instruments against reference instruments provided by the contractor (with calibration certificates for all reference instruments provided)
- A visual check of all process systems to ensure that all elements of the fluoridation works are fully operational and operating within the design parameters.

In addition to the visual inspection of the installation, all process elements shall be run through a series of simulations that represent the possible operating scenarios to confirm that system responses are appropriate, and are as described in the Control Philosophy.

11.2 PRE-QUALIFICATION TESTS

The Pre-Qualification tests shall demonstrate to the Employer, or their Representative, that the fluoridation system is ready to enter the Process Proving stage of the Test on Completion. Following satisfactory completion of the SAT, the Contractor shall utilise the Pre-Qualification Test period to ensure that the treatment process is achieving the required key performance indicators (KPIs) of the project as defined by the Contract.

The Contractor shall submit a declaration to the Employer or their representative, accompanied by the evidence listed above, which states that he is satisfied that they have Pre-Qualified to commence the Process Proving Period. Following issue of this declaration, the Contractor shall be instructed to proceed with Process Proving, and shall be liable for all costs incurred resulting from all subsequent process failures which may result in a re-commencement of the Process Proving Period.

11.3 DOSE OPTIMISATION AND PROCESS PROVING PERIOD

In order to demonstrate the achievement of fluoridation within a distribution network, following completion of a fluoridation installation, the Contractor shall operate the facility for a period to be defined in the Work Order Requirements, following the functional commissioning of fluoridation systems, during which time the Contractor shall prove that the process sufficiently fluoridates the process water. During process proving, the Contractor shall optimise the fluoride dose and the necessary timescale of process proving, so as to minimise

operating cost and the environmental impact of subsequent wastewater disposal. Fluoridation dose optimisation, and the timescale to achieve the required dose at consumer properties, will vary on a site specific basis and at any given time, depending on the underlying fluoride level.

The site specific Works Requirements will contain relevant available records of tested sampling for the existing treated water distributed through the network (i.e. flow rates, underlying fluoride concentration). The foregoing will serve as a guide to Designers as to the required fluoride dose rate.

Details of the distribution system, to be subjected to fluoridation dosing, the fixed points to be used for the laboratory testing of stagnation sampling during the Process Proving period and/or the site specific number and type of pipe test rigs to be provided will be set out in the project specific Work Order Requirements. Following the establishment of compliant fixed or pipe test rig stagnation sampling, process proving compliance will require to be verified by random daytime testing (RDT) across the defined project network at control monitoring locations. The number of RDT samples to be taken monthly thereafter will be determined by the size of the project network and will be similarly set out in the Works Requirements.

Following Taking Over of the completed project, the Contractor shall implement their tendered Process Proving and Monitoring Strategy, following consultation with Irish Water and their approval to proceed. The least possible dose (the Maintenance Dose), shall be established by the Contractor, following progressive reduction of this initial dose rate to the minimum level where the fluoride concentrations are consistently between the range 0.6 mg/L to 0.8 mg/L set in *S.I. 42 of 2007*.

The first stage of process proving compliance shall be deemed complete, when four consecutive weeks of the tested record of sampling, taken from the specified sampling point, show readings below the regulatory parametric level following dosing at the established Maintenance Dose. The final establishment of process proving compliance shall be verified when the RDT testing shows that no more than 2% of RDT samples in the network are outside the range 0.6 mg/L to 0.8 mg/L set in *S.I. 42 of 2007*.

Irish Water shall agree criteria for the acceptance of new or refurbished fluoride dosing plants with the HSE. This will typically entail a test using un-dosed water (for new plants) followed by a surveillance period of at least 30 days in-house daily testing of water supplies. Fortnightly samples should be taken by HSE staff for verification and submitted to the Public Analyst's laboratory for the first six months following commissioning (*Regulation 9, S.I. 42 of 2007*). Where a significant component of the dosing system has been replaced or dosing has ceased for more than 30 consecutive days, the plant operator should prepare an appropriate re-commissioning plan.

12 OPERATION AND MAINTENANCE

The design and layout of the new assets shall enable safe lifting arrangements, access arrangements and facilitate inspection, cleaning, lubrication and maintenance to ensure satisfactory operation under all service conditions.

12.1 OPERATION AND MAINTENANCE MANUALS

The Contractor shall provide fully documented operation and maintenance manuals in accordance with the requirements of the Specification. The manual will provide management and operational and maintenance personnel with a detailed description of the plant and processes. It must contain detailed operating procedures by which the asset may be maintained and operated safely and efficiently. The following information must, at a minimum, be included in the O&M Manuals:

1.00: GENERAL INFORMATION

1.01	The name of the Project.
1.02	Description of the Project works.
1.03	The Fire Safety Strategy for any buildings including drawings showing emergency escape routes, location of emergency and fire-fighting systems, services shut off valves, switches etc.

2.00: CONSTRUCTION & EQUIPMENT INFORMATION

2.01	As-constructed drawings recording details of construction for all permanent works (provided in latest version of AutoCAD, where applicable).
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3.00: SERVICES INFORMATION

3.01	A full description of each of the systems installed, written to ensure that the Employers' staff fully understand the scope and facilities provided.
3.02	A description of the mode of operation of all systems including services capacity and restrictions.
3.03	Piping & Instrumentation Diagrams (P&ID) of each system indicating principal items of plant, equipment, valves etc.

3.04	Asset register including schedules of plant, equipment, valves etc. stating their locations, duties and performance figures. Plant/Serial number, make model, Supplier and associated energy usage details to be included (Maximo utilised, where specified).
3.05	Starting up, operating and shutting down instructions for all equipment and systems installed.
3.06	Control sequences for all systems installed.
3.07	Schedules of all fixed and variable equipment settings established during commissioning.
3.08	Procedures for seasonal changeovers (where relevant).
3.09	Recommendations as to the preventative maintenance frequency and procedures to be adopted to ensure the most efficient operation of the systems.
3.10	Lubrication schedules.
3.11	A list of normal consumable items.
3.12	Fault finding.
3.13	Hidden risks e.g. burial of contaminated materials, unused lift shaft etc.

4.00: OPERATIONAL INFORMATION

4.01	Method Statements and associated Risk assessments for the operational phase of the plant.
4.02	Standard Operating Procedures (SOPs) for routine tasks during the operational phase of the works.
4.03	Operation & Maintenance Phase Traffic Management Plans, including site pedestrian management.
4.04	Details of Electrical Safety / Lock Out Tag Out (LOTO) procedures.
4.05	SCADA manual and associated codes/log on details.
4.06	Confined space working; areas identified and associated operational procedures.
4.07	Site security arrangements including details of CCTV system and security alarm.

5.00: MAINTENANCE STRATEGY

Including: Monitoring, Metering, Isolation, Cleaning, Statutory inspections, Cleaning, Repair, Replacement, Painting, Re-glazing, Fixing of accessories.

5.01	Below Ground
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	Service ducts and trenches.
	Drainage.
	Manhole chambers.
5.02	Primary Structure(s)
	Precast.
	Reinforced concrete.
5.03	Building(s)
	Windows.
	Facades.
	Roofs.
	Balconies.
	Skylights and roof lights.
	Guttering and rainwater goods.
5.04	Services
	Mechanical.
	Electrical.
	Escalator.
	Smoke detectors and fire alarm.
	Emergency/ escape lighting.
	External Lighting.
	Plant room Structure.
	Lifting Equipment
	Water supply.
	Sanitary Systems and equipment.
5.05	Risers and Service Ducts
	Electrical risers.
	Ceiling Voids.
	Floor Voids.
5.06	Finishes
5.07	Maintenance Strategy

13 DECOMMISSIONING OF FLUORIDE DOSING PLANTS

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 IW, the local authority and the HSE.

13.1 REMOVAL AND 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), plant personnel must ensure that the fluoridation chemical storage and dosing equipment is physically isolated from the water supply. Prior to decommissioning, the volume of hydrofluosilicic acid should be reduced to a minimum.

13.2 VOLUME REDUCTION VIA EXISTING DOSING

The bulk storage volume may be reduced by continuing to dose the chemical in a controlled manner. This is dependent on age, safety, and reliability of equipment to be used and appropriate safety precautions should be taken.

13.3 TRANSFER OF CHEMICALS TO ALTERNATIVE SITES

Where chemicals cannot be dosed into the water supply, it may be possible to transfer to an alternative fluoride dosing facility or returned to the supplier. Careful consideration should be given to the health and safety implications of any non-routine chemical handling operations. This acid is extremely corrosive and should be handled with care. The design of delivery vehicles and transportation of hydrofluosilicic acid shall be in accordance with the provisions (including any subsequent amendments) of the *European Communities Carriage of Dangerous Goods by Road and Use of Transportable Pressure Equipment Regulations 2011 (S.I. No. 349 of 2011)*. These regulations give effect to the *European Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR)*. In all cases, the coupling point between the tanker and storage tank fill point must be in a bunded area so that any spillages can be contained and collected for safe and environmentally acceptable disposal.

13.4 DISPOSAL VIA WASTE CONTRACTOR

Where neither of the above methods are possible, or there is a remainder, hydrofluosilicic acid should be disposed of via a licensed waste contractor. The potential long term effects of environmental exposure to the acid 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.

The waste shall be transported by an authorized waste collector, who hold a Waste Collectors Permit in accordance with the *Waste Management (Collection Permit) Regulations, 2001 (SI No. 402 of 2001)* as amended by *S.I. No. 87 of 2008*. The permit must be valid for the period of transport, the waste type and for the area in which the waste is to be transported. The waste must be transported to an EPA licensed facility for disposal/recovery.

13.5 REMOVAL OF PLANT AND EQUIPMENT

All material and equipment which has been exposed to fluoridation for any long period of time shall be removed and disposed of appropriately. This may include pipework and equipment, storage and holding tanks, pumps, dosing lines and dosing point installations, and electrical equipment. The equipment to be disposed of shall be agreed between IW, the local authority and the HSE, and shall be assessed for potential long term effects of environmental exposure.

13.6 INTERACTION WITH EXISTING PROCESSES

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 water leaving the site. 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 process 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.