Irish Water

Chemical Phosphorus Removal Asset Standard

Revision Number	Description of Change	Author(s)	Approved By	Date of Approval
0.1	First Draft	I.Lewin		
0.2	Second Draft	I Clare S Plano		
0.3	With client comments addressed	I.Lewin		
0.4	Sub WTEF version	Ted O'Reilly	Sub WTEF	08/08/2022
0.5	Fifth draft	Ted O'Reilly	Main WTEF	26/08/2022
1.0	First Approval	Ted O'Reilly	Mark Macaulay	06/07/2022

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1 INTRODUCTION

This Chemical Phosphorus Removal Standard specifies the procedures and standards that are required for the design, location and installation of metal salts dosing at wastewater treatment plants (WWTP) for the precipitation of orthophosphate-phosphorus from the wastewater. The standard applies to all WWTPs with a relevant phosphorus related discharge standard requirement.

2 PURPOSE

The Irish Water Standards and Specifications suite of documents describes the minimum standards to be achieved by those engaged in the Design and Construction of Irish Water assets.

3 SCOPE

The Irish Water Standards and Specifications shall apply to all new assets and to all existing assets undergoing refurbishment, replacement or expansion.

DEROGATIONS FROM THE STANDARD

Whilst the minimum requirements of this standard/specification shall be met (where applicable) this document is not intended to stifle innovation by the Contractor, or delay progress. Should the Contractor wish to apply for a derogation from any aspect of the document, they shall submit a Derogation Application to the Employer's Representative and designstandards@water.ie in advance of any proposed departure from the requirements of the specification. The submission of the application does not confer permission to proceed, and the application should be submitted allowing sufficient time for Irish Water to evaluate. Works can only proceed on the basis of the derogation once they have received permission from Irish Water. The submission of a Derogation Application shall not impact on the programme of works for the specified project and shall be made at the risk and expense of the Contractor. Irish Water or the Employer's Representative shall retain the right to reject the application in favour of compliance with the standard/specification.

4 DEFINITIONS

Definition of specific terms used in this document, as per IW-HSQE-PR-101-FM-06

Term	**Definition**
Activated Sludge Process	A continuous process in which waste water is aerated in a tank to reduce the BOD and ammoniacal nitrogen. [secondary treatment process for waste water]
Emission Limit Value	Legally enforceable limit on the physical, chemical or biological characteristics of a point source of emission to water or air, normally expressed as a maximum permissible concentration of a specified substance.
Eutrophication	"eutrophication" means the enrichment of water by nutrients especially compounds of nitrogen and/or phosphorus, causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned [UWWTD and S.I. 254 of 2001]
Final Effluent	Effluent from the last stage of a wastewater treatment plant
Flocculation	Process by which solids in water or waste water aggregate through biological or chemical action so they can be separated from water or waste water.
Flow Meter	(A) Flow Meter (is an) instrument intended to measure continuously, record, and display the volume passing through the measurement transducer.
Monitoring	"monitoring" includes inspection, measurement, sampling or analysis, whether periodically or continuously. [Water Services Act 2007]
Population Equivalent	'1 PE (population equivalent)' means the organic biodegradable load having a five-day biochemical oxygen demand (BOD5) of 60 g of oxygen per day. [UWWTD] [Waste water treatment plants are described in terms of their treatment capacity, which is generally expressed as population equivalents (PE).]
Primary Treatment	'primary treatment' means treatment of urban waste water by a physical and/or chemical process involving settlement of suspended solids, or other processes in which the BOD5 of the incoming waste water is reduced by at least 20 % before discharge and the total suspended solids of the incoming waste water are reduced by at least 50 %; [UWWTD]
Return Activated Sludge	Activated sludge that has been separated from mixed liquor in a secondary settlement tank for further use in an activated sludge process [part of a secondary treatment process for waste water]

Rotating Biological Contactor	Biological contactor in which fixed film is immersed intermittently in the flow to be treated [secondary treatment process for waste water]
Secondary Treatment	“secondary treatment” means treatment of urban waste water by a process generally involving biological treatment with a secondary settlement or other process in which the requirements established in Part 1 of the Second Schedule [SI 254 of 2001] are respected.
Sequencing Batch Reactors	Activated sludge wastewater treatment with discontinuous operation in one tank [secondary treatment process for waste water]
Sewage	“sewage” includes domestic sewage and a combination of domestic sewage and storm water. [Local Government (Water Pollution) Act 1977] ["Waste Water" and "Wastewater" are preferred terms].
Tertiary Treatment	Additional treatment processes which results in further purification than that obtained by applying primary and secondary treatment
Wastewater	“Wastewater” has the same meaning as “Waste Water”. Both terms are in common use in the water industry; “Waste Water” is the term used in the Urban Waste Water Treatment Directive and typically in Irish legislation while "Wastewater" is the term typically used in standards e.g. I.S. EN 16323:2014 - Glossary of wastewater engineering terms. Either "Wastewater” or “Waste Water” can be used, depending on context e.g. "Waste Water" in context of the Urban Waste Water Treatment Directive.

5 ROLES AND RESPONSIBILITIES

The responsibility for ensuring compliance with the Irish Water Standards and Specifications shall lie with Designers and Contractor/Designers. Irish Water reserve the right to inspect all assets at any time to ensure compliance with the Standards and Specifications is being achieved.

6 STANDARD

6.1 Background

Phosphorus is one of the main nutrients (along with nitrogen, in the form of nitrates) contributing to the increased eutrophication of lakes and natural waters. Reducing phosphorus discharged from municipal and industrial wastewater treatment plants can play a key role in the prevention of eutrophication of receiving waters.

Phosphorus enters the wastewater stream primarily in the form of excreted human metabolic products, food residues, and industrial source emissions. In addition, household detergents can also contribute to the phosphorus load. Phosphorus in wastewater is mainly found in the forms of orthophosphate, polyphosphate and organic phosphate.

This document describes the use of chemicals in wastewater treatment plants to reduce orthophosphate phosphorus to meet both orthophosphate and total phosphorus emission limit values (ELV) , with orthophosphate ELVs more commonly applicable in Ireland. Phosphorus related ELVs are not present on every site, only where deemed necessary based on the receiving water requirements.

6.2 Chemical Precipitation of Phosphorus

The chemical reaction for phosphorus removal is based on the precipitation of metal phosphate salts by the addition of metal salts (iron or aluminium) to the wastewater stream prior to settlement or filtration processes.

Several factors influence a works ability to meet a phosphorus permit, including:

- The type of treatment process
- The emission limit value imposed
- The point of application
- The influent phosphorus load, variability, and speciation.

Chemical phosphorus precipitation can be independently undertaken to achieve orthophosphate limits down to less than 0.5 mg/l.

Please note that throughout this document, phosphorus will be understood as the orthophosphate fraction of the Total Phosphorus present in the wastewater.

6.3 Precipitation Agents

There are different types of Iron or Aluminium salts that can be used for phosphorus removal. A list is presented in Table 1 below.

Table 1: Chemicals' characteristics

Name	*Chemical symbol*	*Strength*	*Specific Gravity*	*Colour*
Ferric Sulphate	$Fe_2(SO_4)_3$	11.5 % (as Fe^{3+})	1.52-1.61	Dark brown/orange brown
Ferric Chloride	$FeCl_3$	13.5-14.1% (as Fe^{3+})	1.41-1.46	Dark brown
Aluminium Sulphate	$Al_2(SO_4)_3$	8% (as Al_2O_3)	1.28-1.32	Clear
PAX-XL60	N/A	13.6-14.8% (as Al_2O_3)	1.28-1.32	Translucent yellow
Ferrous Chloride	$FeCl_2$	8.5-13.4% (as Fe^{2+})	1.20-1.35	Pale green to light brown
Ferrous Sulphate	$FeSO_4$	Solid	3.65 (solid)	White-yellow

Iron salts are generally preferred over aluminium salts in the UK because of cost and tight aluminium permits. Aluminium permits are not an issue in Ireland, and it is widely used in other parts of the world. Aluminium is more suitable for sites with UV disinfection to avoid fouling of lamps.

Ferrous rather than ferric is used when dosing into the front end of an ASP as it is lower cost, and the oxygen is available to oxidise the ferrous ions to raise the oxidation state and increase reactivity. For other dosing locations, Ferric sulphate is the most common and accepted chemical.

However, the selection of the precipitation agent needs to be done on a site-by-site basis. If the catchment is not conventional (i.e., large proportion of trade effluent for example), it may be necessary to carry out Jar tests to select the most appropriate chemical.

The chemical selection will depend on several factors:

- Dosing location
- Type of process units on site
- Whole Life Cost
- Risk of availability of a chemical

- Chemical health and safety implications
- Sludge production
- Emission targets

6.4 Process Design

6.4.1 Average Chemical Dosing Rate

The average chemical dosing rate shall be calculated using the following formula:

$$Average\ Chemical\ Dose\ \left(\frac{kg}{day}\right) = \frac{Daily\ PO_4\ (removed) \times Dose\ mass\ ratio}{C}$$

Where:

- $\text{Daily } PO_4 \text{ (removed)} \left(\frac{\text{kg}}{\text{day}}\right) = \text{Influent } PO_4 \text{ load} - PO_4 \text{ load discharged}$
    - $\text{Influent } PO_4 \text{ load} = \text{PE} \times \text{TP yeild} \left(\text{kg}\frac{\text{TP}}{\text{PE}}.\text{d}\right) \times \frac{PO_4}{TP} ratio$
    - $PO_4 \text{ load discharged} = \frac{PO_4 \text{ ELV} \left(\frac{\text{mg}}{\text{l}}\right) \times \text{ave.flow} \left(\frac{m^3}{\text{d}}\right)}{1000}$
- Mass ratio = required chemical / phosphorus mass ratio, to be calculated based on molar ratio required (from table 3) and converting it to a mass based on molecular weight of P and metal salt used
- C (%w/w) = metal ion concentration in product solution

The dosing calculation spreadsheet (IW-TEC-700-06-FM-01) included in IW-TEC-700-06 can be used to calculate the chemical dose requirement.

The TP yield is typically 2 to 2.5 g/PE.d.

The ratio Orthophosphate to Total Phosphorus (PO_4/TP) value depends on the type of sewage and the amount of trade discharges. Typical range is between 0.5 – 0.7.

6.5 Dosing Locations

Dosing can be carried out at different stages of the sewage treatment process. The choice of dosing location will be dependent on several factors:

i. Nature of the sewage
ii. Type of treatment process and configuration
iii. Phosphorus removal target.

When selecting the location of dosing point, the following requirements shall be used to determine the best location:

- Mixing requirements
- Chemical contact time
- Operational access

Location of the dosing rig is then determined by:

- Distance from bulk storage or day tank
- Required pumping head and dosing flow rates

6.5.1 Dosing Location Categories

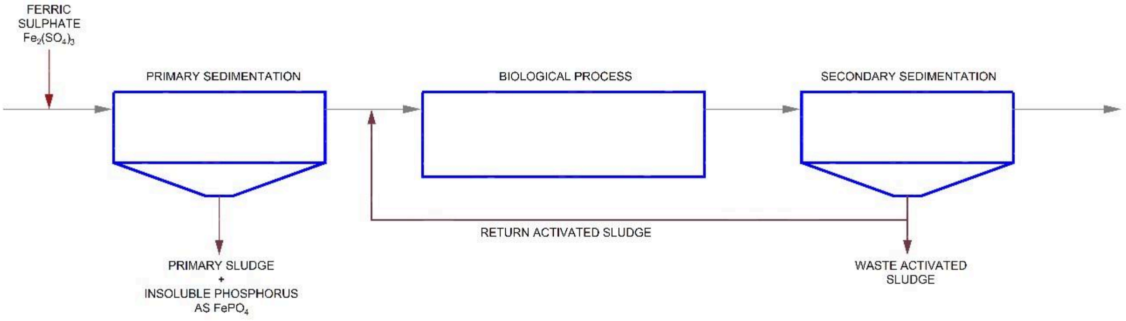
Dosing locations can be generally categorised as follows:

a) pre-precipitation
b) co-precipitation
c) post precipitation

These are described further below.

6.5.1.1 Pre-precipitation

Pre-precipitation is the addition of a chemical to the raw wastewater upstream of primary sedimentation facilities and after the storm separation point and where appropriate shall be sized to include for the impact of any returns. Once added to the wastewater flow, metal salts react with the soluble orthophosphate fraction of the total phosphorus concentration to form the precipitate. Pre-precipitation may require higher chemical dose due to competition of soluble phosphorus with other soluble reactive compounds, such as dissolved metals.



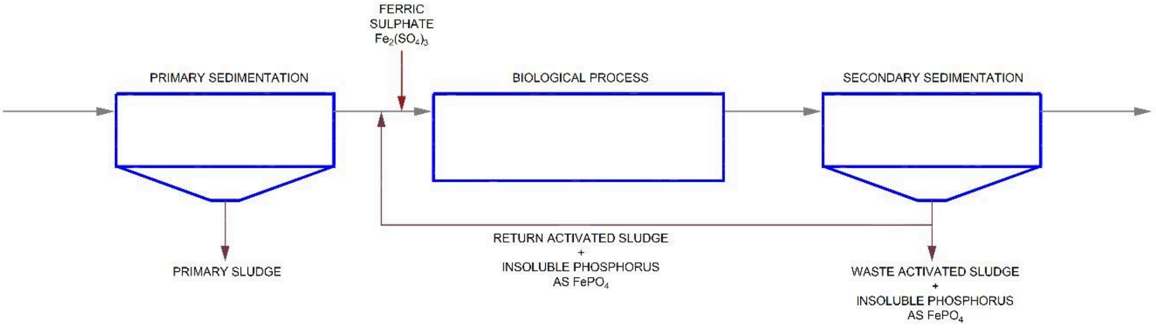
Pre-precipitation on its own is sufficient to meet an Orthophosphate ELV of > 0.7 mg/l.

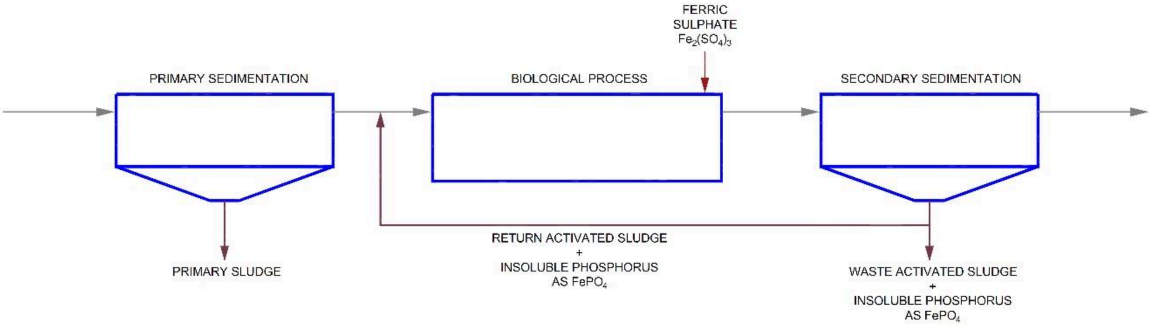
6.5.1.2 Co-precipitation (also known as Simultaneous Precipitation)

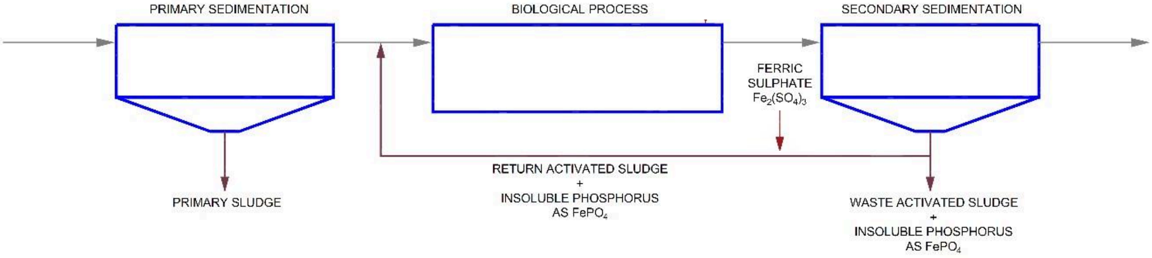
Co-precipitation is the addition of chemical to the wastewater as part of the biological process, where precipitated phosphates are removed with the activated sludge at the secondary stage. Co-precipitation also results in the removal of phosphorus through adsorption, exchange and agglomeration mechanisms.

Several dosing locations are possible:

- Into the settled sewage
- Upstream of the secondary settling tanks
- Into the RAS (Return Activated Sludge)



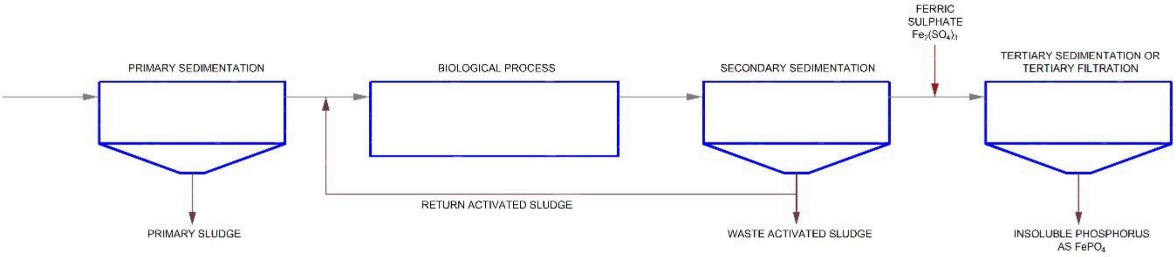




6.5.1.3 *Post precipitation*

Post-precipitation is the addition of chemical to the effluent from the secondary sedimentation stage of a biological process.

This method of phosphorus removal requires sedimentation or filtration facilities post dosing to permit the physical separation of the precipitated chemical and is most often used as a second dose for very low ELVs below 0.5 mg ortho-P/l. For new build sites, coagulation and flocculation prior to the secondary settlement stage will provide the lowest cost solution. For existing sites there may not be sufficient head available prior to secondary settlement and a tertiary filtration process may be required.



6.5.2 Advantages and limitations for dosing point locations

Table 2 below outlines the advantages and limitations of differing chemical dosing locations in conventional activated sludge or extended aeration processes.

Table 2: Comparison of dosing locations advantages and limitations

Dosing Location	*Advantages*	*Limitations*
Pre-precipitation	*Increased BOD and suspended solid removal in the PSTs.* *Lowest risk of high residual metal in the final effluent discharge (although currently this is not a consideration for IW)*	*Least efficient use of metal salts.* *Sludge may be more difficult to dewater than standard primary sludge.* *Limited precipitation of polyphosphates and organic phosphorus, which may be converted to ortho-P during secondary treatment.* *Increased sludge production in comparison to other dosing point locations.* *Risk of phosphorus deficiency inhibiting the downstream biological treatment process.* *Risk of alkalinity deficiency in the downstream process.*
Co-precipitation at inlet of ASP (into the settled sewage, or into the RAS)	*Most effective mixing.* *Longest contact time with wastewater.* *Lower chemical dosage than pre-precipitation.* *Improved settleability of activated sludge.* *Polymer not required.*	*Polyphosphates and organic phosphorus have not hydrolysed to orthophosphate at the dose point, which may result in less efficient reduction of Total P.* *Inert solids added to activated sludge mixed liquor, reducing the percentage of volatile solids.* *Risk of phosphorus or alkalinity deficiency.*
Co-precipitation at inlet of SSTs (Secondary Settling Tanks)	*Polyphosphates and biodegradable fraction of the organic phosphorus has hydrolysed to orthophosphate, improving overall total P reduction.* *Lower chemical dosage than pre-precipitation.* *Improved settleability of activated sludge.* *Polymer not required.* *No risk of phosphorus or alkalinity deficiency.*	*Mixing generally not as effective as the inlet to aeration tank.* *Limited contact time between mixed liquor and chemical.* *Inert solids added to activated sludge mixed liquor, reducing the percentage of volatile solids.* *Ferric dosing may be required instead of ferrous if there is a risk of low D.O. through the FSTs, i.e. higher operating cost.*
Post-precipitation	*Lowest phosphorus concentrations achieved due to maximisation of hydrolysis upstream of dosing point.* *Usually only used in two-point dosing.* *Most efficient metal salt use.* *Separation of activated sludge and heavy iron-based P sludge.* *No risk of phosphorus or alkalinity deficiency.*	*Highest capital cost if additional infrastructure is required.* *Highest risk to final effluent metal content/permit (currently this is not a consideration for IW)*

6.5.3 Choice of Dosing Location Depending on the Process

Depending on the type of treatment processes, the following dosing points locations are recommended:

6.5.3.1 Trickling Filter WWTP (TFs)

For WWTPs utilising trickling filter, the preferred location for dosing to meet ortho-P permits is pre-final settlement tanks, since this reduce the risk that alkalinity dosing will be required.

An alternative dosing location is pre-primary settlement tanks. Dosing at this location significantly reduces the risk of metal carryover (currently this is not a consideration for IW), which in turn reduces the likelihood (or the size) of a Tertiary Solids Removal process being required to meet the future phosphorus consent.

For sites with low phosphorus effluent limits, multiple doses at different stages in the process may be required. Generally, this will consist of a primary dose, significantly reducing phosphorus concentrations, and a polishing dose, further reducing the phosphorus concentrations.

6.5.3.2 Activated Sludge Plants (ASPs)

The preferred dosing point should be co-precipitation at a location that ensures even distribution to all ASP units. The primary choices are into the RAS, settled sewage or RAS/settled sewage mixing chamber (where available), as this provides the best potential for good mixing.

If none of these locations are available consideration can be given to dosing directly into the aeration zone or at the inlet to the settlement tanks.

6.5.3.3 Sequencing Batch Reactor (SBR)

Sequential batch reactor (SBR) is a very prevalent type of activated sludge process throughout the Irish wastewater treatment infrastructure. In SBRs, the flexibility with regards to selection of an appropriate dosing point is often limited.

For SBRs without primary settlement tanks, biological phosphorus removal is the preferred method, as sufficient mixing and reaction time needs to be provided for coagulation prior to sedimentation of the precipitate. However, if chemical precipitation is selected for phosphorus removal, it is considered that the optimal part of the cycle for chemical addition is the last half of the aeration phase. This also avoids the alkalinity and phosphorus deficiency issues.

However, this can be subject to modification depending on:

- The operation cycle of the SBR
- The equipment in place (mechanical mixers or not)
- The required ELVs (for nitrogen and phosphorus)

Consequently, in the event where the Contractor or Designer wishes to propose an alternate location for the addition of the chemical precipitant to the SBR process, their selection shall be justified within the Design Submissions for phosphorus removal and supported by numerical calculations / approximations of dose rates at each proposed location.

6.5.3.4 Rotating Biological Contactor (RBC)

On RBCs, the chemical should be dosed directly prior to the primary settlement tanks if these are separate structures. For RBCs with integrated primary settlement zones, dosing upstream of the RBC is less effective and dosing directly to the biozone is recommended. Desludging frequencies of RBCs with integrated primary settlement zones should be reviewed to ensure that sludge does not accumulate in the primary zone and result in solids carryover into the biozone.

6.5.3.5 Submerged Aerated Filters (SAF)

On SAFs, the chemical should be dosed directly upstream of primary settlement tanks or upstream of humus settlement tanks. Adequate mixing must be available for both locations.

6.5.3.6 Sites with Tertiary Solids Removal (TSR)

On all types of WWTPs with tight orthophosphate limits, typically <0.5mg/l, adequate phosphorus removal may only be achieved through dosing onto a tertiary solids removal process. This is a currently evolving area. It should be noted that typical dosing rates at this point in the process generate significant additional quantities of solids, and that existing TSR systems should be assumed to need extension to take the extra load.

The dosing point can be directly into the feed of the TSR or could be into the feed of the Secondary Settlement Tanks (SST) upstream of tertiary solids removal.

6.6 Number of Dosing Points

6.6.1 Single Dosing Point

Dosing can be carried out at a single point in the process: this will often be adequate.

Additional dosing points will be required if there is no single location where the chemical can be distributed and mixed adequately, at the required point in the treatment process, e.g. on multi-RBC (Rotating Biological Contactor) sites, and on multi block ASPs if there is no point where all the flows are combined.

6.6.2 Simultaneously Dosing at Multiple Points in the Process

With tighter Orthophosphate limits the use of simultaneous dosing to two or more points in the process is becoming more common. Two dosing points are recommended where phosphorus ELVs are to be lower than 0.5mg/l, as also stated in Section 10 of IW-TEC-700-99-04. The first dosing point is often used to remove most of the load and the second dosing point to trim the residual Orthophosphate to achieve the required limit.

6.7 Dosing Ratios

Table 3 below shows range and typical dosing ratios for both Ferric and Aluminium salts at various dosing locations. This is only for ELVs to be achieved of > 0.5 mg/l. For ELVs < 0.5 mg/l, the dosing ratios can be much higher and would need to be determined by Jar testing.

It is important to avoid getting into issues of Phosphorus deficiency in the biological process and a minimum concentration of Total Phosphorus of 1.0 mg/l will need to be maintained at the inlet to the biological process.

Table 3: Typical dosing ratios for ELVs > 0.5 mg/l

Type of salt	***Iron salts***		***Aluminium salts***	
Dosing Point	Range	Assumed	Range Al:TP	Assumed

	Fe:TP Molar ratio		Molar ratio	
Pre-precipitation	1.4 – 2.8	2	1.4 – 2.5	2
Co-precipitation	1 – 3	1.6	1 – 3	1.6
Post-precipitation (as primary dose)	1 - 3	1.4	1 - 3	1.4
Post precipitation (as secondary dose)		7.5		

6.8 Mixing Requirements

Mixing is important in the application of chemicals to sewage. Metal salts hydrolyse to insoluble precipitants within 1-2 seconds. Once hydrolysed, the metal will still react with the phosphorus but over the course of hours rather than seconds, potentially leading to higher dosing rates and accumulation of solids in the downstream processes.

Good engineering practice shall be used to maximise mixing with the existing infrastructure. The Designer shall assess the mixing characteristics of the facility on a site-specific basis. Addition of a static mixer can introduce additional head-loss of around 200 mm.

Dosing in a pipe without static mixer will require a downstream length of at least 40 pipe diameters before the point of application.

6.8.1 Pre-precipitation Mixing

The point of application must be located as far upstream of the primary settlement process stage as possible, where there is good mixing in order to allow as much time as possible for the chemical to react prior to settlement, downstream of storm separation and upstream of any return liquors. This can be achieved for example by dosing into the standing wave downstream of a flow measurement flume.

Effective mixing can also occur when the dose point is located upstream but in close proximity to site returns or where the flow weirs over and there is a drop. It has been found that sacrificing contact time before the primary tanks by moving the dose point to a point of better mixing can achieve better overall Phosphorus removal without increasing dose rates.

If an area of high turbulence cannot be located, then a non-ragging channel mixer shall be considered. If the depth is not sufficient for a channel mixer, then a mechanical mixer shall be installed in a suitable chamber, with a valve bypass arrangement.

6.8.2 Co-precipitation Mixing

Rapid mixing is not required for simultaneous precipitation in ASPs; by its nature, an ASP system retains the sludge for days, so hydrolysed ferric salts still have time to react with soluble phosphate. Good mixing is still required as it will reduce settlement and build-up of phosphate sludge.

Dosing point(s) at the discharge end of the aeration lanes shall be upstream of a point of turbulence to ensure proper mixing and even distribution to final settlement tanks. Dosing directly into the ASP is not allowed.

6.8.3 Post Precipitation Mixing

Mixing at application points for post-precipitation dosing shall be equivalent to that specified for pre-precipitation dosing, to minimize the risk of excessive metal carryover in humus tanks or TSR effluent and consequential risk of failure of TSS consents. Where dosing is before rectangular or pyramidal humus tanks, or directly before TSR, the requirement for additional flocculation shall be investigated.

Notwithstanding section 6.5.3.6 ‘Sites with Tertiary Solids Removal (TSR)’ above, to attain very low Phosphorus ELVs, a dedicated flocculation mixing chamber should be provided for the post-precipitation dosing point prior to settlement or cloth filtration.

6.9 Alkalinity

Special consideration should be given to the fact that chemical precipitation of phosphorus upstream of the biological treatment stage may generate issues in regards of alkalinity and phosphorus deficiency for the biological process, thus resulting in difficulties to nitrify the effluent and to meet the other ELVs in general.

Typical alkalinity consumed by common precipitation agents are shown in the following Table 4:

Table 4: Alkalinity consumed by typical precipitation agents

Coagulant	Alkalinity Consumed (mg $CaCO_3$/mg pure chemical - undiluted)
Ferric sulphate - $Fe_2(SO_4)_3$	0.75
Ferric chloride - $FeCl_3$	0.93
Ferric chloride - $FeCl_3.14\ H_2O$	0.56
Alum - $Al_2(SO_4)_3.18\ H_2O$	0.45
Alum - $Al_2(SO_4)_3.14\ H_2O$	0.51
Aluminium chlorohydrate (ACH) - $Al_2(OH)_5.Cl$	0.29

6.10 Chemical Sludge Production

The addition of iron or aluminium into a wastewater treatment plant leads to the sludge containing more iron/aluminium. Sludge production will increase due to the precipitation of ferric phosphate and ferric hydroxides, and the coagulation effect of ferric, resulting in increased solids and BOD removal.

An increase in sludge production (in sludge dry solids and in sludge volume) and its implication on sludge handling plant (desludging and sludge storage) shall be considered when implementing chemical precipitation. Changes in sludge rheology shall also be considered. Chemical sludges containing iron and aluminium are generally more difficult to process when compared to non-chemical sludges.

Chemical dosing will increase overall sludge production by up to 30% on a dry weight basis. The chemical sludge component shall be estimated as:

Ferric or Ferrous dosing:	2.5 x the average Fe dose (kg/day)
Aluminium dosing:	3.9 x the average Al dose (kg/day)

A site mass balance shall be produced to identify changes needed in the sludge management to accommodate additional sludge due to chemical dosing. The potential for release of phosphorus from digested sludge storage facilities returning to the treatment process via return liquors shall be considered in the Mass Balance. It is generally considered that P release from anaerobic digestion of chemically bound sludge is not a significant issue, however, high concentrations of ferric in the digester can lead to problems with vivianite formation in the digested sludge liquor stream.

6.11 Dosing Control

An automatic chemical dosing system shall be provided. The dosing system shall be capable of providing a number of different dosing methods amongst those listed below (but not systematically all of them):

- Flow proportional
- Pre-programmed diurnal profile
- Constant rate
- In response to a 4-20 mA signal from an external phosphorus monitor (either feedback or feed forward control).

On small sites, it is expected that the most appropriate control system will be constant rate.

Where required, alkalinity dosing control shall be based on post biological treatment pH monitor such that lowering of pH below a specified set point will trigger dosing of alkalinity after the iron coagulant dosing point. Once triggered alkalinity dose control shall be controlled on one of the methods list hereunder. All control methods shall be available within the PLC and the choice of method used on the site shall be operator selectable:

- Alkalinity dosing proportional to the coagulant dosing rate
- Flow proportional alkalinity dosing
- Fixed flow alkalinity dosing.

More details on the dosing control methodologies are reported in the Specification IW-TEC-700-06.

6.12 Instrumentation

6.12.1 Flow Monitoring

Flow measurement is required on the wastewater flow that the chemical is dosed into to allow for flow paced or feed forward control. When inlet flow measurement does not exist, this type of control can not be used. The requirement for P removal will usually not trigger the installation of flow measurement if none is existing.

A flow signal to monitor for high and low influent flow will normally be taken from the inlet works flow meters. The low flow signal will be used to inhibit flow when there is no inlet flow and the high flow signal can be used to cap or limit dosing during storms when dilution results in a lower dose requirement. Where a works has multiple streams requiring more than one dosing point, ideally a flow signal for each stream should be used for control.

To enable 'Feed Forward Control' actual flow readings will be required, from a TSR feed flowmeter for a post precipitation dose i.e. not just a high or no flow signal. This will allow the algorithm to calculate, in conjunction with the phosphate monitor, the ortho-phosphate load required to be removed and hence the mass of metal which must be dosed.

6.12.2 Phosphate Monitors

A whole life cost exercise will be required to justify the installation of a Phosphate monitor for feed forward or feedback control.

To enable 'Feed Forward Control' a phosphate monitor (monitoring ortho-Phosphate) will be required to provide the P concentration for the algorithm in the software to calculate the required dose rate. The phosphate monitor should be installed in a location that provides a representative reading of phosphate in the stream being dosed, prior to the dose point. When selecting a location, consideration needs to be given to access requirements to calibrate the instrument.

6.13 Sampling and Testing Requirements

6.13.1 Sampling

With regards to data collection to inform the design, it is recommended to gather the historical data. A sampling measurement campaign shall be carried out before the implementation of the Ferric dosing solution. The parameters below are the minimum required:

- Flow data (daily averaged data in m^3/d, and hourly instantaneous in l/s)
- WWTP influent – Orthophosphate and Total Phosphorus
- WWTP influent – Alkalinity
- WWTP influent metals – Aluminium and Iron, total and soluble
- Final Effluent Phosphorus – Orthophosphate and total phosphorus
- Final Effluent – Alkalinity
- Diurnal profiles for the above

6.13.2 Process Commissioning

Load proportional dosing for phosphorus removal shall be set to match the measured phosphorus load profile and shall be adjusted during commissioning.

Process commissioning of a P removal scheme has several interrelated activities undertaken by different parties. Commissioning of primary doses and co-precipitation, although not a biological process, requires a maturation period as the flocculation process may take time to stabilise, there may be interactions with the biological processes and dose optimisation will be required to meet the target phosphorus concentration in the final effluent. A post precipitation dose will have a much quicker response and is best not started until the first dose point is achieving the design ortho-P at the dose point.

Table 5: Typical process commissioning tasks during the maturation period

Typical process commissioning tasks
Set dose to 50% of required for 1st week, and increase after that as appropriate
Sampling & dose adjustment – samples submitted for laboratory analysis

Site visits - check to see if downstream process is affected
Site sample sheet to be provided to collate sample results & dose settings
Advise on subsequent chemical deliveries during trial period prior to permit date

There is a maturation phase during which both the effluent P and metal will reduce to stable concentrations. At some works there may be an effect on the biology of the system and other effluent parameters may be affected. Levels of P and iron and the degree of flocculation are all variables within the process that will need to be monitored. The dose shall be adjusted to optimise the process.

Maturation of the process may take considerable time (2 to 12 weeks) depending on the process, the location of the dose points, flocculation and the target phosphorus level. The maturation period also provides a suitable interval for proving the reliability of the M&E equipment. It also allows any outstanding functional testing of the control systems to be completed and process control to be stabilised.

Sludge production can increase by up to 30% and this requires monitoring during the maturation period.

The commissioning period will enable the optimisation of the dose rate, with the view to avoid overdosing, as it can create problems such as reduction of alkalinity, or struvite deposition on the sludge stream.

6.13.3 Testing

Tests on Completion shall be carried out by the Contractor to demonstrate successful performance of the chemical P removal technology. For commissioning and takeover tests IW General Specification should apply (IW-TEC-600-05).

6.14 Health and Safety

The Phosphorus removal Chemical Storage and dosing system shall comply with the requirements of IW-TEC-700-06 and shall take preference over IW Chemical Storage Systems – General Specification IW-TEC-600-06-01.

7 REPORTING (IF REQUIRED)

To be provided by IW WWT Tech Hub if required.

8 REFERENCED DOCUMENTS

Document Name	*Document Number*	*Location*
IW-TEC-700-06	Chemical Phosphorus Removal Specification	*Link*
IW-TEC-600-06	Chemical Storage Systems – General Specification	*Link*
IW-TEC-600-06-01	Chemical Storage Systems – Bulk Storage of Liquid Chemicals	*Link*
IW-TEC-700-99-04	Certificate of Authorisation Waste-Water Treatment Plants Standard	*Link*
IW-TEC-600-05	Commissioning, Testing and Handover – General Specification	*Link*
IW-TEC-700-06-FM-01	Standard Chemical Dosing Calculation Spreadsheet	Link

9 GENERATED DOCUMENTS

Document Name	*Document Number*	*Location*