Irish Water

DESIGN SPECIFICATION: CHEMICAL STORAGE AND HANDLING

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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 requirements for sampling frequency, methods of analysis, compliance monitoring points and the provision of information to consumers.

In addition, Irish Water shall also oversee the collection, treatment and discharge of municipal wastewater in a responsible and sustainable fashion, thereby ensuring that Ireland's inland waterways and coastlines are maintained as healthy habitats for indigenous flora and fauna, as well as remaining suitable for recreational purposes in an increasingly urbanised society. The sufficient treatment of wastewater prior to discharge is also essential to ensure that Ireland's potable water sources, which are predominantly rivers and lakes, are adequately protected from contaminations which may result in public health issues such as illness or infection caused by the ingestion of waterborne viruses, bacteria or protozoa which may be present in raw water supplies.

Chemicals play a critical role in many common treatment processes used for both potable water and wastewater, albeit to a lesser extent for the latter. As a result, chemicals are delivered, handled, stored and dosed at almost every water and wastewater treatment plant under the control of Irish Water. The extent of chemical storage on water and wastewater treatment plant sites will differ from plant to plant, and is dependent on the treatment processes employed, as well as the size and capacity of the facility.

Typically, all potable water treatment plants will, at a minimum, incorporate some level of sodium hypochlorite (NaOCl) storage for disinfection purposes. However, larger or more complex facilities which utilise processes such as pH correction, coagulation, flocculation, oxidation, etc. may very often require more extensive storage and / or batching facilities for many different chemicals (sometimes as many as 6 to 8) in order to ensure a fully functioning and effective treatment process. For wastewater treatment, which is usually implemented as a biological process and is therefore not as chemically dependent as water treatment, the most common chemical is ferric sulphate ($Fe_2(SO_4)_3$), which is used to assist in the removal of phosphorous, especially if the final effluent discharge is to an inland watercourse where phosphorous is the limiting nutrient.

As such, the effective onsite storage and administration, as well as associated delivery and handling practices of what are very often hazardous chemicals at water and wastewater treatment plants are of paramount concern to Irish Water, primarily from a Health, Safety, Quality and Environmental (HSQE) perspective.

This Specification will guide the designer in establishing engineered solutions that deliver robust, reliable and repeatable performance that meet Irish Water's onsite chemical storage and administration objectives, as well as setting in place best practice protocols for chemical handling techniques, delivery routines, and adequate placement of signage to ensure safe and secure transfer, storage and administration.

It should be noted that the application of this document, and every other specification within the 'building block' structure must also give due consideration to the health, safety, operability, environmental, and quality impacts of each installation in addition to the CAPEX and OPEX effects of each proposed design.

This specification outlines the minimum requirements for chemical storage and conveying infrastructure by describing Irish Water's policies towards system selection, design, manufacture, installation, inspection and operation of chemical storage facilities. While the specification is provided as a template to describe Irish Water's specific baseline requirements with regard to chemical storage and handling practices, the appointed Contractor shall retain the role of detailed system Designer and each design shall be carried out on a site specific basis, accounting for all constraints and restrictions therein. If the Designer's contractual remit extends to the operation of the facility post construction or installation, then chemical handling and delivery practices as outlined within this specification shall be complied with throughout the operation and maintenance stages of the contract.

Where appropriate, this Design Specification will make reference 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. For the Chemical Storage and Handling Design Specification, the user should make reference to the following WIMES documents where necessary:

- WIMES 8.02 Chemical Dosing Equipment (General Requirements)
- WIMES 8.02(A) Sodium Hydroxide Dosing Equipment
- WIMES 8.02(B) Sodium Hypochlorite Dosing Equipment
- WIMES 8.02(C) Sulphuric Acid Dosing Equipment
- WIMES 8.02(D) Coagulant and Phosphate Removal Chemical Dosing Equipment
- WIMES 8.02(E) Lime Slurry and Limewater Dosing Equipment
- WIMES 8.02(F) Orthophosphoric Acid Dosing Equipment
- WIMES 8.02(G) Polymer Dosing Equipment
- WIMES 8.02(H) Nitrate Chemical Dosing Equipment
- WIMES 8.02(I) Sodium Bisulphate Dosing Equipment

The above documents shall form the basis of equipment design, manufacture, installation, operation, inspection and maintenance for all chemical storage infrastructure and in tandem with this specification, should be used as a reference point by the Designer to ensure compliance with Irish Water requirements. Where a conflict exists between any of the guidance or reference documents listed throughout this document, then this specification will take precedence.

This Design Specification must be followed for both new and upgrade works where alterations to any aspect of chemical storage infrastructure forms a part of the scope, and it shall be implemented across all classes of water and wastewater pumping and treatment infrastructure under the control of Irish Water.

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 before proceeding with detailed design and installation.

2 LEGISLATION AND GUIDANCE

Irish Water are required to comply with all relevant EU Directives, national legislation and standards in relation to the storage and handling of chemicals. National legislation is largely driven by EU directives and generally aims to ensure that Environmental, Health and Safety responsibilities are fulfilled. This section provides a list of some of the regulations and guidance currently available with regard to the storage and handling of chemicals.

2.1 EU DIRECTIVES

National legislation is largely driven by EU directives which are then implemented into Irish law via Acts and Regulations. When proposing and designing chemical storage facilities in accordance with this specification, the Designer shall comply with all up to date legislation as drafted in response to EU directives. The following list details some of the most relevant EU directives with regard to chemical storage and handling.

- Urban Waste Water Directive (91/271/EEC)
- Waste Framework Directive (2008/98/EC)
- Drinking Water Directive (98/83/EC)
- Dangerous Substances Directive (2006/11/EC)
- Industrial Emissions Directive (2010/75/EU)
- Waste Framework Directive (2006/12/EC)
- Directive on the Classification, Packaging and Labelling of Dangerous Substances (67/548/EC)
- RoHS Directive (2011/65/EU)
- Directive on Pollution Caused by Certain Dangerous Substances Discharged Into the Aquatic Environment of the Community (76/464/EC)
- Directive on the Protection of Groundwater Against Pollution Caused by Certain Dangerous Substances (80/68/EC)
- Directive on Integrated Pollution Prevention and Control (96/61/EC)
- Directive 96/82/EC on the Control of Major Accident Hazards Involving Dangerous Substances (96/82/EC)
- Directive on the Major Accident Hazards of Certain Industrial Activities (82/501/EC)

2.2 HEALTH AND SAFETY LEGISLATION

The presence of hazardous materials, particularly corrosive, oxidising or explosive chemicals on a water or wastewater treatment or pumping facility presents a significant occupational health and safety concern for Irish Water. The safety of all employees, site visitors and the general public is Irish Water's primary concern with regard to the delivery, transfer, storage and administration of chemicals at Irish Water facilities. All Designers and Contractors involved in the design and construction of such facilities shall take cognisance of, and adhere to all aspects of, the relevant health and safety legislation, the most important of which are listed below. The regulations and orders made under the acts listed are not exhaustive and shall be investigated further if in doubt.

- Safety Health and Welfare at Work Act 2005
- Safety Health and Welfare at Work Act 2010
- Safety, Health and Welfare at Work (General Application) Regulations 2007

2.3 ENVIRONMENTAL LEGISLATION

As with occupational health and safety, the presence of hazardous chemicals on a water or wastewater treatment or pumping facility presents a significant environmental concern for Irish Water. Environmental legislation in Ireland is primarily conducted and governed by the EPA in conjunction with the Minister for the Environment, Community and Local Government. It is important to note that the HSA is the authority in Ireland currently responsible for administration of the European Communities (Control of Major Accident Hazards of Certain Industrial Activities) Regulations (1986 – 1992) (COMAH). All Designers and Contractors involved in the design and construction of chemical storage and administration facilities shall take cognisance of, and adhere to all aspects of, the relevant environmental legislation, the most important of which are listed below. The regulations and orders made under the acts listed are not exhaustive and shall be investigated further if in doubt.

- Environmental Protection Agency Act (1992)
- Protection of the Environment Act (2003)
- Waste Management Acts (1996 to 2011)
- European Communities (COMAH – Certain Industrial Activities) Regulations (1986 – 1992)
- Environmental (Miscellaneous Provisions) Act (2011)
- European Communities (Environmental Liability) Regulations (2008 – 2011)
- European Communities (COMAH – Involving Dangerous Substances) Regulations (2000 – 2006)
- Water Services Acts (2007 – 2012).
- Local Government (Water Pollution) Acts (1977 – 1990).
- Dangerous Substances Acts (1972 – 1979)

2.4 LEGISLATION DEALING WITH WATER AND WASTE

The following items of legislation are predominantly concerned with water and waste, to which Designers and Contractors shall adhere while working on Irish Water sites. The list reflects the key items of current legislation.

- European Communities (Drinking Water) (No. 2) Regulations 2007
- Local Government (Water Pollution) Acts 1977-1990
- Water Services Act 2007-2013
- Waste Management Act 1996
- Environmental Protection Agency (Industrial Emissions) (Licensing) Regulations 2013
- EU (Environmental Impact Assessment) (Waste) Regulations 2013
- European Communities (Waste Directive) Regulations 2011

- Waste Management Regulations 2006 - 2010

2.5 LEGISLATION DEALING WITH CHEMICALS AND DANGEROUS SUBSTANCES

All Designers and Contractors involved in the design and construction of chemical storage and administration facilities shall take cognisance of, and adhere to all aspects of, the relevant legislation dealing with chemicals and dangerous substances, the most important of which are listed overleaf. The regulations and orders made under the acts listed are not exhaustive and shall be investigated further if in doubt.

- Chemicals Act 2008 and 2010 Amendment
- Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) Regulations
- Classification, Labelling and Packaging of Substances and Mixtures (CLP) Regulation
- Chemicals Act (Control of Major Accident Hazards involving Dangerous Substances) Regulations 2015
- Dangerous Substances Act 1972 and 1979 Amendment
- RoHS Regulations - Statutory Instrument Number 513 of 2012
- SI 341 of 2005 RoHS Regulations

2.6 RELEVANT GUIDANCE

This section details a number of guidance documents produced by the appropriate regulators which can provide useful information to Designers and Contractors. Also included are a number of guidance documents in relation to chemical storage and handling good practice. The Designer shall identify which guidance documents are most appropriate for their requirements prior to commencement of design operations and proceed accordingly, however compliance with this document will still be required despite the content of listed guidance documents.

<u>HSA Guidance Documents</u>

- A Short Guide to The Safety, Health and Welfare at Work Act, 2005
- Guide to Safety, Health and Welfare at Work (General Applications) Regulations 2007
- Hazard, Labelling and Packaging according to the CLP Regulation Information Sheet
- Guide to the COMAH Regulations 2015
- Guide to the Chemicals Act 2008
- Guidelines to the Safety Health and Welfare at Work (Chemical Agents) Regulations, 2001
- Short Guide to the European Communities (COMAH - Involving Dangerous Substances) Regulations, 2006.

<u>EPA and Enterprise Ireland Guidance Documents</u>

- Storage and Transfer of Materials for Scheduled Activities
- Waste Legislation in Ireland Guidance Document (Enterprise Ireland - environcentre.ie)
- A Guide to *COMAH - Involving Dangerous Substances* Regulations (Enterprise Ireland - environcentre.ie).

<u>Guidance Documents produced by International Environmental Agencies and Organisations</u>

A number of environmental agencies and research organisations have produced helpful guidance documents which are relevant for chemical storage and handling practices. The UK HSE have a number of documents which provide useful information in relation to chemical storage and handling. As implementation of EU Legislation is different from country to country, these documents are not specifically related to Irish Law. However, the documents do provide useful information on chemical storage and have consequently been included in this section. A selection of such documents is outlined below:

- CIRIA Document C598 – Chemical Storage Tank Systems – Good Practice
- CIRIA Report C736 - Containment Systems for the Prevention of Pollution
- WIMES 4.01 – Paints and Polymeric Coatings for Corrosion Protection
- WIMES 8.02 – Chemical Dosing Equipment (pumped systems) for Water and Wastewater Treatment
- DIN 4119 AND 6600: German Standard for Above-ground Cylindrical Flat Bottomed Tanks.

3 HEALTH & SAFETY RELATED TO CHEMICAL STORAGE AND HANDLING

As stated in Section 2.2 the delivery, transfer, storage and administration of hazardous chemicals presents a significant occupational health and safety concern for Irish Water, and the safety of all operational employees, site visitors and the general public is Irish Water's primary concern. Due to the health and safety hazards posed it is essential that all chemical storage operating procedures and facilities are compliant with current Health and Safety Legislation. Designers and contractors shall ensure that chemical storage facilities maintain compliance with standards set out in the Safety, Health and Welfare at Work Acts (2005 and 2010) and Safety, Health and Welfare at Work (General Application) Regulations 2007, as listed in Section 2.2. At a minimum, the requirements outlined in the following sections shall be complied with for all installations.

3.1 RISK ASSESSMENTS

A comprehensive suite of Risk Assessments to address chemical compatibility, delivery, transfer, handling, storage and administration shall be completed and issued to Irish Water, or their representative, with the design submissions / construction documentation relating to each chemical storage facility. All discernible hazards shall be included within these risk assessments, and quantified numerically by the allocation of a score based on the product of ***hazard severity*** (marked out of 5) by the ***likelihood of occurrence*** (marked out of 5). 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 health and safety professional and designs / procedures resulting from the exercise shall be implemented throughout the installation. As well as submission to Irish Water, or their representative, the results of each Risk Assessment shall be displayed onsite to all personnel. Please see Section 5.1 for further details on specific RA requirements.

3.2 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. Through this specification, Irish Water establish that only PPE with the CE mark is suitable for chemical storage and handling purposes. Typical items of PPE that are commonly used for the handling of chemicals include:

- Protective Gloves that conform with European Standard EN374
- Face shields, googles and safety glasses that conform with European Standard EN166
- Rubber or plastic boots
- Chemical suits, overalls and aprons. Protective clothing should conform with EN13034
- Respirators – Either a self-contained breathing apparatus conforming to EN133 or a respirator that is fitted with a vapour filter conforming to EN141.
- Dust masks
- Hard hats

The Risk Assessments as described in Sections 3.1 and 5.1 shall determine the appropriate level / type of PPE which needs to be maintained on each specific site. In the case of chemical 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 each specific chemical. 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.*

3.3 EMERGENCY PROCEDURES

Emergency procedures shall be determined by the completion of each Risk Assessment as described in Sections 3.1 and 5.1 and shall be made known to all relevant personnel by clearly displaying the procedures on highly visible signs both within and outside of the facility. All emergency procedures shall also 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 suitably qualified health and safety professional. In terms of chemical storage and handling, operators and personnel should typically be aware of the following:

- General emergency procedures in terms of contact with chemicals 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 each stored chemical
- Emergency decontamination measures

- Emergency spill protection measures – different procedures may be associated with a large spill to a small spill. Different procedures will be relevant for different chemicals. Different procedures will also be applicable for the same chemical which is delivered in different states (i.e. powder and liquid).

3.4 EMERGENCY WASHING FACILITIES

Emergency washing facilities shall comply with all relevant national legislation. Numbers of wash stations and their most suitable locations shall be determined during completion of the Risk Assessments as outlined in Sections 3.1 and 5.1, and in accordance with the requirements of this specification. At a minimum, the following shall be incorporated into emergency washing facilities at all Irish Water chemical storage facilities:

- Emergency washing facilities shall include drench showers, eyewashes, suitable eye wash solutions, bottles, mirrors, wash down hoses and sufficient space to dislodge contaminated clothing.
- Facilities should be located at suitable areas on the site with access routes free from trip hazards and obstacles. The appropriate number of washing facilities and their locations within the site shall be determined by the completion of the Risk Assessments as described in Sections 3.1 and 5.1 of this specification.
- Emergency washing facilities in the delivery section of the site should comply with the requirements of the proposed chemical supplier.
- Actions must be taken to prevent contamination of any potable water supply connected to emergency washing facilities. This generally will mean supplying appropriate alarm systems and fittings.
- Wash down hoses must be of adequate length for supplying water to the required area.
- Provision should be made against the possible occurrence of freezing of the washing facility. This shall be achieved through thermostatically controlled heat tracing systems and adequate insulation on all washing facilities proposed for outdoor installation, or for any installation where the ambient temperature may fall below 5°C.

3.5 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 potential operators who may not fully appreciate the dangers of the chemicals stored, or their impacts if spillages or mixtures occur. In addition, all necessary infrastructure shall be provided to permit 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 (i.e. chemical batching, etc.). 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 Sections shall be adequately marked in compliance with current health and safety legislation. Signage and GHS labelling will be incorporated at appropriate locations identified in Risk Assessments.

- Chemical type, safety data sheets, procedures and working capacity of storage systems should be clearly displayed at relevant locations.
- Access to tanks is of particular interest from a health and safety point of view. In general, access ways to tanks should be via low level access ways.
- In accordance with WIMES 8.02, access to the bund floor area (where permitted) shall be via a GRP open mesh platform. A minimum of 450mm should be provided around all tanks, and clear screens shall protect against chemical jetting where space is unavailable for adequate bund width.
- All storage accessories and equipment such as pipes, pumps, valves etc. should comply with the health and safety requirements of European Directive 94/9/EC.
- 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 just inside the door of the storage facility. This shall also include details of all delivery, handling and 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.
- Spray out protection should be provided when secondary containment facilities are not available for equipment.
- In the case where an underground container entrance is above ground level, emergency washing facilities shall be located on the same level as the entrance.

4 OVERVIEW OF WATER & WASTEWATER TREATMENT CHEMICALS

Ireland's dependency on surface water sources for potable water supplies has resulted in a requirement to target the removal of natural organic matter (NOM), particularly in the form of dissolved organic carbon (DOC), in a bid to minimise the formation potential of disinfection by-products such as trihalomethanes (THMs) and haloacetic acids (HAAs). The removal of NOM is in addition to the removal of contaminants conventionally associated with potable water clarification, such as turbidity and colour, in preparation of the process water for disinfection by chlorination or ultraviolet irradiation mechanisms.

Accurately controlled coagulation and flocculation systems are one of the most effective ways of maximising NOM removal, but such processes are heavily dependent on the addition of charge neutralisation chemicals, and cationic polymers in order to achieve their desired objective. In addition, maximisation of the effectiveness of coagulation systems is dependent on raw water pH and alkalinity, which must be very accurately controlled to achieve optimum coagulation performance. A result of such extensive chemical addition during treatment, particularly on low alkalinity waters, is the considerable variation of process water pH, which very often must be adjusted prior leaving the plant in order to prevent corrosion of distribution network infrastructure or domestic pipework. Chemical usage on water treatment facilities can therefore be extensive, depending on the characteristics of the raw water and the type of treatment process that exists, or is proposed, on site.

While wastewater treatment processes are not as chemically dependent as water treatment processes, there are still a number of chemicals that are commonly found on sewerage treatment plants or pumping stations, such as ferric sulphate, cationic polymers or sodium / ferric nitrate mixtures; the latter typically being used for control of septicity on long rising mains or gravity sewers.

There are also particular chemicals listed which are commonly used on both water and wastewater treatment processes, such as polyelectrolyte or ferric sulphate. It is also not unusual to see sodium hypochlorite sometimes used on wastewater treatment plants as a means of disinfecting final effluent wash water supplies. However, in many cases a chemical that can be employed for both water and wastewater treatment may be used to achieve very different objectives within the process. For example, some industrial customers may have manufacturing processes which are sensitive to aluminium residuals in the water supply, therefore ferric sulphate may be used as an alternative coagulant to aluminium sulphate. However, when utilised on a wastewater treatment process, ferric sulphate is typically used as an oxidant to precipitate phosphorous from the flow, which subsequently settles out with the activated sludge at the clarification stage.

From the information presented above, chemical storage at water / wastewater treatment and pumping facilities can often be extensive, and the importance of following best practice with regard to chemical storage system selection, design, manufacture, installation, operation, inspection and maintenance cannot be overstated. Parallel to this, the presence of compliant infrastructure is compromised if chemicals are handled in an improper fashion during delivery, batching or transfer. This specification will outline Irish Water's minimum requirements with regard to chemicals which are typically found on water / wastewater treatment and pumping facilities throughout Ireland. While the specification does not cover every chemical that may be encountered, those outlined on Table 1 overleaf are the most commonly used on Irish water / wastewater infrastructure.

Typical Chemicals	Chemical Formula	Also Commonly Called	Allowable Dosing Concentrations (% w/w)	pH at Typical Delivery / Make-up Concentrations	Typical Chemical State in Delivery / Storage	Freezing Temperature at Conc. Noted	Used for Water / Wastewater Treatment	Irish Water Approved Use
Aluminium Sulphate	Al_2SO_4	Alum	8% for batched, 20 – 30% for liquid	0.5 – 2.5	Solid (pellets), Liquid Solution	-7°C	Water	Coagulation
Ferric Sulphate	$Fe_2(SO_4)_3$	Ferric, Iron Sulphate	40% to 50%	0.5 – 2.5	Liquid Solution	-15°C	Water and Wastewater	Coagulation / precipitation of phosphorous
Ferric / Sodium Nitrate Mixture	$Fe(NO_3).Na(NO_3)$	Septiox	38% to 48%	0.5 – 2.5	Liquid Solution	-12°C	Wastewater	Septicity Control
Hydrofluorosilicic Acid	H_2SiF_6	Fluorine	10.9%	< 1.0	Liquid Solution	-16°C	Water	Dental Care
Orthophosphoric Acid	H_3PO_4	Phosphoric Acid	75%	< 1.0	Liquid Solution	-17.5°C	Water	Corrosion Control
Poly-aluminium Chloride	$Al_nOH_mCl_{n-m}$ Basicity Dependant	PACl or ACH Basicity Dependant	10%, 18%	2.0 – 3.0 for 10% 0.5 – 1.0 for 18%	Liquid Solution	-5°C to -20°C	Water	Coagulation
Polyelectrolyte (Cationic / Anionic)	Various	Poly	0.1% to 1.0%	Neutral	Solid (powder), Liquid Solution	0°C	Water and Wastewater	Coagulation Aid / Sludge Binding for Dewatering
Potassium Permanganate	$KMnO_4$	Potash	4% to 5%	??????	Solid (pellets), Liquid Solution	???????	Water	Oxidation of Iron/Mang., Regeneration of Greensand
Sodium Carbonate	Na_2CO_3	Soda Ash	5% to 10%	> 11.0	Solid (powder)	-2°C	Water	pH Correction / Alkalinity Adjustment
Sodium Hydrogen Phosphate	Na_2HPO_4	Disodium Phosphate	4% to 5%	8.0 – 10.0	Solid (powder), Liquid Solution	???????	Water	Corrosion Control
Sodium Hydroxide	NaOH	Caustic, Lye, Caustic Soda	25%, 30%	> 13.0 both concentrations	Liquid Solution	5°C to -7°C	Water	pH Correction / Alkalinity Adjustment
Sodium Hypochlorite	NaOCl	Chlorine	10%	> 11.0	Liquid Solution	-9°C	Water and Wastewater	Disinfection
Sulphuric Acid	H_2SO_4	Acid / Sulphuric	96%	0	Liquid Solution	-14°C	Water	pH Correction

Table 1: Chemicals typically utilised on water and wastewater treatment processes and pumping applications in Ireland.

5 RISK ASSESSMENT DESIGN APPROACH

For each chemical storage installation, the Designer's primary concern shall be ensuring the provision of a safe working environment for all operation, inspection and maintenance activities associated with the delivery, transfer, storage, handling and batching of chemicals used in water / wastewater treatment processes. The Designer shall at all times consider the needs of the manufacturer, installer and end user, and shall also consider the potential environmental impacts of storage infrastructure failure, and put in place the required measures as outlined in this document to ensure the protection of staff and the area surrounding the installation.

Irish Water accepts that individual systems are likely to have unique requirements, and therefore specific solutions shall be developed in each case, however, certain minimum requirements shall apply for each chemical storage installation proposed. Prior to commencement of design, the Designer shall complete the following risk assessments in order to adequately select the most appropriate chemical storage layouts and products and, as much as is reasonably practicable, eliminate hazards that have been identified during the initial design stages.

Risk Assessments Required for the Completion of Chemical Storage Facility Design	
General Risk Assessment	▪ The Designer shall complete a detailed General Risk Assessment for each chemical storage facility proposed. The GRA shall cover the delivery, transfer, storage, handling, and administration of each chemical proposed, and the results of the GRA shall be used to determine mitigation measures to minimise risk for the general layout design. ▪ The GRA shall be submitted to Irish Water, or their representative, before procurement / construction of chemical storage infrastructure commences. ▪ The Risk Assessment shall address all health and safety concerns associated with the future routine operation, inspection and maintenance activities associated with chemical storage and administration facility, as well as the potential impact of infrastructure failure on the surrounding environment.
Chemical Compatibility Risk Assessment	▪ The Designer shall complete a Chemical Compatibility Risk Assessment which shall assess each of the chemicals proposed and ensure that materials of manufacture for transfer, storage, handling and administration are selected in accordance with this document and other relevant guidelines in order to maintain structural integrity for the duration of the facility's design life. ▪ The CCRA shall also asses the compatibility of chemicals proposed to determine if they can be stored together or require segregation. The designer shall ensure that all proposals prevent the mixing of incompatible chemicals (or gases released from chemicals) under any circumstances. ▪ The CCRA shall also identify incompatible storage materials which may result in the gradual release of explosive gases (i.e. hydrogen released from storage of dilute acids in carbon steel tanks, etc.).
PEAZ Assessment	▪ The Designer shall complete a Potentially Explosive Atmosphere Zoning assessment for all chemical storage facilities proposed, which shall identify all possible gases / explosive materials which may be generated, and mitigate accordingly. ▪ The PEAZ assessment shall dictate the selection of all electrical / electro-mechanical equipment proposed for installation in the vicinity of chemical storage facilities, and to assist with determining precise ventilation requirements.

Table 2: Risk assessments required for the completion of chemical storage facility design.

5.1 GENERAL RISK ASSESSMENT

As per Table 2 above, the Designer shall prepare a detailed General Risk Assessment (GRA) for the delivery, transfer, storage, handling and administration for each chemical at each facility proposed, and 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. The GRA for each chemical shall be 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. The basis of the GRA for each chemical 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?

Risk assessments shall be used throughout all chemical storage system selection and design to ensure careful consideration of all potential hazardous occurrences. 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.

If more than one chemical is proposed for storage at a particular site, the designer shall also complete, in addition to the GRA for each individual chemical, a Chemical Compatibility Risk Assessment *between* each chemical, or for the storage facility in its entirety. This shall allow the Designer to adequately assess the risk of storing specialist chemicals (such as one that might generate a hazardous reaction with other chemicals stored on a site), and permit proper consideration of the potential requirement to segregate storage facilities entirely.

5.2 CHEMICAL COMPATIBILITY RISK ASSESSMENT

For installations where more than one chemical is proposed for storage in a single room or area, the designer shall complete a Chemical Compatibility Risk Assessment which will support the General Risk Assessment described in Section 5.1 above. Design proposals shall be developed to mitigate against, minimise or eradicate completely the hazards identified by the Chemical Compatibility Risk Assessment. At a minimum, all design proposals regarding chemical compatibility shall take account of the following in order to reduce ***hazard severity*** and ***likelihood of occurrence*** risk ratings as determined by the Chemical Compatibility Risk Assessment:

- Grouping of each chemical in accordance with its physical and chemical properties (see Section 5.2.2)
- Classification of each chemical in accordance with its GHS hazards (see Section 5.2.3);
- Description of which chemicals proposed are to be fully segregated, and how this shall be implemented

- Potential creation of hazardous areas due to reactions between vapours, storage materials, etc.

The Chemical Compatibility Risk Assessment shall also identify the most suitable materials of manufacture for storage tanks, fittings, instruments, pipework, pumps, etc., and confirm that the Designer's proposal utilises such materials. The completed assessment shall be carried out for the specific concentration of each chemical proposed within the process design and shall be submitted to Irish Water, or their representative, prior to approval of the design of the chemical storage facility. In preparation of the Chemical Compatibility Risk Assessment, the Designer shall take cognisance of the following sections of this specification.

5.2.1 CHEMICAL COMPATIBILITY CONCERNS

Storage of certain hazardous chemicals in close proximity may result in violent reactions if, for any reason, the chemicals come into contact with each other. To exacerbate this issue, gases / vapours gradually released by some chemicals while in storage (sodium hypochlorite and hydrofluorosilisic acid being main concerns at water treatment facilities) may react with other chemicals (or gases / vapours from other chemicals) stored nearby to create a potentially explosive environment. Released gases may also be corrosive to other storage infrastructure, instrumentation or mechanical / electrical equipment which may be installed within close proximity.

The Designer shall therefore ensure that incompatible chemicals are segregated from each other according to compatibility groups and hazard class. While it is a minimum Irish Water requirement that separate bunding is proposed for each differing chemical storage system (i.e. two storage tanks, proposed to hold chemicals of differing properties shall not be permitted to be contained in one bund), the grouping / separation of compatible and incompatible chemicals shall go beyond this, and a clear separation shall be maintained between storage facilities for incompatible materials. This separation may take the form of a clear access route between differently grouped chemicals, which ensures that:

- Differently grouped chemicals are stored at different sides of the storage room, or different sides of the outdoor storage area, with access for operational activities through the middle.
- A minimum separation distance of 3.00m is maintained between the bund walls of differently grouped chemicals
- Chemicals of incompatible groups shall no share common bund walls.

For some chemicals, particularly those that degrade with the release of gas (sodium hypochlorite or hydrofluorosilisic acid as listed above), the storage facilities shall be completely segregated, i.e. the chemical shall be stored in a dedicated and ventilated room, shared with no other chemical(s), processes, mechanical or electrical systems outside those used for the particular chemical in question.

5.2.2 CHEMICAL COMPATIBILITY GROUPS

Water treatment chemicals can generally be divided into six incompatible groups, which are outlined in the table below. The designer shall note that storing incompatible materials together has to potential to create a hazardous reaction such as the production of toxic gas, accelerated corrosion, or an exothermic reaction (a chemical reaction that releases heat), which could result in an explosion and / or fire. Reactions such as this have the potential to be catastrophic, rendering the water / wastewater treatment plant inoperable, and possibly resulting in injury or loss of life.

Chemical Compatibility Groups			
Group I	Acids	**Group IV**	Adsorption Powders
Group II	Bases	**Group V**	Oxidising Powders
Group III	Salts & Polymers	**Group VI**	Compressed Gases

Table 3: Chemical Compatibility Groups.

The Chemical Compatibility Risk Assessment shall identify the most appropriate measures required to mitigate against risks posed by the storage of incompatible materials. The following are general guidelines with regard to using the groupings listed in Table 3 above:

- Liquid chemicals and dry chemicals shall not be stored together regardless of which compatibility group they fall under.
- Chemicals from different compatibility groups shall not be stored together. To ensure the safety of operational personnel and the system itself, each group of incompatible chemicals should be stored separately, with minimum requirements being the maintenance of a 3m distance between bund walls.
- Products such as paint, anti-freeze, detergent, oil, grease, fuel, solvent and beverages shall under no circumstances be stored in the same area as water treatment chemicals.
- All water treatment chemicals shall be stored in a secure, well ventilated area, that can be kept free from moisture (especially dry chemicals), excessive heat, ignition sources and flammable / combustible materials.

Table 4 below classifies the chemicals listed in Table 1 into their relevant groupings, and may be used as a general guidance when completing the Chemical Compatibility Risk Assessment. However the Designer shall note that total reliance on the grouping system is not recommended, and it is important that the characteristics of all individual chemicals proposed for storage are assessed and compared with each other as part of the completion of the Chemical Compatibility Risk Assessment, regardless of group.

To further refine the segregation requirements for storage installations with more than one chemical, the designer shall identify all hazards associated with each individual chemical proposed, in accordance with the Globally Harmonised System (GHS) of Classification and Labelling of Chemicals (see Section 5.2.3 below). The relevant GHS hazards for each chemical can be found on the materials SDS sheet, and this information shall be used to further segregate chemicals beyond the groupings shown in Table 4 if deemed necessary by the findings of the Chemical Compatibility Risk Assessment.

Group I: Acids	**Group II:** Bases	**Group III:** Salts & Polymers	**Group IV:** Adsorption Powders	**Group V:** Oxidising Powders	**Group VI:** Compressed Gases
Hydrofluorosilicic Acid	Calcium Hydroxide	Aluminium Sulphate	Powdered Activated Carbon	Potassium Permanganate	Ammonia
Phosphoric Acid	Sodium Bicarbonate	Ferric Sulphate	Granular Activated Carbon	-	Chlorine Gas
Sulphuric	Sodium	Poly-aluminium	-	-	Carbon

Acid	Carbonate	Chloride			Dioxide
-	Sodium Hydroxide	Polyelectrolytes	-	-	Sulphur Dioxide
-	Sodium Hypochlorite	Sodium Phosphate	-	-	Compressed Air

Table 4: Categorisation of chemicals into compatibility groups. Some additional chemicals also included.

Further to the sub-categorisation in accordance with the GHS, the Designer shall note that while sodium hypochlorite is listed under Group II, and is compatible for storage with other base substances, it shall remain fully segregated from all other chemicals at the facility, by being installed in its own room in accordance with the Irish Water Design Specification IW-TEC-900-05. Similarly, hydrofluorosilicic acid, while compatible for storage with other acids, shall be fully segregated from all other chemicals by being installed in its own room in accordance with the Irish Water Design Specification IW-TEC-900-XX.

The Designer shall ensure that the personnel completing the Chemical Compatibility Risk Assessment, and utilising all grouping and classification mechanisms which support associated risk mitigation measures proposed, is a suitably qualified chemical engineer or a health and safety professional with no less than 10 years' experience in the design of similar systems. All personnel involved in the preparation of this documentation, and all personnel responsible for designing, using and maintaining chemical storage facilities shall be familiar with the limitations of each grouping and classification system and the properties of the materials they are working with.

5.2.3 GHS CHEMICAL HAZARD CLASSIFICATION

The designer shall utilise the Globally Harmonised System (GHS) of Classification and Labelling of Chemicals to further assess (beyond the Chemical Compatibility Groups) the hazards associated with each chemical proposed for storage when designing the layouts for such facilities. The GHS, and information provided within the chemical's SDS sheets, shall be used to determine which chemicals (which may be listed as compatible under the grouping system) shall be segregated in order to minimise overall risk ratings as determined in both the Chemical Compatibility Risk Assessment and the General Risk Assessment. While the chemical grouping system outlined in Section 5.2.2 focuses primarily on chemical compatibility, the GHS is more closely aligned to the health and safety of operational personnel. Both systems shall be considered when designing storage facilities.

The GHS is an internationally agreed-upon system and has been designed to replace the various classification and labeling standards used in different countries by using consistent criteria for classification and labeling on a global level. The GHS classification of hazards is divided into **class** and **category**, which describe the nature and, if applicable, the degree of hazard of the chemical product. In total there are nine hazard classes, which are split over three groups, Physical Hazards, Health Hazards and Environmental Hazards. Each chemical will have a hazard **class**, and within that class are several hazard **categories**, of which one or more may apply. Hazard classes are shown in Diagram 1 below.

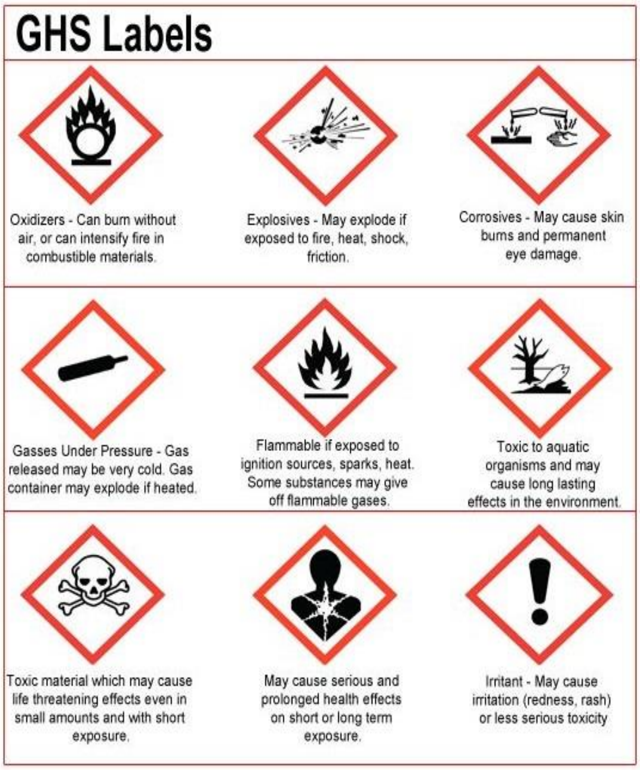


Diagram 1: Globally Harmonised System of Classification and Labelling of Chemicals.

Hazard Groups	Hazard Class	Examples of Hazards
Physical Hazards	Oxidising	Oxidising gases, liquids or solids. Can burn without an air supply, can intensify fire in combustible materials.
	Flammable	Flammable gases / aerosols / liquids / solids if exposed to ignition source, pyrophoric liquids / solids, self-heating substances, substances which emit flammable gas, self-reacting substances and mixtures, organic peroxides.
	Explosive	Unstable explosives, self-reactive substances and mixtures, organic peroxides. Any substance which may explode if exposed to fire, heat, shock or friction.
	Corrosive	Skin corrosion or burns, permanent eye damage, corrosive to metals, concrete or other materials.
	Compressed Gas	Gasses under pressure, liquefied gases, dissolved gasses. Released gas may be very cold or gas container may explode if heated or impacted.
Health Hazards	Irritant	Acute toxicity (oral, dermal, inhalation), eye and skin irritant, skin sensitisation, specific organ toxicity, narcotic effects, respiratory tract irritant, hazardous to ozone layer.
	Serious Health Effects	Carcinogenicity, germ cell mutagenicity, reproductive toxicity, respiratory sensitisation, specific organ toxicity, aspiration toxicity.
	Toxic	Acute toxicity (oral, dermal, inhalation), may result in life threatening effects even in small amounts and with short exposure.
Environmental	Environmentally Damaging	Acute hazard to the aquatic environment, chronic hazard to the aquatic environment, may cause long lasting environmental effects.

Table 5: Hazard Groups, Hazard Classes and examples of hazards. Designers should refer to the *GHS 'Purple Book'* for more detailed information regarding Hazard Categorisation.

The designer shall adhere to the guidelines published in the *GHS 'Purple Book',* United Nations, 2009 which expands upon the following basic steps of chemical hazard classification:

1. Identify the relevant data concerning the hazards of the chemical

2. Determine if the chemical is hazardous based on its physical hazards, health hazards, and environmental hazards as outlined in the SDS sheets.
3. Determine how the chemical's SDS classifies the hazards
4. Identify each of the hazard classes that apply to each chemical
5. Identify the appropriate hazard category within each class of chemical to identify its severity

5.2.4 LIMITATIONS OF GROUPING AND CLASSIFICATION SYSTEMS

While the Chemical Compatibility Grouping System and the Globally Harmonised System of chemical hazard classification are useful tools for design guidance, total reliance on such systems is not recommended, and Irish Water, or their representative, will not accept design proposals for chemical storage facilities which are not supported by the relevant risk assessments (General Risk Assessment, Chemical Compatibility Risk Assessment, PEAZ Assessment) as described in this document.

The Designer shall use the grouping and classification systems only as starting points for the development and completion of all risk assessments, which will ultimately identify the site specific hazards and appropriate mitigation measures on a site specific basis. The designer shall take cognisance of the fact that no single method of determining chemical compatibility is perfect, due to:

- Many chemicals belonging to more than one hazard class leading to confusion as to which class is most appropriate for the chemical in question. Generally, the hazard class that is most important is the determining factor, however;
- The hazard class that is most important can change depending on factors such as quantity of material, and the presence of other chemicals in the storage area.
- Not all chemicals in a given class / group are compatible, e.g., a mixture of certain oxidising liquids can lead to the formation of shock sensitive explosives, despite both oxidising liquids belonging to no other class of chemical.
- Rigid adherence to a classification scheme often leads to inefficient work practices. For example, while the segregation of acids and bases is good practice if stored in their concentrated forms, it may not be practical for numerous dilute solutions, given that mixing may not result in a hazardous reaction.
- The sheer number of exceptions to any classification scheme prevents listing them all in a single convenient reference table.

It is therefore imperative that those working with chemicals, those completing General Risk Assessments, Chemical Compatibility Risk Assessments, Potentially Explosive Atmosphere Zoning Assessments (see Section 5.3) and those responsible for designing, using and maintaining chemical storage facilities be familiar with the limitations of each classification system and the properties of the materials they are working with. As such, all General Risk Assessments, Chemical Compatibility Assessments, and PEAZ Assessments shall be carried out on a site specific and chemical specific basis, by a person or persons suitably qualified or experienced in the preparation of such documentation. The Designer shall utilise the Safety Data Sheets (SDS) to assess the hazards posed by each chemical proposed, and consequently use this information to further refine the categorisation and grouping of the chemicals. This information shall allow identification of incompatible chemicals and facilitate the Designer to implement adequate segregation of chemicals stored on site. Note that all risk assessments shall be completed for chemicals at the storage concentration proposed. If a proposed concentration is changed for any reason during the design process, then each affected risk assessment shall be updated accordingly.

Regardless of the results of the Chemical Compatibility Assessment the Designer shall ensure that the chemicals proposed for use in the treatment process are stored in a fashion that will not permit mixture under any circumstances, especially in the event of storage infrastructure failure. At a minimum, each chemical storage system shall be fully bunded, with only one chemical allowed for storage in each individual bund, and all bunds shall be capable of holding 110% of the volume of the onsite storage capacity for each particular chemical.

5.3 PEAZ ASSESSMENT

A potentially explosive atmosphere zoning (PEAZ) assessment shall be completed in addition to the Chemical Compatibility Risk Assessment on all equipment proposed in the vicinity of chemical storage facilities, and the areas surrounding the equipment shall be zoned accordingly. The assessment shall consider all materials of construction that the chemical could potentially come into contact with, both during normal operation, or due to accidental leaks or spillages. If equipment is retrofitted into an existing building that was not previously classed as a hazardous area, but has become so on the basis of new proposals, the designer shall ensure the replacement of existing plant that is not suitably rated with appropriate 'Ex' rated equipment.

5.4 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, handling, storage, batching 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. Should valves be required they shall be positioned within the bunded area, or alternatively within an enclosure 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 should be capable of being completed without requiring access to the bund, as should all chemical replenishment and/or batching procedures. Access to the bund should only be required in exceptional circumstances or for non-routine maintenance activities.

6 MATERIAL COMPATIBILITY

The Designer shall ensure that the materials used to construct the chemical storage, batching, transfer or dosing equipment are compatible with the chemical to be handled, and shall comply with all relevant standards. This section of the document specifies the materials that shall be used to manufacture equipment to store, batch, transfer and dose chemicals typically associated with water and wastewater treatment.

6.1 TYPICAL STORAGE MATERIALS

Some basic information on materials typically used for storage, batching, transfer and dosing of water and wastewater treatment chemicals is outlined in the following sections. The adequacy of the materials to be used along with any hazards associated with that material during construction or operation of the storage facility shall be considered when completing the General and Chemical Compatibility Risk Assessments. The below guidelines are not exhaustive, and specialist advice from system manufacturers should be sought as part of the design process. Section 6.2 of this document gives more specific information as to material compatibility.

6.1.1 CARBON STEEL

Carbon steel, which includes the subsets of mild steel (0.08% - 0.25% carbon) and high carbon steel (0.25% - 2.00% carbon) is an alloy of iron and carbon, and while suitable for the storage of a large number of chemicals, it can also react with other chemicals such as dilute acids (i.e. < 70% sulphuric acid, resulting in the release of highly flammable hydrogen gas). The compatibility of the chemical to be stored should be assessed when selecting the grade of carbon steel (mild steel, high carbon steel, etc.) for system construction. The designer shall give careful consideration to chemicals whose degradation by-products or dilute forms may be reactive with the grade of carbon steel proposed, even if their concentrated or original forms are not reactive – i.e. as per the sulphuric acid example given above.

Carbon steel is also susceptible to corrosion in the presence of oxygen and water. Adequate material protection (painting, lining, etc.), or use of an alternative material should be considered in cases where corrosion may occur due to exposure to air and atmospheric moisture. Irish Water will not accept a corrosion allowance for carbon steel tanks. In addition, the corrosion of carbon steel is exacerbated by aggressive conditions (such as a saline environment) and by increased temperature. This shall be taken into consideration by the designer where chemicals are proposed for storage within 10km of the coast, or installations where storage facilities may be at a temperature above ambient. Use of any unprotected carbon steel components should also be avoided in environments where they may react with the chemicals present (for example, when hydrogen peroxide contacts carbon steel a violent reaction can occur). Similarly, the use of unprotected carbon steel components shall be avoided where the chemical stored could become contaminated by the release of iron (i.e. iron contamination of sodium hydroxide, iron sulphate contamination of sulphuric acid, etc.).

Carbon steel components can also be susceptible to stress corrosion cracking (e.g. in sodium hydroxide storage applications). The risk of this should be assessed and, if considered significant, an alternative material shall be considered. Reference should be made to the carbon steel supplier’s corrosion tables for corrosion rates for the grade of carbon steel selected, and the tank designer shall issue these tables to Irish Water prior to approval of procurement / fabrication of carbon steel storage or batching tank(s).

6.1.2 STAINLESS STEEL

Stainless steel is an alloy of iron and chromium and is generally less susceptible to atmospheric or moisture corrosion than carbon steel, and so is often used in particularly aggressive environments or where added corrosion protection is required. However, its reduced susceptibility is dependent on the grade of the stainless steel used (304, 316, etc. – dependant on chromium content) and all grades are still susceptible to corrosion in saline environments. Reference should be made to the stainless steel supplier’s corrosion tables for corrosion rates for the grade of stainless steel selected, and the tank designer shall issue these tables to Irish Water prior to approval of procurement / fabrication of stainless steel storage or batching tank(s).

6.1.3 PLASTIC BASED MATERIALS

Plastic based materials are commonly used for the storage and handling of chemicals that are reactive to iron based alloys. System components can be constructed to be resistant to most chemicals provided the component material has been appropriately selected with respect to the chemical that it is designed to store or convey. Common materials used in the manufacture of plastic storage and handling equipment are outlined below:

<u>Glass Reinforced Plastics (GRP)</u>

GRP materials consist of layers of resin and glass fibre laminate surfaced with a chemically resistant resin rich barrier layer. The type of resin used for the barrier layer shall be selected for the required application and may be replaced by a thin inner shell of thermoplastic to form a composite material.

<u>Polypropylene (PP)</u>

Polypropylene is the most versatile and widely used thermoplastic. It offers very high chemical resistance, strength, lightness, absence of colour taint or toxicity, and easy maintenance at a relatively low cost. Polypropylene's strength means it may be used for the production of unreinforced tanks at volumes larger than other plastics, such as high density polyethylene.

<u>High Density Polyethylene (HDPE)</u>

HDPE is not as versatile as PP, and has no price advantage, but it is useful for certain chemicals, such as peroxides and some strong acids. However the relatively low strength of HDPE limits its unreinforced use to smaller tanks.

<u>Un-plasticised Polyvinyl Chloride (uPVC)</u>

uPVC is more costly than PP or HDPE, but cam be used where strong oxidising and reducing chemicals, such as chlorine compounds are stored. uPVC is brittle, so it is best used as a constituent part of a GRP composite.

<u>Polyvinylidene Fluoride (PVDF)</u>

PVDF is more costly than PP, HDPE or uPVC, but should be used for more aggressive chemicals stored at higher temperatures.

<u>Polytetrafluoroethylene (PTFE)</u>

PTFE is a synthetic fluoropolymer with excellent chemical resistance properties. It also has a 'non-stick' property and is particularly useful where sliding action of component parts is required, i.e. in chemical dosing pumps

<u>Ethylene Propylene Diene Monomer (EPDM)</u>

EPDM is a synthetic rubber elastomer with excellent chemical resistivity and is extremely useful in the manufacture of sealing components in aggressive chemical handling equipment, i.e. chemical dosing pumps.

6.2 CHEMICAL SPECIFIC MATERIAL SELECTION

The materials chosen for the manufacture of chemical storage, batching, transfer and dosing equipment shall be selected from the following sections, and be of a grade that is deemed most appropriate for the hazard classification of the chemical in question, at the storage concentrations proposed. However, the designer shall not rely entirely on the information purveyed in this section of the document, and shall consult the chemical tank manufacturer, or material supplier, as to the chemical resistivity properties of the materials proposed for use in the manufacture of all aspects of chemical storage and handling equipment.

6.2.1 ALUMINIUM SULPHATE AT 8% AND 20-30% W/W

Aluminium sulphate [Al_2SO_4] is one of the most common coagulants used at water treatment plants and may be delivered to site in pelletized form (also known as kibbled aluminium) or in liquid solution of typically 20 - 30% concentration. The pelletized form of the chemical is typically batched onsite by operational personnel to concentrations of approximately 8%. All details in the below table assume that the batched chemical is at an 8% w/w concentration, and that delivered solution is as a 20 - 30% w/w concentration. Aluminium sulphate at any concentrations other than those listed will not be acceptable for use on Irish Water treatment facilities.

Infrastructural Element	Components	Approved Materials	Notes
Bulk Storage Facilities	Bulk Storage Tank	Lined Mild Steel PVC or PP Lined GRP / HDPE	-
	Pipework (Rigid)	uPVC, ABS, PE, PP	-
	Valves	Lined Ductile Iron Lined Mild Steel	Natural rubber or fluoropolymer liners
Batching Facilities	Batching Tank	Lined Mild Steel PVC or PP Lined GRP / HDPE	-
	Pipework (Rigid)	uPVC, ABS, PE, PP	-
	Valves	Lined Ductile Iron Lined Mild Steel	Natural rubber of fluoropolymer liners
Dosing Pipework	Pipework (Rigid)	uPVC, ABS, PE, PP	-
	Pipework (Flexible)	Reinforced PVC hose	-
Pump Components	Heads, Valve Seats, Guides	Rigid PVC	-
	Valve Balls	PTFE	-
	Diaphragms	PTFE	-
	Valve Seals	Viton	-
Dosing Arrangement	Withdrawable Injection Fittings	uPVC	-
	Sparge Piping	uPVC	-
Mixing	Static Mixers	Lined Mild Steel pipework with Hastelloy C or PVDF Mixing element	-
General	Gaskets and O-Rings	Viton or Natural Rubber	-

Table 6: Materials approved for use with 8% and 20 – 30% w/w Aluminium Sulphate Al_2SO_4.

Aluminium sulphate at 8% w/w concentration is generally regarded as being only mildly corrosive, but in solutions of 20 – 30% is more aggressive, with a lowered pH. Concrete disintegration may occur across the concentration ranges if there is inadequate sulphate resistance. All concrete which may come into contact with the chemical shall therefore be of an acid resistant grade, or alternatively, suitably lined with one of the approved liners as described in Section 6.3. The designer shall consult with a lining specialist for all concrete plinths, bunds, etc. proposed for use with all aluminium sulphate storage and dosing facilities.

High carbon steel or galvanised steel shall not be used for any parts of the equipment that may come into contact with the chemical, due to the potential for dilute acids to react with the material to generate hydrogen gas. This includes any part of the equipment that could inadvertently come into contact with the chemical through spillages or leaks, e.g. galvanised steel access platforms, etc. Stainless steel (grade 316L) and most polymeric pipework materials (e.g. ABS, PE, PP and PVC) are compatible with aluminium sulphate at typical storage dosing temperatures and may be used as the materials of construction of components comprising the equipment.

6.2.2 FERRIC SULPHATE AT 40 - 50% W/W

Ferric Sulphate [$Fe_2(SO_4)_3$] is typically found at wastewater treatment plants where it is used to chemically precipitate phosphorous from the effluent. It may also be used, albeit less commonly, as a coagulant at water treatment plants which supply industries that may have a process sensitivity to aluminium residuals (thereby making the use of aluminium based coagulants unfeasible). All details in the below table assume that the chemical stored, transferred and dosed is at a 40 - 50% w/w concentration. Ferric sulphate at any concentrations other than 40 - 50% w/w will not be acceptable for use on Irish Water treatment facilities.

Infrastructural Element	Components	Approved Materials	Notes
Bulk Storage Facilities	Bulk Storage Tank	Lined Mild Steel PVC or PP Lined GRP / HDPE	-
	Pipework (Rigid)	uPVC, ABS, PE, PP	-
	Valves	Lined Ductile Iron Lined Mild Steel	Natural rubber or fluoropolymer liners
Batching Facilities	Batching Tank	n/a	n/a
	Pipework (Rigid)	n/a	n/a
	Valves	n/a	n/a
Dosing Pipework	Pipework (Rigid)	uPVC, ABS, PE, PP	-
	Pipework (Flexible)	Reinforced PVC hose	-
Pump Components	Heads, Valve Seats, Guides	Rigid PVC	-
	Valve Balls	PTFE	-
	Diaphragms	PTFE	-
	Valve Seals	Viton	-
Dosing Arrangement	WIFs	uPVC	-
	Sparge Piping	uPVC	-
Mixing	Static Mixers	Lined Mild Steel pipework with Hastelloy C or PVDF Mixing element	-
General	Gaskets and O-Rings	Viton or Natural Rubber	-

Table 7: Materials approved for use with 40 - 50% w/w Ferric Sulphate $Fe_2(SO_4)_3$.

Ferric sulphate at 40 - 50% w/w concentration is corrosive to most metals, including stainless steel (with the exception of grade 316L), and concrete disintegration will occur with inadequate sulphate resistance. All concrete which may come into contact with the chemical shall therefore be of an acid resistant grade, or alternatively, suitably lined with one of the approved liners as described in Section 6.3 of this specification. The designer shall consult with a lining specialist for all concrete plinths, bunds, etc. proposed for use with all ferric sulphate storage and dosing facilities.

High carbon steel or galvanised steel shall not be used for any parts of the equipment that may come into contact with the chemical, due to the potential for dilute acids to react with the material to generate hydrogen gas. This includes any part of the equipment that could inadvertently come into contact with the chemical through spillages or leaks, e.g. galvanised steel access platforms, etc. Stainless steel (grade 316L) and most polymeric pipework materials (e.g. ABS, PE, PP and PVC) are compatible with ferric sulphate at typical storage dosing temperatures and may be used as the materials of construction of components comprising the equipment.

6.2.3 FERRIC / SODIUM NITRATE MIXTURE (SEPTIOX) AT 38 – 48% W/W

Septiox is a mixture of ferric nitrate [$Fe(NO_3)$] and sodium nitrate [$Na(NO_3)$] and is used as an anti-septicity agent which is dosed into flows at wastewater collection networks or pumping stations where there may be issues with extended retention periods, resulting in the release of nuisance odours from manholes and wet wells. All details in the below table assume that the chemical stored, transferred and dosed has a ferric nitrate concentration of 8 – 12% w/w and a sodium nitrate concentration of 30 – 35% w/w. Septiox at concentrations other than that referenced shall not be acceptable for use on Irish Water facilities.

Infrastructural Element	Components	Approved Materials	Notes
Bulk Storage Facilities	Bulk Storage Tank	HDPE, PP PP or uPVC lined GRP	HDPE, PP for tanks < 1000L PP/uPVC Lined GRP for tanks > 1000L
	Pipework (Rigid)	uPVC	-
	Fill Line and associated valves	uPVC	The first unsupported section shall be of metallic construction
	Valves	uPVC	-
Dosing Pipework	Pipework, Valves and Fittings (Rigid)	uPVC	-
	Pipework and Fittings (Flexible)	Reinforced uPVC hose	-
Dosing Pump Components	Heads	PP or PVDF	-
	Valve Seats & Guides	PTFE	-
	Valve Balls	Ceramic	-
	Diaphragms	PTFE	-
	Valve Seals	Viton	-
	Hose (Peristaltic pumps only)	Thermoplastic Elastomer	-
General	Gaskets and O-Rings	Natural rubber, Viton	-

Table 8: Materials approved for use with Septiox [ferric nitrate (8 – 12%) and sodium nitrate (30 – 35%)] solution.

As a dilute acid, Septiox is corrosive to carbon based metals and if in contact, may release hydrogen gas which when combined with air produces a highly flammable gas. Septiox will also cause the slow disintegration of concrete across a range of concentrations. All concrete that may come into contact with Septiox shall therefore be of an acid resistant grade, or alternatively suitably lined with one of the approved liners as described in Section 6.3 of this specification. The designer shall consult with a lining specialist for all concrete plinths, bunds, etc. proposed for use with Septiox storage and dosing facilities.

6.2.4 HYDROFLUOROSILICIC ACID AT 10.9% W/W

Hydrofluorosilicic acid [H_2SiF_6] is added to some water supplies as a means of maintaining dental hygiene amongst consumers. All details in the below table assume that the chemical stored, transferred and dosed is at a 10.9% w/w concentration. Hydrofluorosilicic acid at any concentration other than 10.9% w/w will not be acceptable for use on Irish Water treatment facilities.

Infrastructural Element	Components	Approved Materials	Notes
Bulk Storage Facilities	Bulk Storage Tank	PE, PP (tanks < 1000 L) uPVC lined GRP (tanks > 1000 L) Rubber Coated Steel (tanks > 1000 L)	-

	Pipework (Rigid) Fill Lines and associated valves	uPVC uPVC Note that uPVC pipework shall be adequately supported to withstand mechanical vibration / impact during filling.	Class E (15 bar) or Class 7 (12 bar after threading) pipe shall be used to minimise the effects of chemical embrittlement on pipework integrity. Double union, ¼ turn ball valves to be used throughout
	Valves	Hastelloy, uPVC, PP, PE	Thermoplastic valves may be used on small tanks (< 1000 L)
Batching Facilities	Batching Tank	n/a	-
Dosing Pipework	Pipework, Valves and Fittings (Rigid)	uPVC	As per bulk storage tank pipework
	Pipework and Fittings (Flexible)	PP, PE, PE multi-layer composite, reinforced PVC hose	-
Dosing Pump Components	Heads	Rigid PVC	-
	Valve seats and guides	Rigid PVC	-
	Valve balls	PP	-
	Diaphragms	PP or CSM Rubber (Hypalon)	-
	Valve seals	Viton	-
Dosing Arrangement	WIFs	????????????????????	
	Sparge Pipes	????????????????????	-
Mixing	Static Mixers	????????????????????	-
General	Gaskets, O-Rings	Viton	-

Table 9: Materials approved for use with 10.9% w/w hydrofluorosilicic acid H_2SiF_6.

Hydrofluorosilicic 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 hydrofluorosilicic 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 hydrofluorosilicic acid storage and dosing facilities.

6.2.5 ORTHOPHOSPHORIC ACID AT 75% W/W

Orthophosphoric acid (H_3PO_4) is sometimes used at water treatment plants which distribute to areas where plumbosolvency (i.e. the leaching of lead from municipal or domestic pipework) or cuprosolvency (i.e. the leaching of copper from domestic pipework) may be a concern. The addition of orthophosphoric acid at low concentrations reacts with lead and hardness ions to form an insoluble protective coating on the internal surfaces of the distribution system. This coating prevents the leaching of lead or copper to the water supply, with the continued dosing of orthophosphoric acid maintaining the protective layer. All details in the below table assume that the chemical stored, transferred and dosed is at a 75% w/w concentration. Orthophosphoric acid at any concentration other than 75% w/w will not be acceptable for use on Irish Water treatment facilities.

Infrastructural	Components	Approved Materials	Notes

Element			
Bulk Storage Facilities	Bulk Storage Tank	HDPE or PP/PVC lined GRP	PP/PVC Lined GRP shall be used for large storage tanks (> 5000L)
	Pipework (Rigid)	PP or uPVC	
	Fill Lines and associated valves	PP or uPVC	The first unsupported section shall be made from lined carbon steel of grade 316L SS
	Valves	PP or uPVC	
Batching Facilities	Batching Tank	n/a	n/a
Dosing Pipework	Pipework, Valves and Fittings (Rigid)	PP or uPVC	-
	Pipework and Fittings (Flexible)	Reinforced PVC hose	-
Dosing Pump Components	Heads	PP or PVC	-
	Valve seats and guides	PTFE or PVC	-
	Valve balls	Ceramic or PTFE	-
	Diaphragms	PTFE	-
	Valve seals	Viton	-
Dosing Arrangement	WIFs	Stainless Steel (Grade 316L)	-
	Sparge Pipes	PP or uPVC	-
Mixing	Static Mixers	Fusion bonded epoxy coated mild steel pipework with SS (Grade 316L) mixing element	-
General	Gaskets, O-Rings	EPDM, Hypalon, Neoprene, Viton	-

Table 10: Materials approved for use with 75% w/w orthophosphoric acid H_3PO_4.

Orthophosphoric 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 mildly corrosive to concrete, and may cause slow disintegration if in contact. All concrete that may come into contact with orthophosphoric acid shall therefore be of an acid resistant grade, or alternatively suitably lined with one of the approved liners as described in Section 6.3 of this specification. The designer shall consult with a lining specialist for all concrete plinths, bunds, etc. proposed for use with orthophosphoric acid storage and dosing facilities.

6.2.6 POLY-ALUMINIUM CHLORIDE (PACL) AT 10 – 18% AL_2O_3 W/W

Poly aluminium chloride [$Al_2(OH)_{(x)}Cl_{6-x}$], also known as PACl, is particularly useful as a coagulant on low alkalinity raw waters, due to the PACl compound being pre-hydrolysed [i.e. hydroxide (OH^-) ions are already present in the PACl compound before it is added to an alkaline solution]. This property allows PACl to have a much lower alkalinity demand than aluminium sulphate. PACl is available in various pre-hydrolysed states; 50% pre-hydrolysed [$Al_2(OH)_{(3)}Cl_3$], or 83% pre-hydrolysed [$Al_2(OH)_{(5)}Cl_1$], the latter also known as aluminium chlorohydrate (ACH). The higher the pre-hydrolysed percentage, the lower the alkalinity demand of the chemical. All details in the below table assume that the chemical has a 10 - 18% Al_2O_3 content, with a solution concentration of 25 – 40%.

Infrastructural Element	Components	Approved Materials	Notes
Bulk Storage Facilities	Bulk Storage Tank	Lined Mild Steel PVC or PP Lined GRP / HDPE	-
	Pipework (Rigid)	uPVC, ABS, PE, PP	-
	Valves	Lined Ductile Iron Lined Mild Steel	Natural rubber or fluoropolymer liners
Batching Facilities	Batching Tank	Lined Mild Steel PVC or PP Lined GRP / HDPE	n/a
	Pipework (Rigid)	uPVC, ABS, PE, PP	n/a
	Valves	Lined Ductile Iron Lined Mild Steel	Natural rubber of fluoropolymer liners
Dosing Pipework	Pipework (Rigid)	uPVC, ABS, PE, PP	-
	Pipework (Flexible)	Reinforced PVC hose	-
Pump Components	Heads, Valve Seats, Guides	Rigid PVC	-
	Valve Balls	PTFE	-
	Diaphragms	PTFE	-
	Valve Seals	Viton	-
Dosing Arrangement	WIFs		-
	Sparge Piping		-
Mixing	Static Mixers	Lined Mild Steel pipework with Hastelloy C or PVDF Mixing element	-
General	Gaskets and O-Rings	Viton or Natural Rubber	-

Table 11: Materials approved for use with 25 - 40% w/w poly-aluminium chloride $Al_2(OH)_{(X)}Cl_{6-x}$.

Poly-aluminium chloride is corrosive to most metals at concentrations where the pH < 2, and rapid concrete disintegration will occur with inadequate resistance. All concrete which may come into contact with the chemical shall therefore be of a grade resistant to PACl, or alternatively, suitably lined with one of the approved liners as described in Section 6.3 of this specification. The designer shall consult with a lining specialist for all concrete plinths, bunds, etc. proposed for use with poly-aluminium chloride storage and dosing facilities.

High carbon steel or galvanised steel shall not be used for any parts of the equipment that may come into contact with the chemical, due to the potential for dilute acids to react with the material to generate hydrogen gas. This includes any part of the equipment that could inadvertently come into contact with the chemical through spillages or leaks, e.g. galvanised steel access platforms, etc. Most polymeric pipework materials (e.g. ABS, PE, PP and PVC) are compatible with poly aluminium chloride at typical storage dosing temperatures and may be used as the materials of construction of components comprising the equipment.

6.2.7 POLYELECTROLYTE AT 0.1 – 1.0% W/W

Polyelectrolyte is utilised on both water and wastewater treatment plants, often as a coagulation aid for sludge thickening processes. In addition, for water treatment, a cationic polyelectrolyte solution is typically used to promote the growth (flocculation) of coagulated contaminants, upstream of subsequent clarification process stages. Polyelectrolyte can be delivered to site as a solution or as a powder, however for processes with a large poly demand it is much more economical to receive powder deliveries and batch the chemical to the desired concentration onsite. All details in the below table assume that the chemical delivered and stored (if delivered as solution) or batched and dosed (if delivered as powder), is at a concentration of between 0.1 – 1.0% w/w.

Infrastructural Element	Components	Approved Materials	Notes
Bulk Storage Facilities	Bulk Storage Tank	GRP, HDPE	-
	Powder Silo	Mild steel	Silo to be painted externally
	Pipework (Rigid)	ABS, uPVC	-
	Fill Lines and associated valves	Galvanised mild steel	Applies for both liquid and powder deliveries
	Valves	ABS, uPVC	-
Batching Facilities	Screw Conveyor	Mild steel	-
	Powder Hopper	Stainless Steel (Grade 304L)	-
	Screw Feeder	Stainless Steel (Grade 304L)	-
	Dispersion Unit	Stainless Steel (Grade 304L)	-
	Batching Tanks	GRP, HDPE, Stainless Steel (304L)	-
	Pipework, Valves & Fittings	ABS, uPVC	-
Dosing Pipework	Pipework, Valves & Fittings (Rigid)	ABS, uPVC	-
	Pipework & Fittings (Flexible)	Reinforced PVC hose	-
Dosing Pump Components (Diaphragm Pumps)	Heads	Rigid PVC	-
	Valves Seats & Guide	Rigid PVC	-
	Valve Balls	PTFE	-
	Diaphragms	PTFE	-
	Valve Seals	Viton	-
Dosing Pump Components (PC Pumps)	Rotor	Chromium plated steel, stainless steel (Grade 316)	-
	Stator	Nitrile Rubber	-
Dosing Arrangement	WIFs	ABS, FBE Coated mild steel, stainless steel (Grade 316), uPVC	-
	Sparge Pipes	As per WIFs	-
Mixing	Static mixers	PP	-
General	Gaskets, O-Rings	Viton or EPDM	-

Table 12: Materials approved for use with 0.1 – 1.0% cationic or anionic polymers.

Polyelectrolyte solutions are generally not corrosive and no special protection of concrete is required for structures which may come into contact with the chemical. Batching systems can however result in the spread of polyelectrolyte powder to all parts of the batching facility, therefore poly make up systems shall be adequately separated from other chemical storage facilities to prevent contamination of associated treatment chemicals.

6.2.8 POTASSIUM PERMANGANATE AT 4 – 5% W/W

Potassium permanganate [$KMnO_4$] is used on water treatment plants for the regeneration of Greensand, a filter media which is typically used in filtration processes designed for the removal of iron and manganese. Regeneration may be carried out on a continuous basis (Continuous Regeneration) by dosing potassium permanganate into the raw water feed to the filter, or on an intermittent basis (Intermittent Regeneration) by dosing the chemical into the water used for filter backwashing. As well as regenerating Greensand, potassium permanganate also oxidises iron and manganese from their soluble forms to their insoluble forms, thereby allowing their removal in the filtration process.

Potassium permanganate is usually delivered to site in powdered form and is batched to the required concentration, typically 4 – 5% w/w, depending on whether it is to be used for continuous or intermittent regeneration purposes. All details in the below table assume that the chemical batched, stored, transferred and dosed is at a concentration of 4 - 5% w/w.

Infrastructural Element	Components	Approved Materials	Notes
Batching Facilities	Screw Conveyor	Mild Steel	In neutral or alkaline solutions
	Powder Hopper	Stainless Steel (Grade 304 or 316)	In neutral or alkaline solutions
	Screw Feeder	Stainless Steel (Grade 304 or 316)	In neutral or alkaline solutions
	Dispersion Unit	Stainless Steel (Grade 304 or 316)	In neutral or alkaline solutions
	Batching Tanks	HDPE, Stainless Steel PVC or PP Lined GRP / HDPE	HDPE for tanks < 1000L
	Pipework, Valves & Fittings	uPVC, PE, PP	-
Dosing Pipework	Pipework, Valves & Fittings (Rigid)	uPVC, PE, PP	-
	Pipework & Fittings (Flexible)	Reinforced PVC Hose	-
Dosing Pump Components (Diaphragm Pumps)	Heads	Rigid PVC	-
	Valves Seats & Guide	Rigid PVC	-
	Valve Balls	PTFE	-
	Diaphragms	PTFE	-
	Valve Seals	Viton, EPDM	-
Dosing Arrangement	WIFs	uPVC, Stainless Steel	SS only in neutral / alkaline solutions
	Sparge Pipes	uPVC, Stainless Steel	SS only in neutral / alkaline solutions
Mixing	Static mixers	uPVC, EPDM, Ceramic (< 3 bar) Stainless Steel , PTFE, EPDM (> 3 bar)	Stainless steel only in neutral / alkaline solution
General	Gaskets, O-Rings	Viton, EPDM	-

Table 13: Materials approved for use with 4 – 5% w/w potassium permanganate $KMnO_4$

While potassium permanganate is a strong oxidant, at concentrations typically found on water treatment facilities, it is generally not corrosive to most metallic substances provided the solvent is neutral or alkaline, and does not pose a disintegration threat to concrete bunds or plinths. Specialist painting or linings are therefore not required for concrete structures associated with potassium permanganate batching or dosing systems.

6.2.9 SODIUM CARBONATE AT 5 – 10% W/W

Sodium carbonate (Na_2CO_3) is very commonly used at water treatment plants for alkalinity boosting and pH correction purposes. It may sometimes be used to boost the pH of the water entering the plant for effective coagulation purposes, and also for treated water leaving the plant as a means of corrosion control for distribution pipework. Sodium carbonate is usually delivered to site in powdered form, and is manually batched to the required concentrations (most commonly 5 – 10% w/w) by operational staff.

Due to the labour intensive nature of sodium carbonate batching, it is typically utilised in smaller plants only, with sodium hydroxide being the preferred method of alkalinity boosting / pH correction at larger facilities. All details in the below table assume that the chemical is batched and dosed is at a 5 – 10% w/w concentration. Sodium carbonate at concentrations other than that referenced above may be permitted, but not without the prior approval of Irish Water or their representative. In such circumstances the designer shall submit documentation confirming that existing or proposed batching infrastructure is sufficiently resistant to corrosion at the sodium carbonate concentration proposed.

Infrastructural Element	Components	Approved Materials	Notes
Batching Facilities	Screw Conveyor	Mild steel	-
	Powder Hopper	Stainless Steel (Grade 304 or 316)	-
	Screw Feeder	Stainless Steel (Grade 304 or 316)	-
	Dispersion Unit	Stainless Steel (Grade 304 or 316)	-
	Batching Tanks	GRP, HDPE, Stainless Steel (Grade 304 or 316)	HDPE for tanks < 1000L GRP or SS for tanks > 1000L
	Pipework, Valves & Fittings	ABS, uPVC	-
Dosing Pipework	Pipework, Valves & Fittings (Rigid)	ABS, uPVC	-
	Pipework & Fittings (Flexible)	Reinforced PVC hose	-
Dosing Pump Components (Diaphragm Pumps)	Heads	Rigid PVC	-
	Valves Seats & Guide	Rigid PVC	-
	Valve Balls	PTFE	-
	Diaphragms	PTFE	-
	Valve Seals	Viton or EPDM	-
Dosing Arrangement	WIFs	uPVC, Stainless Steel	-
	Sparge Pipes	uPVC, Stainless Steel	-
Mixing	Static mixers	uPVC, PFTE, EPDM, Ceramic (< 3 bar) Stainless Steel, PTFE, EPDM (> 3 bar)	-
General	Gaskets, O-Rings	Viton or EPDM	-

Table 14: Materials approved for use with 5 – 10% w/w sodium carbonate $Na_2(CO_3)$.

At the concentrations typically found on water treatment facilities, sodium carbonate is generally not corrosive to most metallic substances, and does not pose a disintegration threat to concrete bunds or plinths. Specialist painting or linings are therefore not required for concrete structures associated with sodium carbonate batching or dosing systems.

6.2.10 SODIUM HYDROGEN PHOSPHATE AT 4 – 5% W/W

Sodium hydrogen phosphate (also known as disodium phosphate) [Na_2HPO_4] may be used as an alternative to orthophosphoric acid as a means of plumbosolvency or cuprosolvency control. The chemical is usually supplied in a powdered form and batched onsite to the desired concentration, typically 4 – 5% w/w, however it is also commercially available as a liquid solution. All details in the below table assume that the chemical batched, stored, transferred and dosed is at a 4 - 5% w/w concentration.

Infrastructural Element	Components	Approved Materials	Notes
Bulk Storage Facilities	Bulk Storage Tank	PVC Lined GRP / HDPE	-
	Pipework (Rigid)	uPVC, ABS, PE, PP	-
	Valves	Lined Ductile Iron Lined Mild Steel	Natural rubber or fluoropolymer liners
Batching Facilities	Batching Tank	PVC Lined GRP / HDPE	n/a
	Pipework (Rigid)	uPVC, ABS, PE, PP	n/a
	Valves	Lined Ductile Iron Lined Mild Steel	Natural rubber of fluoropolymer liners
Dosing Pipework	Pipework (Rigid)	uPVC, ABS, PE,	-
	Pipework (Flexible)	Reinforced PVC hose	-
Pump Components	Heads, Valve Seats, Guides	Rigid PVC	-
	Valve Balls	PTFE	-
	Diaphragms	PTFE	-
	Valve Seals	Viton	-
Dosing Arrangement	WIFs		-
	Sparge Piping		-
Mixing	Static Mixers	Stainless Steel 316L	-
General	Gaskets and O-Rings	Viton or Natural Rubber	-

Table 15: Materials approved for use with 4 – 5% w/w sodium hydrogen phosphate Na_2HPO_4

Sodium hydrogen phosphate is mildly corrosive to certain metals, including aluminium, zinc and galvanised iron and hydrogen gas may be liberated when the chemical is in contact with these materials, which may lead to the creation of an explosive atmosphere when mixed with air. Sodium hydrogen phosphate at 4 – 5% concentration is generally not corrosive to concrete, however if stronger concentrations are proposed, then the Designer shall consult with a lining specialist for all concrete plinths, bunds, etc. proposed for use with sodium hydrogen phosphate storage and dosing facilities. If the chemical at the concentration proposed is deemed to pose a risk to the integrity of concrete structures, the all materials proposed which may come into contact with the chemical shall be of a resistant grade, or alternatively suitably lined with one of the approved liners as described in Section 6.3.

6.2.11 SODIUM HYDROXIDE AT 25 - 30% W/W

Sodium hydroxide [NaOH] is very commonly used at water treatment plants for alkalinity boosting and pH correction purposes. It may sometimes be used to boost the pH of the water entering the plant in order to create optimum conditions for coagulation, and also used for treated water leaving the plant as a means of corrosion control for distribution pipework. All details in the below table assume that the chemical stored, transferred and dosed is at a 25 or 30% w/w concentration. Sodium hydroxide at any concentrations other than 25 or 30% w/w will not be acceptable for use on Irish Water treatment facilities.

Infrastructural Element	Components	Approved Materials	Notes
Bulk Storage Facilities	Bulk Storage Tank	Mild steel. If iron contamination cannot be tolerated use lined mild steel, stainless steel (304L), PVC or PP Lined GRP or HDPE.	Mild steel is suitable for sodium hydroxide concentrations up to 47% and service temperatures up to 50°C. Suitable linings include EPDM, PP and PTFE/PVDF
	Pipework (Rigid) Fill Lines and associated valves	> 27% NaOH: stainless steel (304L) ≤ 27% NaOH: PE, PP Stainless steel (304L)	**Stainless Steel:** PN16 flanged, ASTM A312/ANSI B36.19M ≤ 3/4" – schedule 40S > 1" – schedule 10S **PE/PP:** Fusion Welded
	Valves	Mild Steel. If iron contamination must be avoided use lined mild steel or stainless steel (304L).	Thermoplastic valves may be used on smaller tanks (typically < 5m^3)
Dosing Pipework	Pipework, Valves and Fittings (Rigid)	> 27% NaOH: stainless steel (304L) ≤ 27% NaOH: PE, PP	-
	Pipework and Fittings (Flexible)	PTFE, PE, PE multi-layer composite, PTFE stainless steel jacketed hose, braided PVC hose	-
Dosing Pump Components	Heads	Rigid PVC, PP, stainless steel	-
	Valve seats and guides	Rigid PVC, PP, stainless steel	-
	Valve balls	PTFE, PP, stainless steel	-
	Diaphragms	PFTE laced EPDM, Viton	-
	Valve seals	Viton, EPDM	-
Dosing Arrangement	WIFs	Stainless Steel	-
	Sparge Pipes	Stainless Steel or Thermoplastics	-
Mixing	Static Mixers	uPVC, PFTE, EPDM, Ceramic (< 3 bar) Stainless Steel, PTFE, EPDM (> 3 bar)	-
General	Gaskets, O-Rings	Viton or EPDM	-

Table 16: Materials approved for use with 25 - 30% w/w sodium hydroxide NaOH.

Sodium hydroxide is corrosive to certain metals, including aluminium, brass and zinc, and when in contact with these materials hydrogen is liberated which, when mixed with air, may create an explosive atmosphere. Sodium hydroxide at concentrations above 20% is also corrosive to concrete, therefore all concrete structures which may come into contact with the chemical shall be of a resistant grade, or alternatively suitably lined with one of the approved liners as described in Section 6.3. The designer shall consult with a lining specialist for all concrete plinths, bunds, etc. proposed for use with sodium hydroxide storage and dosing facilities.

6.2.12 SODIUM HYPOCHLORITE AT 10% W/W

Sodium hypochlorite (NaOCl) is the most common chemical found on water treatment plants due to its efficacy for viral and bacterial disinfection of potable water supplies. It may also sometimes be used as an oxidant to facilitate the precipitation of particular target contaminants. All details in the below table assume that the chemical stored, transferred and dosed is at a 10% w/w concentration. Sodium hypochlorite at any concentrations other than 10% w/w will not be acceptable for use on Irish Water treatment facilities.

Infrastructural Element	Components	Approved Materials	Notes
Bulk Storage Facilities	Bulk Storage Tank	HDPE (tanks < 1000 L) uPVC lined GRP (tanks > 1000 L) EPDM Lined Steel (tanks > 1000 L)	-
	Pipework (Rigid) Fill Lines and associated valves	uPVC uPVC or EPDM / Fluoropolymer lined steel. Note that uPVC pipework shall be adequately supported to withstand mechanical vibration / impact during filling.	Class E (15 bar) or Class 7 (12 bar after threading) pipe shall be used to minimise the effects of chemical embrittlement on pipework integrity. Double union, ¼ turn ball valves to be used throughout
	Valves	EPDM / Fluoropolymer lined steel	Thermoplastic valves may be used on small tanks (< 1000 L)
Batching Facilities	Batching Tank	n/a	-
Dosing Pipework	Pipework, Valves and Fittings (Rigid)	uPVC	As per bulk storage tank pipework
	Pipework and Fittings (Flexible)	PFTE, PVDF, PE, PE multi-layer composite, stainless steel jacketed PTFE hose, reinforced PVC hose	-
Dosing Pump Components	Heads	Rigid PVC	-
	Valve seats and guides	Rigid PVC	-
	Valve balls	PTFE	-
	Diaphragms	PTFE, CSM Rubber (Hypalon)	-
	Valve seals	Viton	-
Dosing Arrangement	WIFs	uPVC (< 6 bar) Hastelloy / titanium (> 6 bar)	Stainless steel shall not be used
	Sparge Pipes	uPVC	-
Mixing	Static Mixers	Fusion bonded epoxy coated mild steel or thermoplastics	-
General	Gaskets, O-Rings	Viton or EPDM	-

Table 17: Materials approved for use with 10% w/w sodium hypochlorite NaOCl.

Sodium hypochlorite is corrosive to many metals, including iron, cobalt, copper and nickel. In addition to this, contact with such metals increases the rate of sodium hypochlorite degradation, resulting in a less effective disinfectant, the release of chlorine gas and oxygen, and the corrosion of chemical storage infrastructure. Sodium hypochlorite, while not overly corrosive to concrete, will cause slow disintegration if in contact, therefore all concrete which may come into contact with the chemical (regardless of concentration) shall be of a resistant grade, or alternatively, suitably lined with one of the approved liners as described in Section 6.3. The designer shall consult with a lining specialist for all concrete plinths, bunds, etc. proposed for use with sodium hypochlorite storage and dosing facilities.

6.2.13 SULPHURIC ACID AT 96% W/W

Sulphuric acid is very commonly used at water treatment plants which take their water supplies from high alkalinity sources as a means of pH suppression in advance of coagulation. All details in the below table assume that the chemical stored, transferred and dosed is at a 96% w/w concentration. Sulphuric acid at any concentrations other than 96% w/w will not be acceptable for use on Irish Water treatment facilities.

Infrastructural Element	Components	Approved Materials	Notes
Bulk Storage Facilities	Bulk Storage Tank	Mild steel. Lined mild steel or stainless steel (316L) if iron contamination cannot be tolerated. PVC lined GRP.	A passivating layer of iron sulphate forms on mild steel surfaces, which prevents further corrosion.
	Pipework (Rigid)	Lined mild steel or PVDF. Suitable linings include glass or fluoropolymers (e.g. FEP, PFA, PTFE, PVDF) *Note that mild / stainless steel is not suitable for pipework as the high fluid velocities erode the passivating iron layer.*	If moisture traps are not fitted, moisture ingress into vent / overflow pipework can reduce the acid concentration and render mild / stainless steel unsuitable for use.
	Valves	Lined Ductile Iron Lined Cast Steel	fluoropolymer linings
Batching Facilities	Batching Tank	n/a	n/a
	Pipework (Rigid)	n/a	n/a
	Valves	n/a	n/a
Dosing Pipework	Pipework, Valves and Fittings (Rigid)	Mild steel or PVDF. Lined mild steel or stainless steel (316L) if iron contamination cannot be tolerated.	Pipework to be sized correctly. High fluid velocities will erode passivating layer. Mild Steel < 0.6 m/s S/S < 2.0 m/s
	Pipework and Fittings (Flexible)	PVDF or PTFE lined stainless steel braided hose.	-
Dosing Pump Components	Heads	Stainless Steel (316L) or PVDF	-
	Valve seats and guides	Alloy 20 or PTFE	-
	Valve balls	Hastelloy C or PTFE	-
	Diaphragms	PTFE	-
	Valve seals	Viton	-
General	Gaskets and O-Rings	Filled PTFE and Viton	-

Table 18: Materials approved for use with 96% w/w sulphuric acid H_2SO_4.

Sulphuric acid is highly corrosive to carbon based metals at concentrations less than 70%, and causes the disintegration of concrete across a range of concentration. While concentrations of less than 96% w/w will no longer be accepted on Irish Water sites, sulphuric acid dosing systems will make use of carrier water for injection purposes, resulting in the onsite dilution of the chemical. All materials selected for carrier water injections shall therefore be resistant to H_2SO_4 at the expected dilute concentration. All concrete which may come into contact with the chemical (regardless of concentration) shall be an acid resistant grade, or alternatively, suitably lined with one of the approved liners as described in Section 6.3. The designer shall consult with a lining specialist for all concrete plinths, bunds, etc. proposed for use with sulphuric acid storage and dosing facilities.

6.2.14 DESIGN CONSIDERATIONS FOR POLYMERIC STORAGE TANKS

The designer shall ensure of the following when proposing polymeric based tanks for chemical storage facilities:

- All polymeric tanks proposed for installation outdoors shall be adequately protected against degradation by ultraviolet (UV) light by the used UV stabilisers. The design life of the tank shall not be reduced due to exposure to UV light. This is an important consideration when selecting materials for construction or an external protective finish for tanks where UV is likely to be prevalent
- The design life of polymeric bulk chemical storage tanks is typically measured in fill cycles rather than years, therefore in order to meet the minimum design life requirements, the designer shall ensure that the fill frequency of each tank is considered.
- The degree of damage to plastic tanks in the event of a fire may be more significant than that of metal based tanks.
- Some plastic materials may have adverse static accumulation properties which shall be taken into account when selecting materials for use in a potentially explosive atmosphere. This shall be considered when completing the potentially explosive atmosphere zoning (PEAZ) assessment as part of the Chemical Compatibility Risk Assessment.

6.3 CONCRETE LININGS

The following linings are suitable to protect concrete infrastructure (bunds, plinths, floors, etc.) which may come into contact with the chemicals outlined in the previous sections of this document.

1. Chlorinated Rubber

Chlorinated rubber surface treatment consists of a trowel-applied mastic of heavy consistency up to 3 mm thick, or multiple coats of specially formulated lower-viscosity types can be brushed or sprayed on to a maximum thickness of 0.25 mm. An absolute minimum of 0.1 mm (applied in two coats) is recommended for chemical exposure. In general, concrete should age for two months before this treatment. The concrete may be damp but not wet, as excessive moisture may prevent adequate bonding. It is advisable to thin the first coat, using only the producer’s recommended thinner (other thinners may be incompatible). A coating dries tack-free in an hour, but a 24-hour interval is recommended between coats.

2. Chlorosulfonated Polyethylene (Hypalon)

Four coats of about 0.05mm each and an appropriate primer are normally recommended to eliminate pinholes. Thinning is not usually required, but to reduce viscosity for spray application, the producer’s recommended thinner should be used up to a limit of 10% of the amount of coating used. Each coat dries dust-free within 10 to 20 minutes, and the treatment cures completely in 30 days at 21 °C and 50% relative humidity. A fill coat of grout or mortar is required since the paint film will not bridge voids in the concrete surface. Moisture on the surface may prevent good adhesion. These coatings are expensive and must be applied by trained personnel.

3. Vinyls

Of the vinyls available, polyvinyl chloride, polyvinyl chloride acetate, and polyvinylidene chloride are the ones used extensively in corrosion control for concrete structures. The resins are soluble only in strong solvents. Due to the high viscosity of the resins, only solutions of low solids content can be made. Multiple coats are therefore required for adequate film thickness. Vinyls should generally be sprayed onto dry surfaces, as their fast drying (30 minutes) makes brush application difficult. Vinyl chloride coatings make good top coatings for vinyl chloride acetate and others, but do not themselves adhere well directly to concrete.

4. Bituminous Paints, Mastics and Enamels

Asphalt or coal-tar coatings may be applied cold (paints and mastics in cutback or emulsion form) or hot mastics and enamels). Two coats are usually applied to surface-dry concrete: a thin priming coat to ensure bond and a thicker finish coat. The priming solution is of thin brushing consistency and should be applied to cover the surface completely; any uncoated spots should be touched up. When the primer has dried to a tacky state, it is ready for the finish coat. Multiple coats should be applied at right angles to each other to ensure continuity and avoid pinholes.

Emulsions are slower drying, more permeable, and less protective than the other coatings. The producer's recommendations on service and application temperatures should be strictly observed. Bituminous mastics may be applied cold or heated until fluid. Cold mastics are cutbacks or emulsions containing finely powdered siliceous mineral fillers or bitumen-coated fabrics to form a very thick, pasty, fibrous mass. This mass increases the coating's resistance to flowing and sagging at elevated temperatures and to abrasion. Thin mastic layers, about 1 mm thick, are troweled on and allowed to dry until the required thickness has been obtained. Hot mastics should be poured and troweled into place in layers 16 mm to 25 mm thick. Enamels should be melted, stirred, and carefully heated until they reach the required application temperature. If an enamel is heated above the producer's recommended temperature, it should be discarded. If application is delayed, the pot temperature should not be allowed to exceed 190 °C. When fluid, the enamel should be applied quickly over tacky cutback primer, since it sets and hardens rapidly.

5. Polyester

These resin coatings are two- and three-part systems consisting of polyester, peroxide catalyst, and sometimes a promoter. The amount of catalyst must be carefully controlled because it affects the rate of hardening. The catalyst and promoter are mixed separately into the polyester. Fillers, glass fabrics, or fibres used to reduce shrinkage and coefficient of expansion compensate for the brittleness of resin and increase strength. Polyesters are usually silica filled except for hydrofluoric acid service, which requires non-siliceous fillers such as carbon. Coatings with a 2- to 3-hour pot life generally cure in 24 to 36 hours at 24 °C. Shorter curing periods require reduced pot life because of high heats of reaction. Coatings are sensitive to changes in temperature and humidity during the curing period. Some coatings can be applied to damp surfaces at temperatures as low as 10 °C. The alkali resistance of some polyesters is limited. It is recommended that trained personnel apply the coatings.

6. Epoxy

These coatings are generally a two-package system consisting of epoxy resin—which may be formulated with flexibilizers, extenders, diluents, and fillers—and a curing agent. The coating properties are dependent on the type and amount of curing agent used. The common curing agents suitable for curing are amines, polyamines, amine adducts, polyamides, poly-sulphides, and tertiary amines. The polyamide cured epoxies have less chemical resistance but better physical properties. The designer shall follow the formulator's recommendations for the best application procedures, temperatures, and allowable working life. Epoxies are usually trowel or roller applied. Generally, two coats must be applied to eliminate pinholes, especially on rough or porous surfaces. Epoxy toppings can be low or high-build; with aggregate added, they can be up to 6 mm thick.

7. Neoprene

These coatings may be one- or two-part systems. The one-part system is used as a thinner film than the two-part and generally has a lower chemical resistance. It cures slowly at room temperature, and some curing agents may limit its shelf life. The two-part system may require a holding period between mixing and application. To allow evaporation of water from the concrete, application of either system should not begin for at least 10 days after removal of formwork. Some coatings require primers while others are self-priming. Adhesion is often improved by application of a diluted first coat to increase penetration of the surface. Each coat should be sufficiently solvent-dry before the next application; however, if it becomes too fully cured, it may swell and lose adhesion. Three coats, 0.05 mm to 0.08 mm each, are normally recommended to eliminate the possibility of pinholes. For immersion service, minimum dry thickness should be 0.5 mm.

8. Chemical Resistant Masonry Units, Mortars, Grouts and Concretes

Chemical-resistant brick and tile are usually solid, kiln-fired masonry units made from clay, shale, or mixtures thereof for masonry construction. Units can also be made from carbon, graphite, or other materials where additional chemical resistance is required. Chemical-resistant mortar or grout must be used to fill the joints between chemical-resistant brick or tile. Mortars are troweled on the sides and bottom (or faces to be bonded) of the brick to about 3 mm thickness before the brick is placed. Grouts are usually applied to joints, about 6 mm wide, after the masonry units are set in place on the floor. Commonly used mortars and grouts include:

- Asphaltic and bituminous membranes
- Epoxy resin mortars or grouts
- Furan resin mortars or grouts
- Hydraulic cement mortars or grouts
- Phenolic resin mortars
- Polyester resin mortars
- Silicate mortars
- Sulphur mortars
- Vinylester resin mortars
- Sulphur concretes
- Polymer concretes
- Silicate based concretes

9. Sheet Rubber

Soft natural and synthetic rubber sheets 3 mm to 13 mm (1⁄8 in. to 1⁄2 in.) thick may be cemented to concrete with special adhesives. Sometimes two layers of soft rubber are used as a base, with a single layer of hard rubber over them. Chemical-resistant synthetics available as sheeting are neoprene, polyvinylidene chlorideacrylonitrile, plasticized polyvinyl chloride, poly-isobutylene, butyl, nitrile, polysulfide, and chlorosulfonated polyethylene rubbers.

7 GENERAL LAYOUT DESIGN OF CHEMICAL STORAGE FACILITIES

While not all of the hazards listed in Table 5 are relevant to chemicals typically found on water / wastewater treatment facilities, the designer shall ensure that chemical storage layouts are designed to minimise the risk of physical, health or environmental hazardous occurrences. The completion of the General Risk Assessment, Chemical Compatibility Risk Assessment, and PEAZ Assessment as described in Section 5 of this document, and the mitigation measures proposed to ensure that risk ratings are maintained below a score of 5 for all hazards identified, shall form the basis for the general layout design of the chemical storage facilities. However, the designer shall also adhere to the general layout requirements outlined within this section of the document

7.1 INDOOR / OUTDOOR CHEMICAL STORAGE

The suitability of chemicals for indoor or outdoor storage shall be determined by the physical volume of the chemical to be stored onsite, the susceptibility of the chemical to freezing, the susceptibility of the chemical to degradation in higher temperatures, and the safety and security requirements of the particular chemical. Due to restrictions such as space on site, conditions of planning permission, etc. it is not possible to definitively specify the indoor or outdoor storage of chemicals on a general basis, however, where possible, the designer shall adhere to the following requirements:

General Requirements for Indoor v Outdoor Storage of Chemicals	
Indoor Storage	▪ All powder storage silos, unless the designer can propose a method to prevent the ingress of moist air into the storage tank
	▪ All chemical batching facilities, including manual systems (i.e. sodium carbonate), or fully automated systems (i.e. poly make-up). Includes all powder storage facilities.
	▪ For a single chemical, all volumes less than or equal to 12,000 litres (i.e. 2 No. 6,000 litre bulk tanks) where space and planning permission allows.
	▪ All chemicals which have a freezing temperature above - 18°C, and where the installation of an internal tank heating system is impractical or unsafe.
	▪ All chemicals which suffer degradation in elevated temperatures, and where the installation of an internal tank chilling system is impractical or unsafe.
	▪ All sodium hypochlorite storage facilities (without exception)
	▪ All hydrofluorosilicic acid storage facilities (without exception)
	▪ All bagged solid chemicals (sodium carbonate, polyelectrolyte, kibbled alum, etc.)
Outdoor Storage	▪ For a single chemical, volumes in excess of 12,000 litres (i.e. 2 No. bulk storage tanks,

	each in excess of 6,000 litres), provided it is practicable and safe to implement the installation of a internal tank heating and / or chilling system
	▪ For a single chemical, volumes in excess of 12,000 litres (i.e. 2 No. bulk storage tanks, each in excess of 6,000 litres) which have a freezing temperature below - 18°C and do not suffer chemical degradation in ambient temperatures of up to 30°C.

Table 19: General requirements for indoor vs outdoor chemical storage and batching facilities.

When designing for outdoor facilities, the designer shall ensure that all delivery, storage, transfer, batching and dosing infrastructure is designed to remain fully operational in outside air temperatures as low as -18°C and as high as 30°C. All sufficient tank heating/chilling, lagging, and heat tracing shall be implemented (where safe to do so), to maintain each chemical above its specific freezing / crystallisation temperature and below its accelerated degradation temperature. Where it is deemed unsafe to implement such systems due to concerns over ignition, etc. then the designer shall allow for indoor installation of that chemical.

All indoor chemical storage facilities shall be designed to be maintained between temperatures of 10°C and 20°C (with the exception of sodium hypochlorite which may be maintained to between temperatures of 5°C and 20°C) in all climatic conditions between a minimum outside air temperature of -18°C and a maximum outside air temperature of 30°C.

7.2 STORAGE TANK SECURITY

All buildings / rooms which store chemicals, or house chemical batching 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. 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.

All outdoor chemical storage installations shall be located at dead ended areas, where there is no through traffic. Outdoor storage tanks which are not contained within concrete bunds (i.e. tanks which have integrated weather shrouded bunds) shall be protected from accidental impacts by traffic bollards, spaced no more than 2.00m apart. The bund walls for all outdoor chemical storage installations shall be a minimum distance of 10.00m from the fenced site boundary in order to minimise risk of vandalism from outside the perimeter. All access manways, filling valves, access ladders, 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.

7.3 INAPPROPRIATE STORAGE LOCATIONS

While chemical storage layout designs shall be completed on a site specific basis, the designer shall remain obliged to ensure that the facilities for chemical storage are located at the most appropriate locations available on the site. However, the designer shall avoid, as much as is reasonably practicable given the site conditions, installation in the following areas:

- Roof top installation, including roof tops of underground tanks, pumping stations, etc.
- Adjacent to watercourses; installations to be kept as far as reasonable practicable from watercourses

- Adjacent to drainage systems; leakage of chemical should not end up in adjacent watercourses
- Within potential floodplains
- In areas where wind loading may be high
- Adjacent to external roads, main site thoroughfares, high risk delivery routes, etc.
- Adjacent to site boundaries, especially is the boundary is in close proximity to residential areas, public areas / parks or leisure facilities
- Adjacent to stairs or elevated walkways
- Adjacent to storage areas for incompatible chemicals, or sources of ignition

7.4 ACCESS AND ESCAPE ROUTE REQUIREMENTS

The designer shall ensure that sufficient access to chemical storage facilities is provided for the safe completion of routine operational activities, as well as all necessary inspection and maintenance activities. Where elevated platforms are required to access tank roofs, they shall be installed at a level above the top of the tank, which shall prevent structural damage or risks associated with liquid surging in the event of catastrophic tank failure. Elevated platforms shall be accessed by stairs (not by ladders), and all supports for access platforms/stairs shall be outside bund walls. For all elevated access platforms over 5.00m in length, two stairways shall be provided (one at each end of the platform) to ensure an escape route is available in the event of a hazardous occurrence. Material selection for access platforms and stairs shall take account of the chemicals to be stored and shall not be compromised by corrosion due to chemical proximity, and in the case of steel work, not be susceptible to the release of hydrogen gas in the presence of certain chemicals (see Section 6.2 for further details). All elevated platforms shall be no less than 1.20m wide.

Adequate ground level access to chemical storage facilities shall be provided for both indoor and outdoor installations. Clear and unobstructed access to bund walls shall be provided for all chemicals, and in the case of indoor installations, two access doors (one at either end of the room) shall be provided for all chemical storage facilities. This will ensure an escape route is available in the event of a hazardous occurrence. For all rooms which store more than one chemical, a main access thoroughfare (walkway) no less than 3.00m wide (measured from bund wall to bund wall) shall be provided along the full length of the building / room. All access doors shall be sized to permit the removal of a tank up to 2.00m in diameter, without requiring the removal of flanges, connections, overflow pipes, vents or instruments.

Where indoor installations incorporate chemicals of different groupings or classifications (see Section 5 for further details) the main access thoroughfare may form the segregation area between the chemicals (see Section 7.5 below). Similarly, where outdoor installations incorporate chemicals of different groupings or classifications, the chemical delivery access road or turning circle may form the segregation area between the chemicals. Walkway thoroughfares may also be provided in outdoor installations to supplement access routes for delivery vehicles. All widths for access thoroughfares, roads, etc., through chemical storage facilities shall be governed by the route’s use as a segregation zone. The actual access route width shall be determined by the identification of the appropriate hazard mitigation measures within the General Risk Assessment and Chemical Compatibility Risk Assessment. At a minimum, widths for access infrastructure shall be as described in Table 20 below.

Access Type / Location	Minimum Width Requirements	Actual Width Requirements	Entrance / Exit Requirements
Indoor Access Thoroughfare (Walkway)	3.00m	As determined by completion of RAs	Dual Entrance / Exit (i.e. doors at either end of room)
Outdoor Access Thoroughfare (Walkway)	3.00m	As determined by completion of RAs	Dual Entrance / Exit (i.e. no access obstructions permitted)
Outdoor Access Thoroughfare (Vehicular)	7.00m	As determined by completion of RAs	Single Entrance / Exit (i.e. no through road)
Outdoor Access Turning Circle	As Required	As Required	Single Entrance / Exit (i.e. no through road)
Elevated Access Platform	1.20m	As determined by completion of RAs	Dual Access for platforms > 5m long, single access otherwise

Table 19: General requirements for access routes to indoor and outdoor chemical storage and batching facilities.

7.5 CHEMICAL SEGREGATION CLASSES

As stated in Section 7.4, access routes to chemical storage facilities may also be considered as the segregation zones between incompatible chemicals, as determined by the completion of the General Risk Assessment and Chemical Compatibility Risk Assessment. The widths of access routes between grouped chemicals shall be at a minimum as described in Table 19, but shall be widened depending on the requirements of the mitigation measures as identified by the risk assessments. Major factors which shall influence the segregation distances / widths shall include the reactivity of particular chemicals if in contact with each other, and the volume of chemical to be stored (i.e. the catastrophic failure of a storage tank shall not result in the ingress of chemical to the bunded area of another tank through liquid surges). Segregation shall be completed in accordance with the Segregation Classes as listed in Table 20 below, and as described in the schematics in the following sections.

Segregation Class	Class Description	Implementation
Class I	If completion of the General Risk Assessment and Chemical Compatibility Risk Assessment reveals that no further segregation beyond that outlined in Sections 5.2.2 and 5.2.3 is required, then chemicals groups / classes shall be segregated in accordance with Class I.	Chemicals of differing Groups (i.e. Group I – VI) and differing GHS classifications shall be segregated in accordance with minimum width requirements outlined in Table 19. (i.e. 3m between bunds for indoor/outdoor access walkways, 5m for vehicular access)
Class II	If completion of the General Risk Assessment and Chemical Compatibility Risk Assessment reveals that further segregation beyond that outlined in Sections 5.2.2 and 5.2.3 is required, then chemicals groups / classes shall be segregated in accordance with Class II.	Minimum distances between segregated areas shall be determined by the hazard mitigation measures identified in the GRA and CCRA. Class II minimum distances, as determined by the RAs, shall not be less than those for Class I segregation.
Class III	If completion of the General Risk Assessment and Chemical Compatibility Risk Assessment reveals that full segregation (i.e. chemicals stored indoors, in separate rooms) is required, then chemicals groups / classes shall be segregated in accordance with Class III.	Each chemical categorised as Segregation Class III shall be stored in its own room, with no other chemicals or processes present. All associated filling/batching/dosing equipment may be installed in this room also. Note that NaOCl and H_2SiF_6 shall be

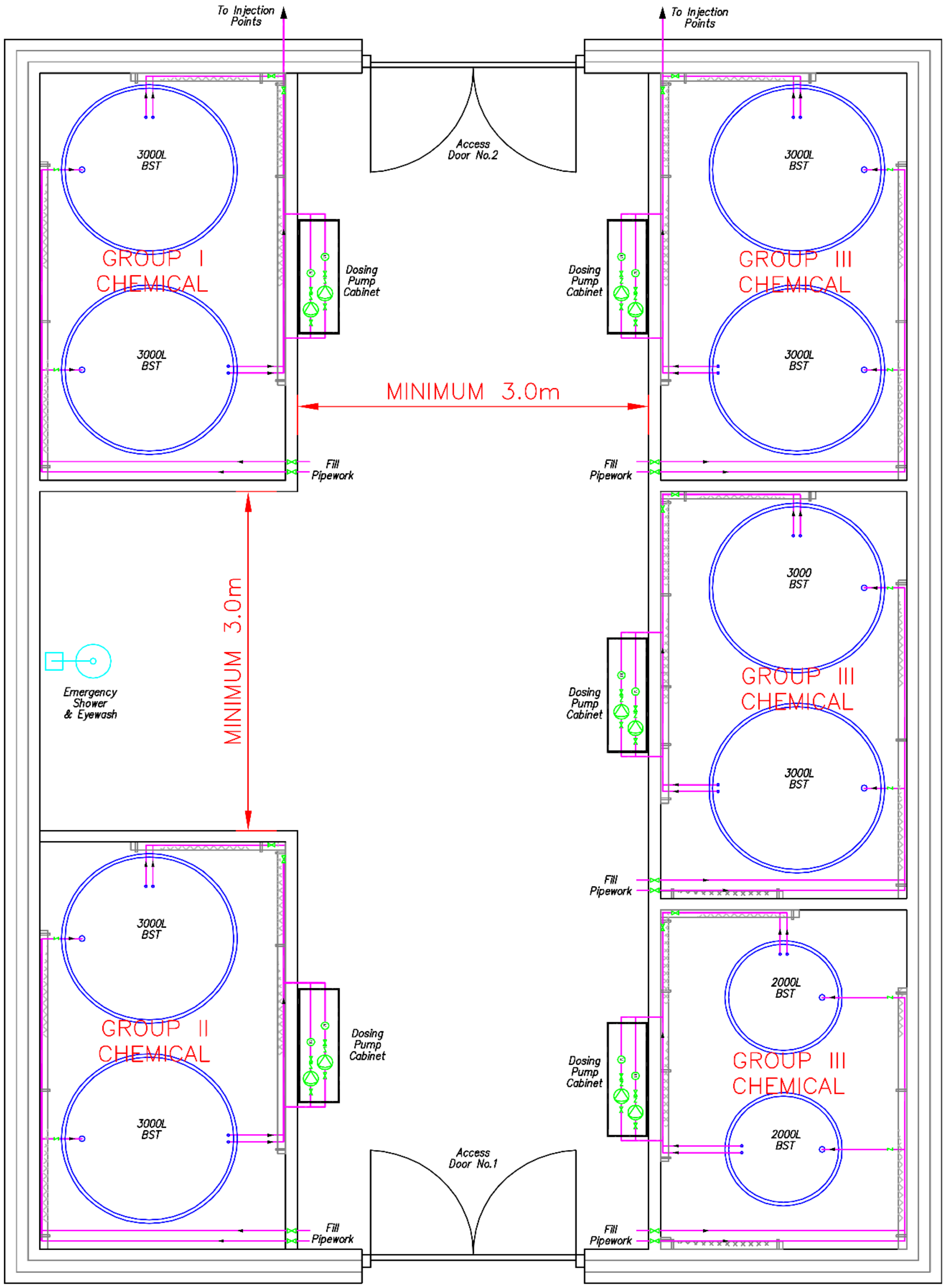
		automatically categorised as Class III.

Table 20: General description of chemical segregation classes.

As specified in Section 7.2, the bund walls of chemical storage facilities located outdoors shall not be constructed / installed less than 10m from the fenced site boundary. While this provides protection against vandalism from outside the site, it also facilitates an walkway route for inspection and maintenance, a vehicular route for more heavy duty maintenance (cherry picker, scissors lift, mobile access platform), as well as an additional escape route and segregation zone in the event of an emergency or hazardous occurrence.

7.5.1 SEGREGATION CLASS I

Schematics showing the general requirements for Segregation Class I is shown overleaf. This represents the minimum Irish Water requirements for separation of chemicals from different Groups or Hazard Classes, and shall apply as the minimum requirement for all installations. While Irish Water accepts that the designer may not be able to comply fully with the installation requirements as shown in certain site specific conditions, they shall comply with the minimum segregation distances as indicated. **The designer shall note that the actual separation distances shall be determined by the completion of the General, Chemical Compatibility and PEAZ Risk Assessments and shall take into account the reactivity of the chemicals if in contact, and the volumes of chemicals proposed for storage.** The schematic below shows a typical layout for a Class I segregation of chemicals in an indoor installation. Class I segregation shall be acceptable for use if the General Risk Assessment and Chemical Compatibility Risk Assessment reveals that no further segregation beyond that outlined in Section 5.2.2 and 5.2.3 of this specification is required.



Note: 5 No. different chemicals stored indoors, and segregated according to Class I requirements.

Diagram 2: Class I segregation of chemicals in an indoor installation.

The schematic overleaf shows a typical layout for a Class I segregation of chemicals in an outdoor installation. Class I segregation shall be acceptable for use if the General Risk Assessment and Chemical Compatibility Risk Assessment reveals that no further segregation beyond that outlined in Section 5.2.2 and 5.2.3 of this specification is required.

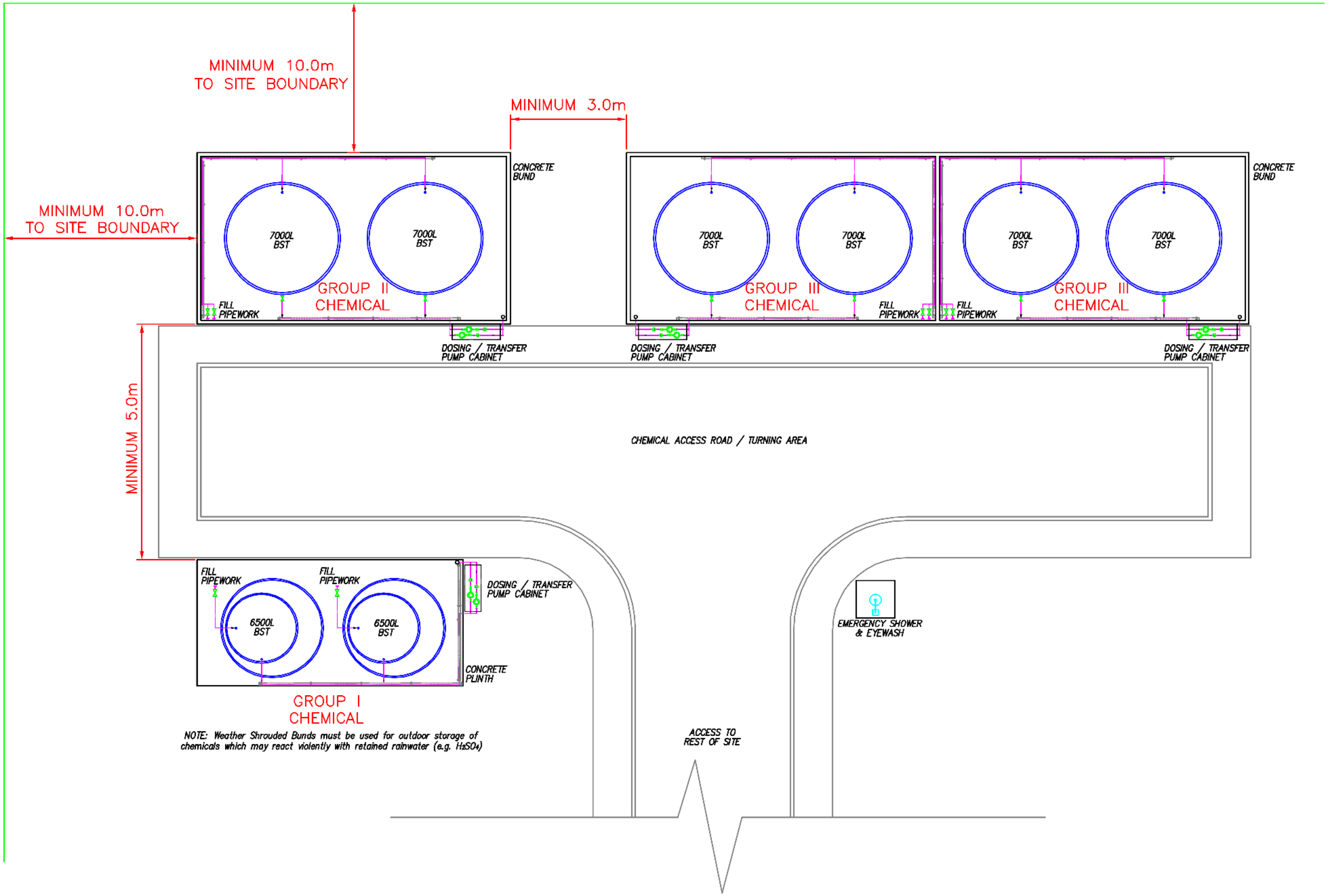


Diagram 3: Class I segregation of chemicals in an outdoor installation.

7.5.2 SEGREGATION CLASS II

Segregation Class II shall expand upon the layouts of Segregation Class I, in that if the General Risk Assessment, Chemical Compatibility Risk Assessment and PEAZ Assessment identify two chemicals within the same grouping or hazard classification that, if stored in close proximity, pose a potential risk to the health and safety of operational staff, to the quality and performance of the dosing and treatment system, or threaten the ecology of the surrounding environment, then those chemicals shall also be segregated in accordance with minimum requirements of Segregation Class I. Minimum separation distances for Class II installations shall be as outlined under Segregation Class I. **The designer shall note that the actual separation distances shall be determined by the completions of the General, Chemical Compatibility and PEAZ Risk Assessments, and shall take into account the reactivity of the chemicals if in contact, and the volumes of chemicals proposed for storage.** Segregation Class II installations may be installed indoors or outdoors, as per Class I installations.

7.5.3 SEGREGATION CLASS III

Segregation Class III shall be used when the completion of the General Risk Assessment, the Chemical Compatibility Risk Assessment and the PEAZ Assessment identifies a hazard mitigation measure of complete segregation of one or more particular chemicals from all others. Segregation Class III shall be used for chemicals which have specific storage requirements due to;

- Temperature sensitivity resulting in degradation of chemical potency
- Potential for the creation of a poisonous or explosive atmosphere by the release of noxious gases / vapours
- Potential for the corrosion of pumping, instrumentation and electrical equipment in the presence of the chemical

Chemicals which are identified for storage under Class III Segregation shall be fully isolated from all other chemicals and processes on the site (i.e. each chemical identified, as well as all its associated storage, pumping and control equipment shall be installed within its own dedicated room), and under no circumstances shall be permitted for storage outdoors. Each Class III storage facility shall incorporate sufficient ambient heating and cooling systems (internal tank heating / chilling systems not permitted for Segregation Class III), and incorporate forced ventilation facilities which allow a minimum of 10 air changes per hour. All such facilities shall also incorporate gas monitoring and alarm systems for the chemical in question, and a visual display outside the storage room shall indicate to plant operators that conditions within the enclosed space are suitable / unsuitable for entry. Segregation Class III facilities shall be kept locked at all times, with operational staff being the only persons authorised for entry. Visitors to the site (delivery personnel, maintenance and service personnel, site audit personnel, etc.) shall not be permitted entry to Segregation Class III storage facilities without the supervision of operational staff. The designer shall note that sodium hypochlorite [NaOCl] and hydrofluorosilicic acid [H_2SiF_6] shall always be considered chemicals which require Class III segregation.

7.6 GENERAL LAYOUTS FOR LIQUID BULK STORAGE SYSTEMS

All liquid bulk storage tank installations shall be completed in accordance with one of the three *General Layouts* as described in this section of the specification. Each installation shall also incorporate features that are common to all layouts, as described in Section 7.6.1 below. Note that all General Layouts shown assume the storage of only one chemical in a particular room / area. Where more than one chemical is proposed for storage in a single room / area, then the segregation requirements of Section 7.5 shall apply, with site specifics determined by the hazard mitigation measures identified by the completion of the General Risk Assessment, the Chemical Compatibility Risk Assessment, and the PEAZ assessment.

7.6.1 COMMON FEATURES

There are a number of features which shall be common to all liquid bulk storage tank installations, regardless of the proposed capacity of the facility. The designer shall at a minimum allow for duty / standby dosing and transfer pumping system, and an emergency shower shall be provided for every installation. The storage volume shall be determined by the designer and based on a minimum of 30 days storage, and a maximum of 90 days. For chemicals which are subject to degradation while in storage (e.g. sodium hypochlorite, see IW-TEC-900-05 Disinfection Specification for further details), the storage period shall be minimised. For chemicals which do not degrade in storage, this period shall be maximised, as far as site specific restrictions allow. Note that when calculating tank capacity it is normal practice to discount the space between the tank 'high' level and 'overflow' levels (i.e. freeboard).

The storage volume will determine whether a single tank or dual tank installation will be required, or whether the tanks may be installed indoors or outdoors. Where dual tank storage is required, the total volume is to be divided equally over the capacity of both bulk tanks (i.e. required storage volume = 2000 litres, tank size & configuration = 2 x 1000 litre tanks) and each bulk tank will be supplied complete with an ultrasonic level measurement device.

Single bulk storage tanks with capacities ≤ 250 litres may be placed in their own individual plastic bunds, but indoor tanks which have capacities in excess of 250 litres must be contained within a common cast in situ concrete bund. Similarly, all indoor dual tank installations shall be contained within a common concrete bund. Leak detection level indicators (LI003) shall be provided in all bunds, as shown in the schematics in the following sections, and shall be of probe type instruments (conductivity probes, capacitance probes, etc.). Ultrasonic level probes will not be permitted for use as leak detection sensors 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.

Each dosing 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 schematics. An actuated valve system shall facilitate the changeover from the duty to standby source tank, and shall be controlled by the bulk tank ultrasonic level sensors. Changeover between source tanks shall only be done once the e levels within the duty tank are low and a sufficient supply is held within the standby tank. Note that all dosing 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. 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 treated water pipe. Below ground injection points are to be provided with adequate access to allow routine or preventative maintenance to be carried out. Chemical flow meters (FI002 & FI003) shall be required where proposed pumps do not incorporate a digital display showing instantaneous and totalised flow rates.

If the designer proposes that the liquid bulk storage systems are to be installed in an existing room / building, then they shall demonstrate, to the satisfaction of Irish Water or their representative, the suitability of that building for use, i.e. show that the building is large enough to accommodate all relevant features of the *General Layouts* and demonstrate how it will be implemented within the existing structure in accordance with the appropriate *General Layout* diagram. The designer shall 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. Note that existing blockwork walls will not be permitted to act as bunded containment – all bunds shall be of purpose built cast in-situ concrete construction in accordance with BS8007:1987 Design of Concrete Structures for Retaining Aqueous Liquids, even if proposed within existing rooms or buildings. Irish Water will reserve the right to reject any proposed layout design that does not meet the above criteria.

For all *General Layouts* proposed, the designer shall ensure that direct and unobstructed access to the bulk tanks, day tanks (if provided) and pumping system is available at all times to allow access for routine operational duties. The transfer distance between the bulk storage tank and the day tank shall be kept to a minimum. This shall apply regardless of whether the system is part of an upgrade to an existing facility, a retrofit of an existing process or an installation of a complete new build treatment works (or part thereof).

The designer shall ensure that all indoor areas which contain installations associated with bulk storage of liquid chemicals shall be dry environments that can be maintained at a temperature of between 10°C - 20°C, in all climatic conditions down to a minimum external air temperature of -18°C and to a maximum external air temperature of 30°C. This is to be achieved by the installation of a thermostatically controlled heating and ventilation system. All indoor facilities which house liquid chemical bulk storage tanks shall incorporate a forced ventilation system designed to turn over the entire volume of air in the room a minimum of 2 times each hour (with the exception of Class III segregated facilities which shall require 10 air changes per hour).

7.6.2 GENERAL LAYOUT NO.1 (STORAGE CAPACITY ≤ 250 LITRES)

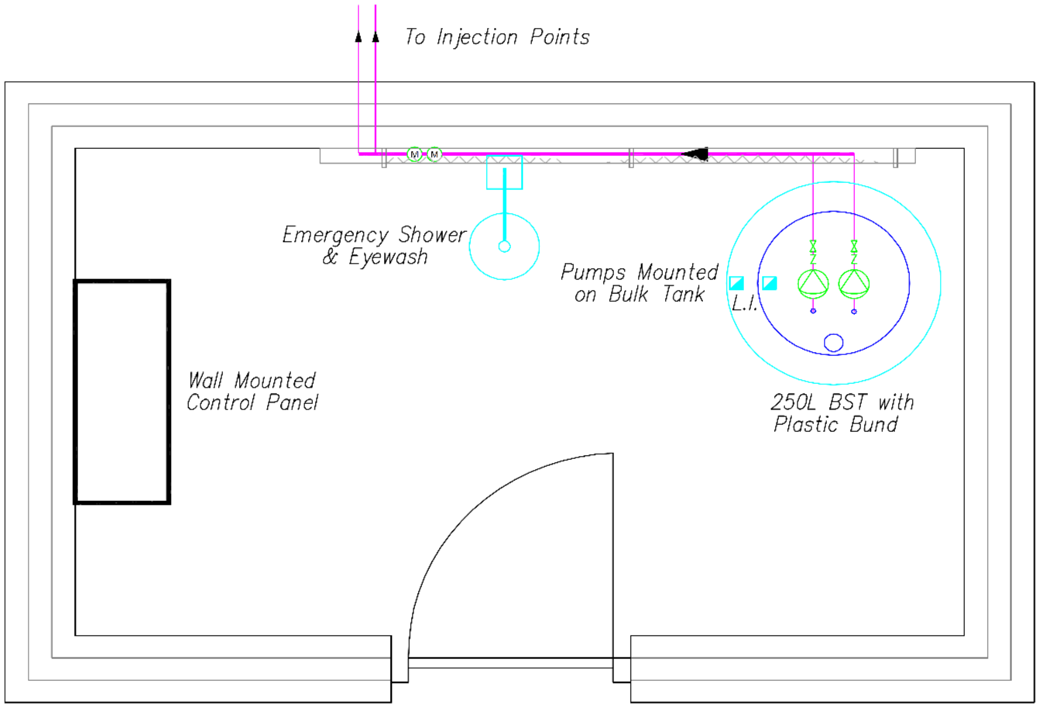
General Layout No.1 shall be implemented for all liquid bulk storage tank installations where the storage capacity of the particular chemical is 250 litres or less. Each bulk tank may be provided with its own independent plastic bund, and dosing pumps may be mounted on top of the bulk tank. The designer shall ensure that the tank mounted pumps do not obstruct replenishment of the chemical stocks and should not have to be temporarily relocated during tank filling. If the pumps cannot be accommodated on top of one of the bulk tanks without causing an obstruction, then they shall be mounted on a stainless steel pedestal, which is to allow the pumps to be mounted no lower than the top of the proposed bulk tank. This pedestal shall also act as a drip tray and should incorporate a drain back to one of the bunds to allow spillages arising from pump disconnection or leakages to be contained. Fill lines will not be required for installations where the total storage capacity is less than 250 litres.

All valves throughout the system should be easily accessible by the plant operator, with isolation valves and non- return valves provided on the pump delivery lines. In addition, each of the chemical flowmeters shall be capable of being isolated by upstream and downstream valves so that they can be 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 (suction and delivery) is to be designed to minimise gas locks and should be in accordance with WIMES 8.02(A).

All aspects of *General Layout No.1* for liquid bulk storage installations shall be installed indoors, in a dry environment that can be maintained at a temperature of between 10°C - 20°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 and ventilation system.

An emergency shower and eyewash shall be provided within the dosing building and shall be supplied with a water pressure of between 2–3 bar. As a shower tray constitutes a trip hazard, especially if an operator's sight has been compromised by exposure of their facial area to a hazardous chemical, the floor area surrounding the shower should be sloped towards the drain in order to prevent flooding of the floor area. As the shower will be installed indoors in a temperature controlled area, there shall be no requirement for insulation or heat tracing.

Storage of a single chemical is shown in Diagram 4 below, but multiple chemicals may be stored provided the segregation requirements of Sections 7.4 and 7.5 are met. Control panels may be mounted in the chemical storage room for retrofit installations of single chemicals, but for all new builds, or retrofits where more than one chemical is proposed, control panels shall be centralised in a separated control room.



Note:
1 No. 250 Litre Dosing Tanks Shown: ø650mm x 1100mm
1 No. 250 Litre Bunds Shown: ø 917mm x 520mm high

Diagram 4: General Layout No.1 for liquid bulk storage tanks ≤ 250 litres.

7.6.3 GENERAL LAYOUT NO.2 (250 L < STORAGE CAPACITY < 12,000 L)

General Layout No.2 shall be implemented for all liquid bulk storage tank installations where the total bulk tank capacity is in excess of 250 litres but less than 12,000 litres. Both bulk tanks are to be installed within a common concrete bund, with dosing pumps to be installed in an enclosed cabinet in an accessible position outside of the bund. Each bulk tank is to be provided with ultrasonic level measurement, and the common bund will incorporate a leak detection system which will also take the form of a level measurement device. Fill lines will be required in all bulk tanks with capacities larger than 250 litres, and shall be installed so that personnel completing replenishment of the chemical do not have to enter the bunded area. A 'traffic light' alarm system, controlled by the ultrasonic level sensors in each of the bulk tanks shall allow the chemical delivery operator to determine when the tank is full.

The cabinet in which the dosing pumps are to be mounted should be fully enclosed, and incorporate a transparent polycarbonate hinged door which will allow the plant operator to view the pumps without opening the enclosure. The base of the cabinet shall also act as a drip tray and should incorporate a drain back to the bund to allow spillages arising from pump disconnection or leakages to be contained. All pumping accessories such as chemical flow meters and calibration tubes should be contained within this cabinet, which shall be installed at chest height on an adjacent wall, or on a stainless steel support stand. 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 installed in a dedicated concrete bund (separate to the bund containing the storage tanks), or mounted on an elevated plinth within the chemical storage bund provided they can be readily accessed for routine service and maintenance without entering the bund itself.

All valves throughout the system should be easily accessible by the plant operator. The valves which select the source tank from where the chemical is pumped shall be mounted within the bund, albeit in a location where they can be accessed by site staff without entering the bund. Similarly, isolation valves for the dosing pumps and chemical flowmeters should be contained within the dosing cabinet enclosure. Each of the chemical flowmeters shall be capable of being isolated by upstream and downstream valves so that they can be 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 (A).

All aspects of General Layout No.2 installations shall be installed indoors, in a dry environment that can be maintained at a temperature of between 10°C - 20°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 and ventilation system.

An emergency shower and eyewash shall be provided within the chemical storage and dosing building and shall be supplied with a water pressure of between 2–3 bar. As a shower tray constitutes a trip hazard, especially if an operator’s sight has been compromised by exposure of their facial area to a hazardous chemical, the floor area surrounding the shower should be sloped towards the drain in order to prevent flooding of the floor area. As the shower will be installed indoors in a temperature controlled area, there shall be no requirement for insulation or heat tracing.

General Layout No.2 shall be in accordance with the layout drawing below, and the building may be extended as required to accommodate storage and dosing systems for other chemicals proposed for use on the site, provided that the segregation requirements of Sections 7.4 and 7.5 are met. Control panels may be mounted in the chemical storage room for retrofit installations of single chemicals, but for all new builds, or retrofits where more than one chemical is proposed, control panels shall be centralised in a separate control room.

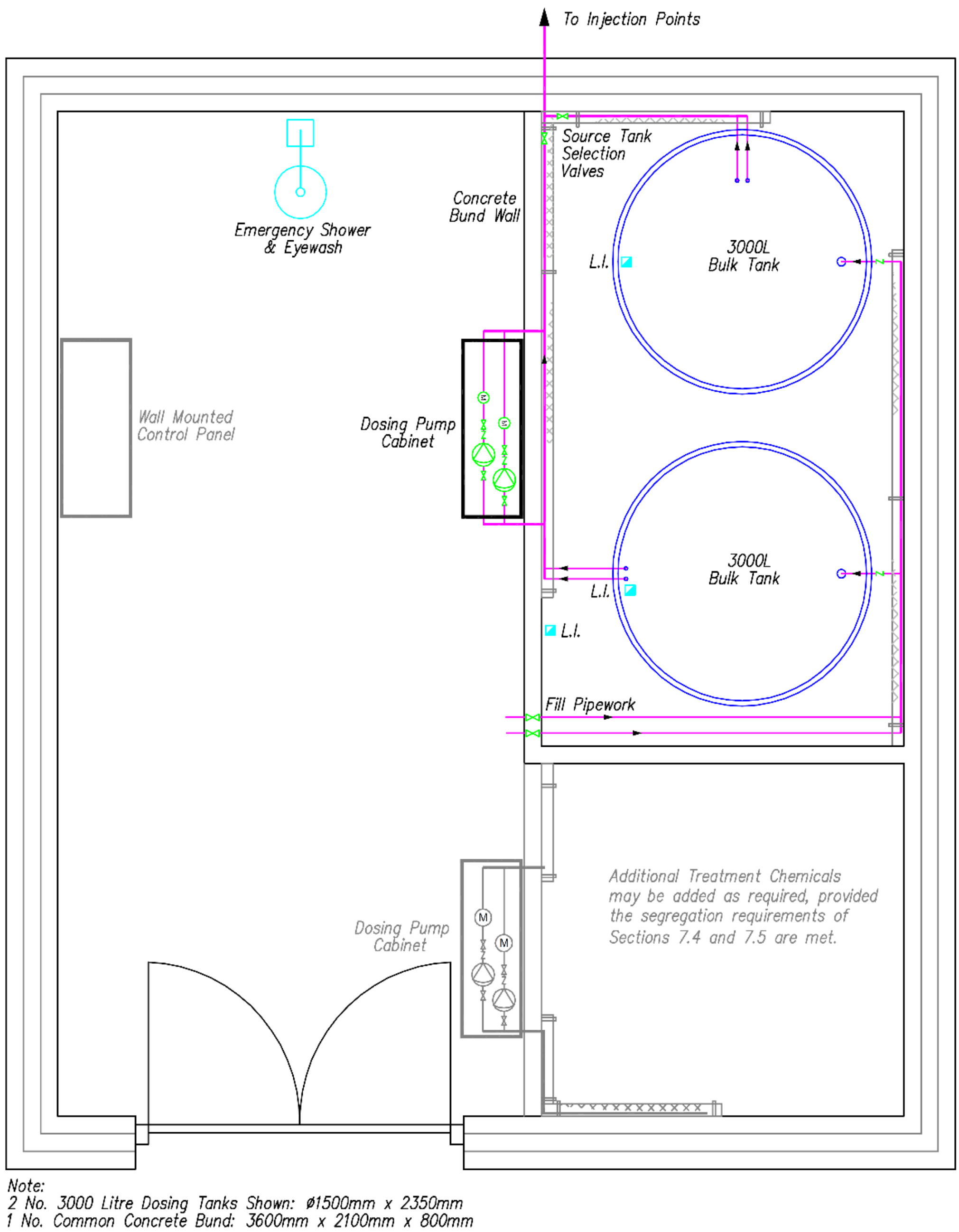


Diagram 5: General Layout No.2 for liquid bulk storage volumes > 250 litres but < 12,000 litres.

7.6.4 GENERAL LAYOUT NO.3 (STORAGE CAPACITY > 12,000 L)

General Layout No.3, which incorporates 2 No. bulk storage tanks installed outdoors, shall be implemented on installations where the total bulk storage capacity is in excess of 12,000 litres, and where the chemical proposed for storage can be maintained above its freezing temperature by the safe provision of an internal heating system and lagging. Storage tanks which contain chemicals which, in the event of tank failure, may react with rainwater (e.g. sulphuric acid) shall incorporate integrated, weather shrouded bunds to fully protect from the ingress of water. Where reaction with rain water is not a concern, open concrete bunds may be provided.

From outdoor liquid bulk storage tanks, all chemicals shall be transferred to an internally installed day tank of no greater than 250 litre capacity. All tanks installed externally shall incorporate a heating system which shall be designed to automatically maintain the temperature of the chemical above its freezing / crystallisation point during all climatic conditions in which external air temperatures fall to -18°C. Similarly, external bulk storage tanks which store chemicals that are subject to degradation in increased temperature shall incorporate a chilling system to automatically maintain the chemical at its recommended storage temperature during all climatic conditions in which external air temperatures rise to 30°C.

Chemical transfer will be completed on an automatic basis by a transfer pump installed within the day tank bund, or within the external storage tank bund, and controlled by level sensors mounted in the bulk tanks and day tank. Suction pipework from the transfer pump shall enter the bulk tanks above the maximum liquid level in order to prevent discharge of the chemical in the event of a leak developing in the suction pipework. Each bulk tank will also incorporate its own independent filling pipe, which shall allow ease of chemical stock replenishment. A 'traffic light' alarm system, controlled by the ultrasonic level sensors in each of the bulk tanks shall allow the chemical delivery operator to determine when the tank is full. Point level indicators mounted in the shrouded / open concrete bunds shall also be installed to act as leak detection devices. All external pipework (fill lines, transfer lines, bund drainage pipework, etc.) shall be heat traced and lagged so as to maintain operation in climatic conditions in which external air temperatures fall to -18°C.

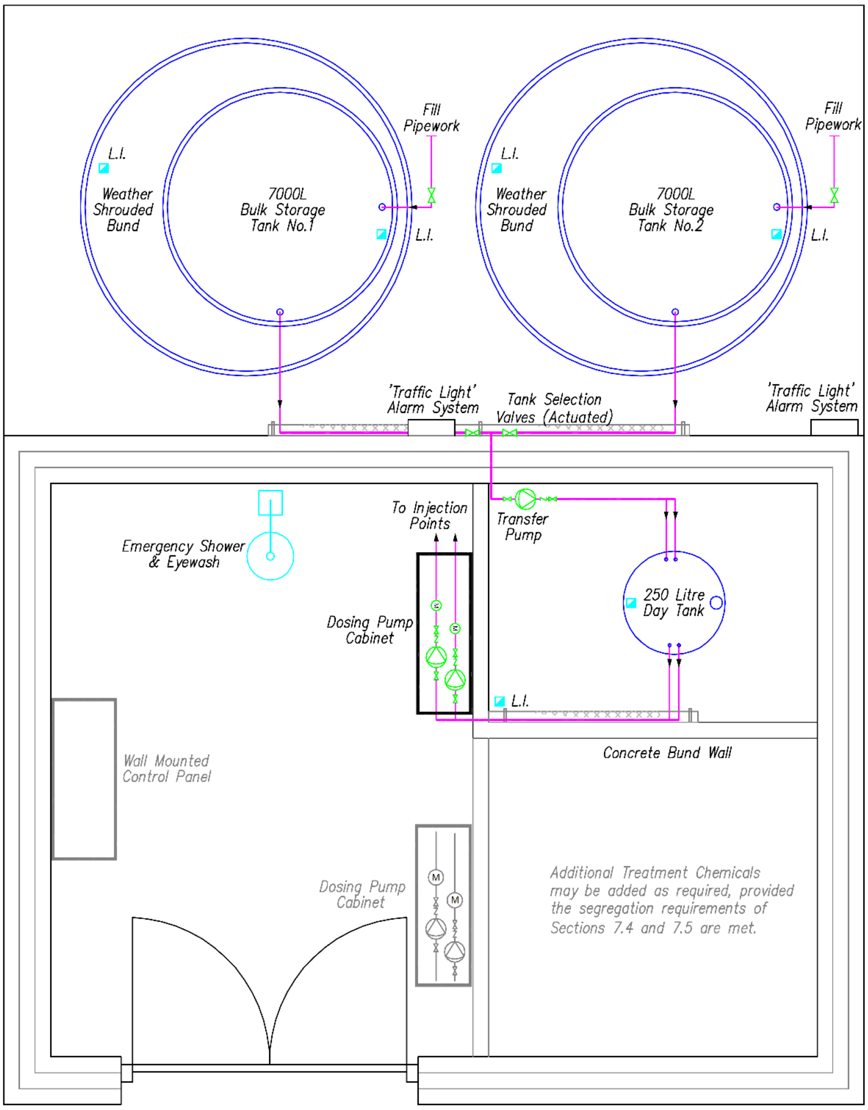
Dosing pumps shall be installed in an enclosed cabinet in an accessible position outside of the concrete day tank bund. Each day tank is to be provided with ultrasonic level measurement, and the bund will incorporate a leak detection system which will also take the form of a point level measurement device. The cabinet in which the dosing pumps are to be mounted should be fully enclosed, mounted at chest level, and incorporate a transparent polycarbonate hinged door which will allow the plant operator to view the pumps without opening the enclosure. The base of the cabinet shall also act as a drip tray and should incorporate a drain back to the bund to allow spillages arising from pump disconnection or leakages to be contained. All pumping accessories such as chemical flow meters and calibration tubes should be contained within this cabinet, which shall be installed at chest height on an adjacent wall, or on a stainless steel support stand. 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 installed in a dedicated concrete bund (separate to the bund containing the storage tanks), or mounted on an elevated plinth within the chemical storage bund provided they can be readily accessed for routine service and maintenance without entering the bund itself.

Each of the chemical flowmeters shall be capable of being isolated by upstream and downstream valves so that they can be 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 (A).

All valves throughout the system should be easily accessible by the plant operator. The actuated valves which select the source bulk tank from where the chemical is transferred 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.

An emergency shower and eyewash shall be provided within the chemical storage and dosing building and shall be supplied with a water pressure of between 2–3 bar. As a shower tray constitutes a trip hazard, especially if an operator's sight has been compromised by exposure of their facial area to a hazardous chemical, the floor area surrounding the shower should be sloped towards the drain in order to prevent flooding of the floor area. As the shower will be installed indoors in a temperature controlled area, there shall be no requirement for insulation or heat tracing.

General Layout No.3 shall be designed in accordance with the layout drawing below, and the building / outdoor storage area may be extended as required to accommodate storage and dosing systems for other chemicals proposed for use on the site, provided that the segregation requirements of Sections 7.4 and 7.5 are met. Control panels may be mounted in the chemical storage room for retrofit installations of single chemicals, but for all new builds, or retrofits where more than one chemical is proposed, control panels shall be centralised in a separated control room.



Note:
2 No. 7000 Litre Bulk Storage Tanks Shown: ø2120mm x 2600mm
1 No. 250 Litre Day Tank: ø650mm x 1100mm

Diagram 6: General Layout No.3 for liquid bulk storage volumes > 12,000 litres.

7.7 GENERAL LAYOUTS FOR MANUAL BATCHING SYSTEMS

Each manual chemical batching / make-up system installed at new treatment plants, or retrofitted at existing facilities, shall have a minimum capacity of 1000 litres, and a maximum capacity of 2100 litres, with additional batching tanks added as required. The designer shall allow for a total makeup tank capacity sufficient to prevent the manual chemical batching frequency exceeding once per week. Each make up tank will have a valved water supply which passes through a flowmeter with a localised digital display to allow the plant operator measure the exact quantity of water being used in each batch make up. The flowmeter reading shall be a totalised value (not an instantaneous reading) and shall be resettable to zero after each use. The solid chemical to be batched will be weighed, and the appropriate quantity to make up the required concentration shall be added by hand from the bagged supply on site. An industrial, floor mounted weighing scales shall be included within each proposal for a manual batching / make-up systems. **(include info on bag cutters / handlers here?)**

An ultrasonic level sensor will be installed on each make-up tank to monitor the levels of chemical solution available for dosing and notify the plant operator when batch replenishment is required. The level sensors shall also activate the make-up tank mixers when set to 'Automatic' mode, and a positive level is detected within the make-up tank (mixer cut-in and cut-out levels shall be adjustable on the system HMI). Leak detection level indicators shall be provided in all bunds and shall be of probe type instruments (conductivity probes, capacitance probes, etc.). 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 make-up tanks.

All liquid bulk storage tank installations shall be completed in accordance with one of the two *General Layouts* as described in this section of the specification. Each installation shall also incorporate features that are common to all layouts, as described in Section 7.7.1 below. Note that all *General Layouts* shown assume the batching / make-up of only one chemical in a particular room / area. Where more than one chemical is proposed for storage in a single room / area, then the segregation requirements of Section 7.5 shall apply, with site specifics determined by the hazard mitigation measures identified by the completion of the General Risk Assessment, the Chemical Compatibility Risk Assessment, and the PEAZ assessment.

7.7.1 COMMON FEATURES

All chemical batching / make-up, storage and administration facilities should be sited in a cool area out of direct sunlight, and all make-up tanks shall be installed within concrete bunds to contain spillages due to tank failure, pipework failure, etc. If the designer proposes that the pH / alkalinity adjustment system is to be installed in an existing room / building, then they shall demonstrate, to the satisfaction of Irish Water or their representative, the suitability of that building for use, i.e. show that the building is large enough to accommodate all features of the *General Design* and show how it will be implemented within the existing structure in accordance with the *General Layout* diagrams as set out in the following sections. The designer shall 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. Note that existing blockwork walls will not be permitted to act as bunded containment – all bunds shall be of purpose built cast in-situ concrete construction in accordance with BS8007:1987 Design of Concrete Structures for Retaining Aqueous Liquids, even if proposed within existing rooms or buildings. Irish Water will reserve the right to reject any proposed layout design that does not meet the above criteria.

For all *General Layouts* proposed, the designer shall ensure that direct and unobstructed access to the make-up tanks is available at all times to facilitate chemical batching, with transfer distances for solid chemicals kept to a minimum. This shall apply regardless of whether the system is part of an upgrade to an existing facility, a retrofit of an existing system or a complete new build treatment works (or part thereof).

Each dosing pump is to have its own independent suction pipework and, in the case of multiple batching / make-up tank installations, each pump should be capable of taking its supply from each of the make-up tanks. An actuated valve system shall facilitate the changeover from the active tank to the standby tank, and shall be controlled by the make-up tank ultrasonic level sensors. In automatic mode, changeover between source tanks shall only be done once chemical solution levels within the active tank are low and a sufficient supply is held within the standby tank. However the plant caretaker shall be able to toggle between the source make-up tanks on the system HMI. Note that all dosing pumps shall always take their supply from the same make-up tank, i.e. when the source tank is changed, it shall be changed for duty and standby pumps.

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 treated water pipe. Below ground injection points are to be provided with adequate access to allow routine or preventative maintenance to be carried out. Chemical flow meters shall be required where proposed pumps do not incorporate a digital display showing instantaneous and totalised flow rates.

For all installations, dosing pumps shall be mounted in a dedicated dosing pump cabinet, with a clear polycarbonate door to allow the plant operator to view the pumps without opening the cabinet. The cabinet shall incorporate a drain at its base, with all spillages due to pump/pipework disconnection routed to the make-up tank bund. If the specified pumps are too large to fit in the dosing cabinet, then they shall be installed in a dedicated concrete bund (separate to the bund containing the storage tanks), or mounted on an elevated plinth within the chemical storage bund provided they can be readily accessed for routine service and maintenance without entering the bund itself.

All non-return valves and isolation valves used in the isolation of the dosing pumps shall also be contained within this dosing cabinet or bund. The dosing cabinet may be wall mounted, or mounted on a stainless steel access platform (in the case of General Layout No.2) if proposed. The installation location of the pumps should not interfere with the day to day operational duties of the plant, and shall not cause an obstruction to routine operational duties, i.e. they shall never have to be temporarily moved to facilitate duties such as chemical batching / make-up / replenishment.

While Irish Water accepts that certain site variations may apply with regard to layout, pipework routes, electricity supplies, access, etc., particularly on existing treatment facilities, the designer shall endeavour to comply with the basic layouts as described in the section of the document. Variations from the General Layouts as shown shall not be acceptable without the prior approval of Irish Water, or their representative.

7.7.2 GENERAL LAYOUT NO.1

General Layout No.1 shall be implemented on installations where the height of each chemical make-up tank is lower than 1.20m and the plant operator can add chemical, in solid form, without over-extension of reach, or without entering the bund. For *General Layout No.1* installations, the plant operator shall be capable of completing all routine duties, including inspection of the tank internals, mixers, instruments, etc. without entering the bunded area.

There shall be no upper limit for total make-up volumes on *General Layout No.1* installations, nor shall there be a limit on the number of make-up tanks proposed, provided the contractor has allowed for the required make up volume to ensure a maximum make-up frequency of once per week, without exceeding the 1.20m tank height limit. Each make-up tank shall however, be restricted in its footprint size so that it is capable of being removed intact from the chemical make-up and administration room.

The designer may add make-up tanks as necessary to meet the chemical demand of the plant, provided that all requirements the *General Design* and *General Layouts* are met. The concrete bund shall provide storage capacity of 110% of the volume of the largest make-up tank, but the bund wall shall not exceed 800mm in height, as measured from the finished floor level outside of the bund wall.

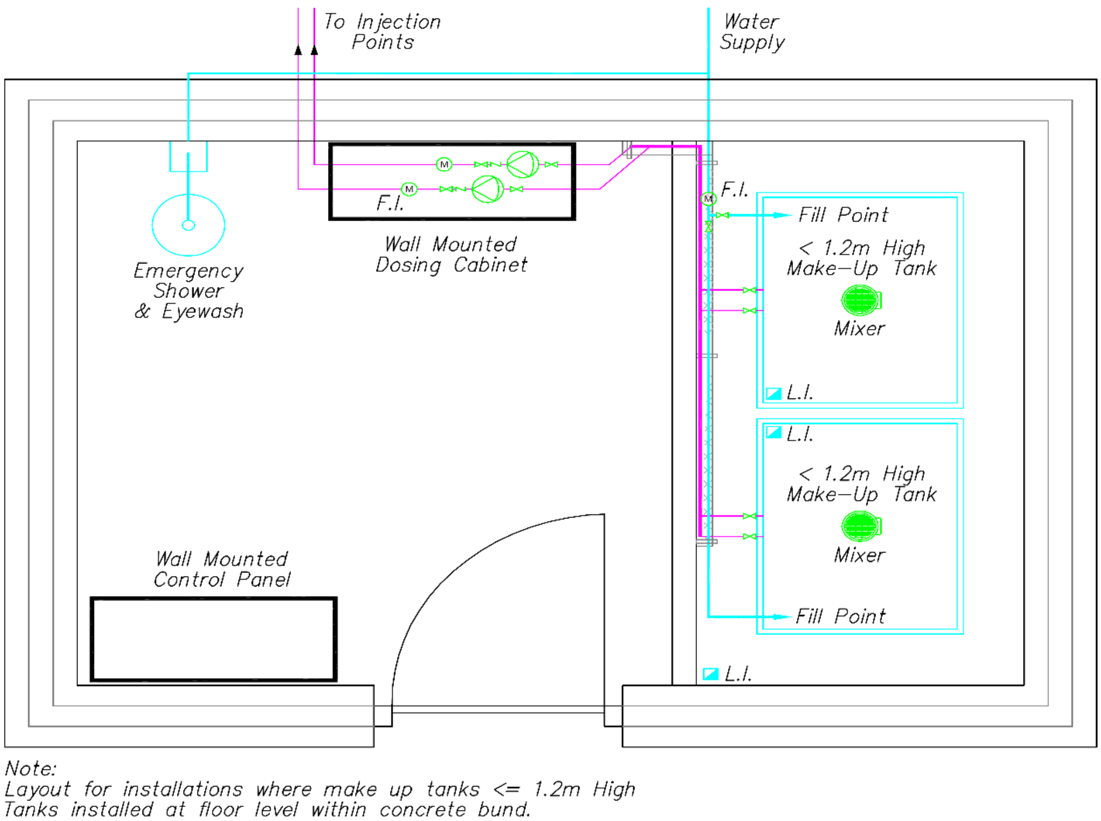


Diagram 7: General Layout No.1. Make-up tank height < 1.20m. Designer may add additional tanks as necessary to achieve volumes required to maintain batching frequency to a maximum of once per week.

7.7.3 GENERAL LAYOUT NO.2

General Layout No.2 shall be implemented on installations where the height of each chemical make-up tank is greater than 1.20m and the plant operator cannot add chemical, in solid form, without over-extension of reach, or without entering the bund. For *General Layout No.2* installations, a stainless steel access platform shall be provided within the chemical make-up room to allow the plant operator complete all routine duties, including chemical batching, inspection of the tank internals, mixers, instruments, etc. without entering the bunded area.

The access platform may rest on top of the 800mm bund wall, which shall be structurally designed to support this load. There shall be no upper limit for total make-up volume on *General Layout No.2* installations, nor shall there be a limit on the number of make-up tanks proposed, provided the contractor has allowed for the required make up volume to ensure a maximum make-up frequency of once per week. Each make-up tank shall however, be restricted in its footprint size so that it is capable of being removed intact from the chemical make-up and administration room.

In addition, the maximum allowable height for a make-up tank installed under *General Layout No.2* shall be 2.10m. The designer may add make-up tanks as necessary to meet the chemical demand of the plant, provided that all requirements the *General Design* and *General Layouts* are met. The concrete bund shall provide storage capacity of 110% of the volume of the largest make-up tank, but the bund wall shall not exceed 800mm in height, as measured from the finished floor level outside of the bund wall.

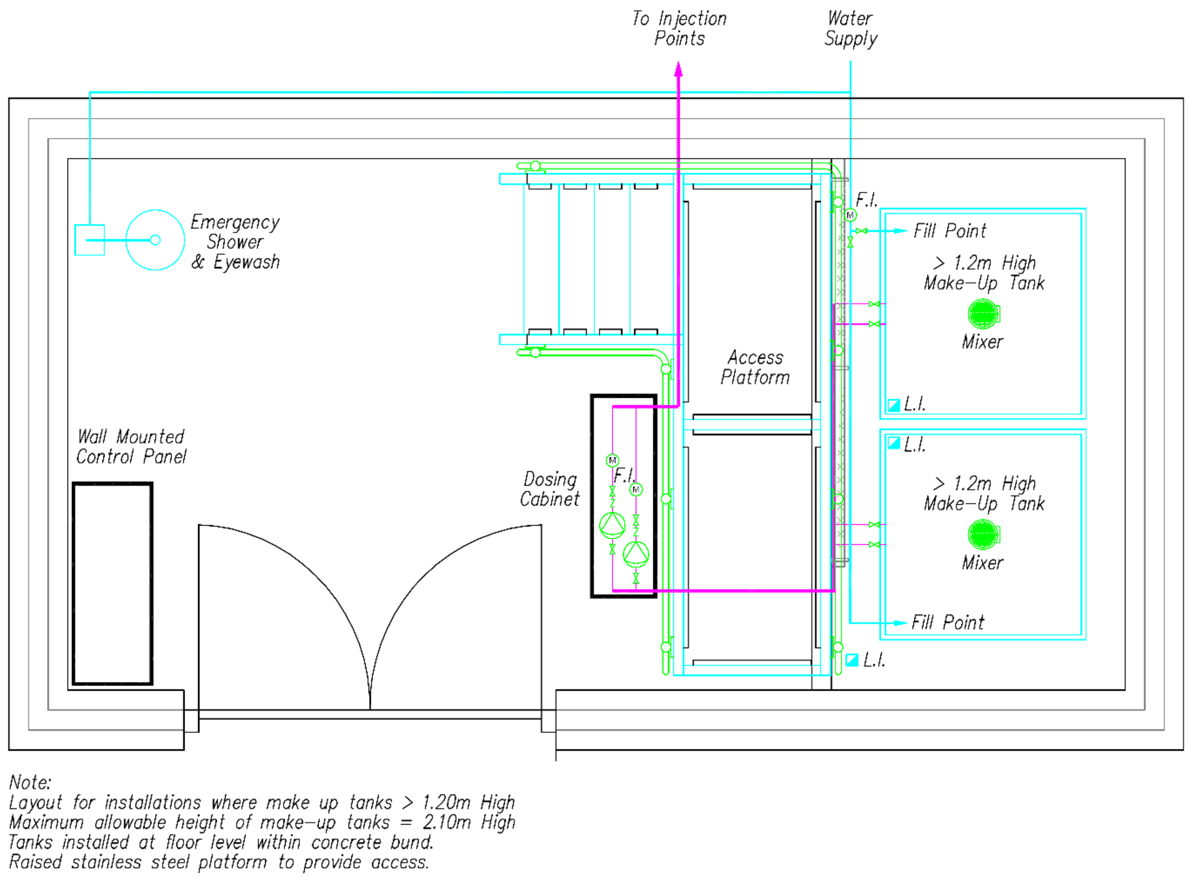


Diagram 8: General Layout No.2. Make-up tank height > 1.20m, up to a maximum of 2.10m. Designer may add additional tanks as necessary to achieve volumes required to maintain batching frequency to a maximum of once per week.

7.8 GENERAL LAYOUTS FOR AUTOMATIC BATCHING SYSTEMS

Each automatic chemical batching and make-up system installed at newly constructed Irish Water treatment plants, or retrofitted at existing facilities, shall be as per outlined in this section of the specification. Chemical batching shall be completed on a fully automated basis, controlled by the level detected in the batching tank – i.e. when the batch level is low, make-up of a new batch is triggered. The entire system shall be sized so as to provide a consistent supply of the required chemical, at the required concentration, to the treatment process. Each batching tank shall be sized to store a minimum of 12 hours' worth of chemical solution – i.e. no more than two batches shall be made up every day. This is in order to allow for a certain amount of system redundancy in the event of failure of the batching system, and facilitates the manual make-up of batches on a short term basis while repairs or replacements to the automatic system are carried out.

Each automatic chemical batching / make-up tank shall incorporate a water supply which passes through a flowmeter with a localised digital display, as well as an actuated valve which will automatically control the quantity of water to be added to produce the desired concentration of chemical solution. This concentration will be operator adjustable on the system HMI screen. The make-up water flowmeter digital readout shall be capable of locally displaying a totalised and instantaneous value, which shall in turn be transmitted to the system PLC. The solid chemical shall be transferred from the storage silo to the batching tank by an automated transfer auger which shall administer a defined quantity of material with each initiation, in accordance with the concentration requirements as entered on the HMI screen.

Three level indicators shall monitor the levels of chemical solid being stored on site. Two will be point level measurement devices (diaphragm switches, vibratory probes, capacitance probes or rotary paddles) and will generate a digital signal which indicates if the material contained in the storage silo is at a high or low level. The third shall be a plumb bob device or a guided wave radar system capable of continuously monitoring the levels of stored solid materials. An ultrasonic level sensor will be installed on the batching tank to monitor the levels of chemical solution available for dosing and initiate an automatic batching of chemicals when stock is low. This level sensor shall also activate the batching tank mixer when set to 'Automatic' mode, and a positive level is detected within the tank (mixer cut-in and cut-out levels shall be adjustable on the system HMI). A leak detection level indicator shall be provided in all bunds, as shown in Diagram 9, and shall be of probe type instruments (conductivity probes, capacitance probes, etc.). 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 chemical batching / make-up tanks.

All solid chemical batching / make-up, transfer and administration facilities shall be installed indoors, in a dry environment, where a temperature of between 10°C - 20°C can be maintained at all times, in all climatic conditions. This is particularly relevant to the powder storage silo(s), as the solidification of powdered chemical while in storage in damp conditions poses major operational issues for automated batching systems. All silos shall however be capable of being replenished from outside the silo building, by means of a pneumatic silo fill pipe which will protrude through the external wall of the silo building.

All automatic batching / make-up tanks shall be installed within concrete bunds to contain spillages due to tank failure, pipework failure, etc. It is permissible to install automated batching / make-up tanks in the same room as other chemical make-up / storage / administration facilities, provided the segregation requirements of Sections 7.4 and 7.5 are met, and the designer ensures that bunds are fully compartmentalised and there is no risk of mixing of chemicals within containment bunds in the event of batching tank failure or pipework failure. The designer shall also ensure that the automatic batching systems are fully enclosed, and that the escape of chemical dust from the transfer and batching process is prevented at all times. If the designer cannot guarantee a fully enclosed system, the entire batching system must be isolated in its own dedicated batching room. Note that Irish Water will not permit sodium hypochlorite dosing systems to be installed in the same room as any other chemical make-up or administration systems (see IW-TEC-900-05 for further details).

If the designer proposes that the automatic batching system, or part thereof (storage silo, etc.) is to be installed in an existing room / building, then they shall demonstrate, to the satisfaction of Irish Water or their representative, the suitability of that building for use, i.e. show that the building is large enough to accommodate all relevant features of the *General Layout* and show how it will be implemented within the existing structure in accordance with the diagram as set out overleaf. The designer shall 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. Note that existing blockwork walls will not be permitted to act as bunded containment – all bunds shall be of purpose built cast in-situ concrete construction in accordance with BS8007:1987 Design of Concrete Structures for Retaining Aqueous Liquids, even if proposed within existing rooms or buildings. Irish Water will reserve the right to reject any proposed layout design that does not meet the above criteria.

For existing plants where an automatic batching / make-up facilities are being retrofitted or upgraded, the systems may be installed in rooms with other chemical storage or batching equipment, provided the designer can demonstrate that the requirements of the *General Layouts* are met, the chemical segregation requirements of Section 7.4 and 7.5 are fulfilled, and provided that the system is fully enclosed and has been designed to prevent the escape of chemical dust. Again, if the designer cannot guarantee a fully enclosed automatic batching system, the entire batching system must be isolated in its own dedicated batching room.

For the *General Layouts* proposed, the designer shall ensure that direct and unobstructed access to the batching tank and silo is available at all times to allow access for routine operational duties. The transfer distance between the storage silo and the batching tank shall also be kept to a minimum. This shall apply regardless of whether the system is part of an upgrade to an existing facility, a retrofit of an existing batching system or an installation of a complete new build treatment works (or part thereof).

Each dosing pump is to have its own independent suction and delivery pipework as shown in Diagram 9, as well as its own injection fitting to the process water pipe 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 treated water pipe. Below ground injection points are to be provided with adequate access to allow routine or preventative maintenance to be carried out. Chemical flow meters shall be required where proposed pumps do not incorporate a digital display showing instantaneous and totalised flow rates.

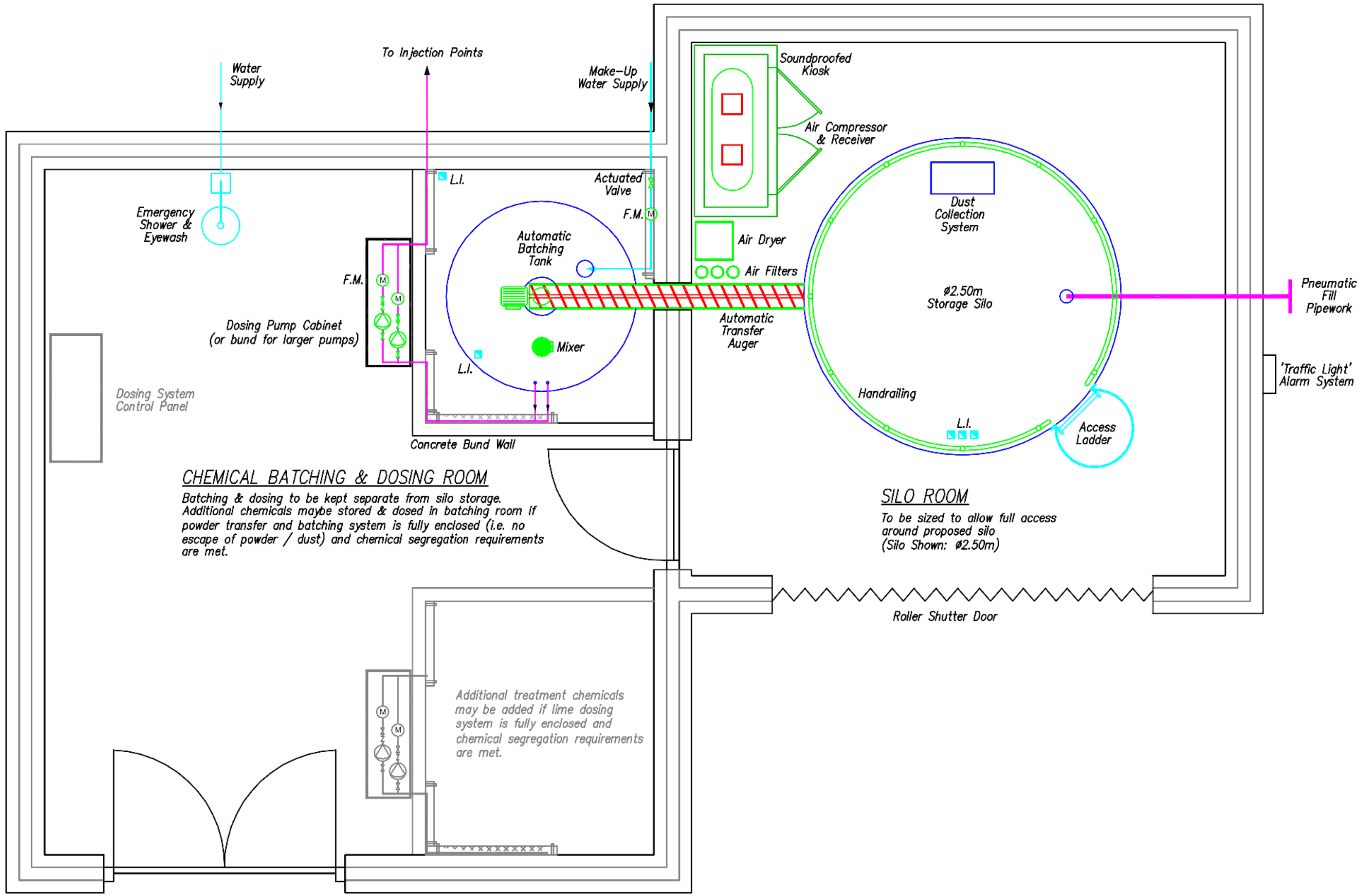


Diagram 9: General Layout for fully automated solid / powder silo storage, transfer, batching and administration system.

For all installations, dosing pumps shall be mounted in a dedicated dosing pump cabinet, with a clear polycarbonate door to allow the plant operator to view the pumps without opening the cabinet. The cabinet shall incorporate a drain at its base, with all spillages due to pump/pipework disconnection routed to the batching tank bund. If the specified pumps are too large to fit in the dosing cabinet, then they shall be installed in a dedicated concrete bund (separate to the bund containing the storage tanks), or mounted on an elevated plinth within the chemical storage bund provided they can be readily accessed for routine service and maintenance without entering the bund itself. All non-return valves and isolation valves used in the isolation of the dosing pumps shall also be contained within this dosing cabinet or bunded area. The pumps should never have to be temporarily moved to facilitate routine operational duties, such as manual chemical replenishment, inspection or maintenance procedures.

While Irish Water accepts that certain site variations may apply with regard to layout, pipework routes, electricity supplies, access, building orientation, etc., particularly on existing treatment facilities, the designer shall endeavour to comply with the basic layout as described in the section of the document. Variations from the General Layout as shown shall not be acceptable without the prior approval of Irish Water, or their representative.

7.9 GENERAL LAYOUTS FOR POWDER SILOS

All powder storage silos shall be housed indoors, unless the designer can propose a method to prevent the ingress of moist air into the storage tank that is deemed acceptable by Irish Water, or their representative. Indoor powder storage facilities shall be capable of being maintained at temperatures of between 10°C and 20°C, in all external air temperatures between -18°C to 30°C. Powder storage silos shall be generally be laid out as sown in Diagram 9, Section 7.8. Where more than one powdered chemical is to be stored on site, the designer shall ensure that the General Risk Assessment, the Chemical Compatibility Risk Assessment and the PEAZ Assessment takes account of this, and that the segregation classes as outlined in Sections 7.4 and 7.5 are fulfilled.

The silo shall be installed within the building so that full access to all areas is permitted for all routine and non-routine operational and maintenance duties. A roller shutter door shall be sized and installed to permit the installation or removal of all equipment (with the exception of the silo itself), and an overhead gantry crane shall be provided in all indoor silo installations to allow safe removal of equipment or hoisting / lowering of equipment to or from the roof of the silo. Access ladders shall not be permitted for silos over 3.00m tall. For all installations where the silo exceeds 3.00m, an access stairs and platform shall be provided to permit access to the roof of the silo. Access stairs shall be a minimum of 1.00m wide.

All equipment associated with the powder storage silo (air compressor for internal agitation system, air filters and driers, dust collection system, etc.) shall also be installed in the silo room, and shall be easily and safely accessible for all routine and non-routine operation and maintenance activities. All silos shall be capable of being replenished from outside the silo building, by means of a pneumatic silo fill pipe which will protrude through the external wall of the silo building. Lockable valves shall be provided on the fill lines to which only plant caretakers shall have keys. Fill lines shall be clearly labelled showing the chemical that is to be conveyed, and a 'traffic light' visual display linked to the analogue level monitoring system shall allow delivery personnel to see when the tank is nearing full capacity.

8 BULK STORAGE, BATCHING AND SILO TANK GENERAL DESIGN

Bulk chemical storage tanks, batching tanks and powder storage silos shall be designed to provide a safe and secure working environment for all operational staff, as well as all visitors to site, and minimise the risks of dangerous occurrences associated with the storage, delivery, transfer and dosing of chemicals during both routine and non-routine operational activities. The designer shall ensure that the design of each storage tank is carried out in accordance with this section of the specification.

8.1 DESIGN OF BULK STORAGE TANKS

All bulk storage, batching and silo tanks proposed for installation at Irish Water treatment facilities shall comply with CIRIA Document '*C598 – Chemical Storage Tank System – Good Practice*' and shall be designed, constructed and tested in accordance with the following standards:

- Vertical Steel Tanks (site fabricated) BS2654 or BS EN 14015, as appropriate
- Horizontal Steel Tanks (shop fabricated) BS2594 or BS EN 12285-2, as appropriate
- Dual Laminated GRP Tanks BS4994 or BS EN 13121, as appropriate
- Thermoplastic Tanks BS EN 12573, as appropriate

GRP or steel tanks proposed for liquid chemical storage or batching purposes shall be lined with an appropriate chemically resistant material (PVC, PP, etc.) for the majority of storage applications. The lining shall be selected on the basis of compatibility with the chemical to be stored or batched (see Section 6 for further details). All thermoplastic tanks shall be designed with an overall safety factor (S) of 2.0 (Category 2.0) as defined in BS EN 12573. Dual laminate GRP tanks shall be designed, manufactured and tested in accordance with Category 1.0 or Category 2.0, as appropriate, and as described in BS 4994 / BS EN 13121.

All silos proposed for the bulk storage of solid chemicals shall be designed so that powders are maintained in a dry condition at all times. Unless the designer can propose a method to prevent the ingress of moist air into the storage tank, all silos proposed shall be housed indoors. Sufficient space shall be available around each silo to allow items such as the silo filter to be lowered to the ground or hoisted to the roof. Overhead gantry cranes shall be provided for this purpose, and also to facilitate the removal / reinstallation, or relocation of ancillary silo equipment such as the transfer auger, air compressor, etc.

The following specifications shall be adhered to for all bulk storage, and batching tanks proposed for the on-site storage and make-up of both liquid and solid chemicals:

- At a minimum, tank design shall consider the most severe combination of the following loads:
  - The static head of the stored chemical (operating and test conditions)
  - The weight of the tank and the stored chemical **(the importance of considering the specific gravity of the proposed chemical for storage cannot be underestimated in this regard)**
  - Wind and snow loads if tanks are located outdoors

- Loads applied during transport and erection
- Loads imposed by personnel during erection and operation

- The designer / tank manufacturer shall provide Irish Water, or their representative, with a list of all major design assumptions made during tank design, prior to the tank being approved for manufacture. These design assumptions shall include, but not be limited to;
  - Tank design life
  - Corrosion allowance
  - Number of fill / empty cycles
  - Delivery temperature of the dosing chemical
- Steel tanks shall be designed with a zero corrosion allowance, on the basis that these surfaces shall be coated with a protective liner in accordance with Section 6 of this document, and WIMES 4.01. All steel tanks proposed shall be inspected on a regular basis.
- Vertical, cylindrical tanks shall be free standing with conical roofs (with the exception of powder silos which shall be flat roofed). The aspect ratio shall be a maximum of 1:3 for normal storage duties.
- All tank materials, linings, and/or protective coatings proposed shall be suitable for prolonged exposure to the stored chemical.
- Roofs of all outdoor storage tanks shall be self-draining with an established system for preventing moisture ingress.
- For storage of solid powdered chemicals, the main condition required is that the contents are held in a consistently dry / cool state. For silos storing solid powdered chemicals, the following shall therefore apply:
  - All silos shall be housed indoors, in temperature controlled environments in order to minimise the ingress of moisture and subsequent solidification of powdered chemicals. Outdoor silo installations shall only be considered by Irish Water if the designer can propose a method to satisfactorily prevent the ingress of moist air into the storage tank.
  - Rat-holing shall be prevented by optimising the silo outlet port size. Dry air agitation systems, vibration systems, etc. shall be used to sufficiently agitate the tank contents, thereby preventing rat-holing, reducing risk of solidification and ensuring even depletion of stock held within each silo.
  - A pressure relief system and reverse air jet filter should be located at the top of each silo. These systems should operate in accordance with the recommendations detailed in Section 6.1.3.2 of WIMES 8.02.

8.2 CHEMICAL STORAGE CAPACITY

The volume of chemical storage on-site shall be determined by the designer in accordance with chemical demands. While appropriate storage periods will differ from chemical to chemical, and may be affected by onsite conditions (indoor v outdoor storage, difficulty of winter access, etc.), in general, bulk liquid storage facilities shall be sized to hold a minimum of 28 days’ worth of chemical, and a maximum of 90 days. Silos designed for the storage of solids shall be designed to hold a minimum of 90 days’ worth of chemical, and a maximum of 180 days. For chemicals which are subject to degradation while in storage (e.g. sodium hypochlorite, see IW-TEC-900-05 Disinfection Specification for further details), the storage period shall be maintained at the lower end of the allowable scale (i.e. 28 days for NaOCl). For chemicals which do not degrade in storage, this period shall be maximised to the higher end of the allowable scale, as far as site specific restrictions allow. Note that when calculating tank capacity it is normal practice to discount the space between the tank 'high' level and 'overflow' levels (i.e. freeboard).

8.2.1 BULK STORAGE TANK (LIQUID) CAPACITY

Sizing of bulk storage tanks for liquid storage shall be carried out in accordance with the Section 8.2 above, or, in accordance with a specific Irish Water specification for that chemical (e.g. IW-TEC-900-05 in the case of Sodium Hypochlorite). The designer shall specify the degradation propensity of the chemical proposed, and offer justification as to the volume of chemical storage selected.

For all liquid chemicals where storage requirements for a single chemical are less than or equal to 250 litres, a single polymeric storage tank may be proposed. However for all designs which require storage of a particular liquid chemical in excess of 250 litres, dual tank installations shall be proposed. This is required to provide redundancy in the event of tank failure or to facilitate routine / non-routine maintenance.

For all dual tank installations, the escape of contents from one tank shall not prevent the operation of the other tank. Tanks shall not be interconnected, and pumping systems shall have the capability to draw from either chemical tank. Each tank in a dual tank installation shall have its own filling point and filling line.

8.2.2 BULK STORAGE TANK (SOLID) CAPACITY

Sizing of silos for bulk solids storage shall be carried out in accordance with the Section 8.2 above, or, in accordance with a specific Irish Water specification for that chemical. The designer shall specify the degradation propensity of the chemical proposed, and offer justification as to the capacity of chemical storage selected.

For all solid chemicals where storage requirements for a single chemical are less than or equal to 12,000 litres, a single steel storage silo may be proposed. However for all designs which require storage of a particular solid chemical in excess of 12,000 litres, dual silo installations shall be proposed. This is required to provide redundancy in the event of tank failure or to facilitate routine / non-routine maintenance.

For all dual tank installations, the escape of contents from one tank shall not prevent the operation of the other tank. Tanks shall not be interconnected, and batching systems shall have the capability to draw from either chemical silo. Each silo in a dual tank installation shall have its own filling point and filling line.

8.2.3 MAKE-UP AND BATCHING TANKS CAPACITY

For chemical make-up or batching tanks, a minimum per tank volume of 1000 litres shall be proposed, with a maximum volume of 2100 litres, but tank footprints shall not exceed a size that will prevent them from being removed from their bund / storage area intact. Batching tanks should also be sized so that mixing equipment provides sufficient agitation for the entire contents of the tank (i.e. mixers are centrally mounted and creates the required turbulence at the tank walls), and that centrally mounted mixers/motors can be readily accessed for routine maintenance without entering the bunded area.

Sufficient batching volume shall be provided to ensure a maximum chemical make-up frequency of once per week is not exceeded, therefore there shall be no upper limit on the number of chemical batching tanks proposed, and the designer may add additional tanks as required to meet the chemical demands of the plant. In general the height of batching / make-up tanks shall not exceed 2.10m in height, and all tanks exceeding 1.20m shall be provided with access platforms for make-up / service operations, or alternatively, installed in a bund that has been recessed into the storage room floor.

For all dual tank installations, the escape of contents from one tank shall not prevent the operation of the other tank. Tanks shall not be interconnected, and batching systems shall have the capability to draw from either chemical silo. Each silo in a dual tank installation shall have its own filling point and filling line.

8.3 DESIGN LIFE OF BULK STORAGE TANKS

The design life of polymeric bulk chemical storage tanks is typically measured in fill cycles rather than years, with one cycle being the equivalent to one fill and one emptying. For the purposes of this specification, one cycle shall be considered complete if the tank has been emptied to below 50% of its capacity, and subsequently replenished. The designer shall ensure that proposed polymeric storage tanks are designed to permit an adequate number of fill cycles to allow the tank to be used for a minimum of 20 years. The designer shall submit with their proposals, the expected frequency of replenishment, as well as the number of cycles that the tank is rated for. Plant operators will be required to keep records of the fills for each polymeric bulk storage tank onsite. For all steel tanks used for batching and / or silo storage purposes, the minimum design life shall be 25 years.

The designer shall also ensure that all polymeric tanks are adequately protected against degradation by ultraviolet (UV) light, particularly for when polymer based tanks are proposed for outdoor installation. Polymeric tanks are commonly constructed using UV stabilisers, however they still have a finite life and advice should always be sought from tank manufacturers as to their safe design life. This is an important consideration when selecting materials for construction or an external protective finish for tanks where UV is likely to be prevalent, and the effects of exposure to UV light shall not reduce the design life of the tank to below the minimum requirements.

8.4 TANK LABELLING AND NAMEPLATES

All bulk storage tanks for both liquid and solid chemicals, as well as batching / make-up tanks shall be provided with a label, which, at a minimum details the following information:

- Name of stored / batched chemical
- Relevant COSHH data
- Emergency spill contact number
- Concentration of stored chemical
- Maximum fill capacity
- Specific gravity of chemical

In addition to the tank label described above, all tanks in excess of 1000 litres storage capacity, proposed for the bulk storage of both liquid and solid chemicals, or for batching purposes, shall be provided with a nameplate, permanently fixed to the tank, detailing the following information, at a minimum:

- Tank manufacturer
- Chemical density

- Tank serial number
- Date of manufacture of tank
- Materials of construction of the tank
- The chemical the tank is designed to store
- Chemical reduction factor
- Tank manufacturer's contact details, including address, telephone number and web address
- Design temperature
- Location for use – internal or external
- Maximum fill capacity
- Category of tank
- Calculated design life (No. of fill cycles)
- Chemical Concentration / Specific Gravity

9 BULK STORAGE, BATCHING AND SILO TANK ANCILLARIES

As stated in Section 8 of this document, chemical storage facilities shall be designed to provide a safe and secure working environment for all operational staff, as well as all visitors to site, and minimise the risks of dangerous occurrences associated with the storage, delivery, transfer and dosing of chemicals during both routine and non-routine operational and maintenance activities. Facilities shall also be designed to minimise, or prevent entirely, the environmental impact of a system failure, i.e. leakage of chemical to an adjacent water course or drain. In addition to the requirements outlined in Sections 6, 7 and 8 of this document, the designer shall provide all bulk storage tank ancillary equipment where appropriate, in accordance with this section of the specification. Such ancillary equipment includes, but is not limited to; bunding, secondary containment, venting, fill lines, instrumentation, temperature control, solids handling and gas monitoring alarm systems which may be required in order to ensure safe delivery, transfer, storage and dosing of all chemicals.

While some of the above accessories (i.e. bunding) will be applicable to all chemical storage facilities, others will be specific for each, and determination of which shall be required for each particular chemical is specified in the following sections. Each chemical specific ancillary requirements shall be considered when using Section 7 of this document as certain chemicals may have storage, heating and ventilation requirements that conflict with those of other chemicals. The designer shall refer to the WIMES 8.02 suite of documents for additional information in relation to storage tanks accessories, but where there is a conflict between WIMES and this document, this document shall take precedence.

9.1 BUNDING

All liquid chemical storage and batching facilities shall be bunded in order to contain spillages in the event of failure. This includes bulk storage tanks, day tanks, batching / make-up tanks and all automated make up systems. Note that there is no requirement for the bunding of solid storage silos. All valves, pumps, and other equipment associated with the delivery, transfer, batching, storage and dosing of chemical solutions shall be positioned, where reasonably practicable, in a location which allows spillages at interfaces to be contained within the bund. This may be achieved by mounting the equipment within the bund (provided bund access is not required for regular operational duties), over the bund, or over a spill tray which allows leaked chemicals gravitate back to the bund. While both concrete bunds and self-bunded polymeric tanks will be permitted, their use will be restricted to the conditions as outlined in the Table below. Note that all self-bunded polymeric tanks proposed for installation outdoors shall be weather shrouded to prevent collection and retention of rainwater.

Bund Type	Allowable Usage	Notes
Polymeric Bunds (Open Topped)	Allowable only on indoor storage facilities where storage capacity is < 250L	All indoor storage capacities in excess of 250L will require 2 No. storage tanks in a common concrete bunded area.
Polymeric Bunds (Weather Shrouded)	Allowable only on outdoor facilities where storage capacity is < 12,000L	Not applicable to all chemicals as some must be stored indoors regardless or storage capacity, i.e. sodium hypochlorite, hydrofluorosilicic acid.
Concrete Bunds	Allowable on all indoor and outdoor storage facilities regardless of storage capacity.	All batching / make-up tanks (included automatic make up tanks) must be enclosed in a concrete bund. All concrete bunds to be suitably lined.

Table 21: General requirements for storage tank bunding facilities.

The designer shall design all bunding infrastructure in accordance with WIMES 8.02, the major points of which are listed below.

- Bunding shall comply with the relevant parts of CIRIA Document '*C598 – Chemical Storage Tank System Design – Good Practice*'.
- Components / systems that are unsuitable for immersion in the dosing chemical / rainwater shall be positioned above the expected top liquid level of the bund. Components / systems positioned below the expected top liquid level of the bund shall be expected to come into contact with dosing chemical / rainwater and all materials shall be selected accordingly.
- The bund material / protective coating and type of bund construction shall be resistant to corrosion / degradation (see Section 6 for material compatibility) by the dosing chemical / rainwater and shall be suitable for immersion in the dosing chemical / rainwater without deterioration or degradation for a minimum of 7 days.
- Blockwork walls will not be permitted to act as bunded containment – all bunds shall be of purpose built cast in-situ concrete construction in accordance with BS8007:1987 Design of Concrete Structures for Retaining Aqueous Liquids, even if proposed within existing rooms or buildings.
- Open topped bunds are not permitted for use on outdoor storage installations for chemicals that may be violently reactive with retained rainwater (e.g. sulphuric acid).
- Bunds shall be designed to resist all hydrostatic and hydrodynamic forces that may be imposed upon it, due to either the bund filling with dosing chemical / rainwater to the bund flood level, or sudden tank failure (i.e. wave effects).
- The bund capacity shall be 110% of the total storage capacity of the largest tank or 25% capacity of the volumetric sum of all disconnected tanks within the bund, whichever is the greater. If tanks are connected at a low level during operation, the bund capacity shall be 110% of the total storage capacity of all connected tanks.
- Penetrations for pipework, ducting, conduit, etc. shall not be routed through bund walls or bases.
- Interconnecting pipework, tubing or ducting, etc. between bunds shall not be permitted.
- Bunds shall only house tanks / batching systems containing one type of dosing chemical.

- Bund walls shall be positioned far enough away from tanks and associated pipework systems to ensure that all leaks are contained (i.e. to avoid jets of dosing chemical spraying over the bund walls). If this is not practicable due to space restrictions, suitable splash screens shall be provided. Splash screens shall be manufactured from a clear material that is resistant to corrosion / degradation by the dosing chemical.
- Adequate space shall be provided between tanks and bund walls to allow access to components / systems for inspection purposes and plant maintenance. In addition, the space between the tank and bund wall shall be sufficient to ensure that escape routes are not blocked in the event of a burst / leak, i.e. it shall be possible to escape from the bund without the need to cross directly in front of, or through, bursts or leaks.
- To facilitate the removal of dosing chemical / rainwater from open topped outdoor concrete bunds, the floor of the bund shall be sloped towards a sump, which will be fitted with a submersible pump.
- A suitably rated, permanently installed submersible pump with appropriate lengths of flexible hose attached to the outlet connections shall be provided for removing rainwater from outdoor bunds / bund sumps. The pump shall be provided with a local manual isolator (i.e. it shall not start automatically).
- If a sloping bund floor is proposed, all tanks shall be mounted on a level plinth. Bund sumps shall not be provided with drains.
- The use of electrical junction boxes within the bund envelope shall be kept to an absolute minimum. If junction boxes must be placed within the envelope, they shall be positioned so that they are easily accessible, at a height that is a suitable distance above the bund floor level. Junction boxes shall be IP65 rated, and materials of construction shall be resistant to corrosion / degradation by the dosing chemical.
- A level sensor shall be provided within all bunds / bund sumps to generate an alarm if the dosing chemical / rainwater level in the bund / bund sump exceeds a pre-set level. The level sensor shall be resistant to corrosion / degradation by all liquids it is likely to come into contact with.
- Supports / fixings for tanks, pipework systems and other components / systems shall not compromise the integrity of the bund floor or protective lining.

9.2 SECONDARY CONTAINMENT

Pipework systems in excess of 25mm in diameter, which carry chemicals outside of bunded areas shall all be provided with secondary containment (i.e. dosing pipework shall be sleeved or double walled). All materials used for secondary containment shall be resistant to corrosion / degradation by the dosing chemical and effectively sealed. Secondary contained pipework shall be installed with a 1:100 fall, so that leakages can gravitate effectively to a suitably located drainage valve and catchpot. Where possible, catchpots shall incorporate an overflow facility which is routed back to the main bund, or alternatively to s suitable containment systems or receptacle. All secondary containment shall be designed so that it can be easily drained, flushed, and if necessary dismantled, to facilitate the safe removal of damaged / leaking components, and flow direction shall be clearly indicated.

9.3 TANK CONNECTION REQUIREMENTS

At a minimum, the designer shall comply with the following pipework and connection specifications for all tanks. Piping and connection requirements will vary depending on the chemical in question, for instance, some chemicals will require ventilation to the storage room only, whereas other chemicals will require ventilation to the atmosphere. Similarly, powder chemicals stored in silos will have different requirements than liquid chemicals held in bulk storage tanks. All pipework used shall be chemical specific and selected in accordance with Section 6 of this document, as well as relevant sections of WIMES 8.02. The general requirements listed in Section 9.3.1 below will apply for all tanks, regardless of type (liquid retaining, solid retaining, batching), unless otherwise noted;

9.3.1 GENERAL PIPEWORK AND CONNECTION REQUIREMENTS

The design shall ensure that the following specifications are complied with for all forms of tank installation, regardless of function (bulk liquid storage, bulk solid storage, batching, etc.), capacity or orientation.

- Pipework systems shall be designed to withstand the maximum pressure experienced by the system.
- The pipework layout and connections shall be simple and all components shall be of a material that is resistant to the chemical to be conveyed. Pipework components shall not pass through bund walls.
- A design file shall be required for all piping systems which carry a corrosive liquid or solid. The file shall outline the material of construction, and dimensions of all pipes, valves, and fittings used in the installation.
- The piping system must be resistant to internal corrosion from any associated chemical or protected by means of a suitable coating or internal lining.
- Pipework must also be protected from external corrosion and mechanical impact, e.g. collision with delivery vehicles, pallet trucks, swinging doors, foot traffic, etc.
- Pipework connections to tanks should be of the bolted flange type (PN16).
- All pipework (where size allows) shall be labelled with the name of chemical it conveys as well as identification of the flow direction.

9.3.2 PIPEWORK AND CONNECTIONS FOR LIQUID HOLDING BST > 250L

The designer shall ensure that all the following pipework and connections are included for on all bulk storage tanks with a capacity in excess of 250 litres which are designed to hold liquid chemicals. The same requirements will apply for all batching / make-up tanks with capacities in excess of 1000 litres.

- **Filling Line:** Each individual tank shall be provided with an independent filling line which will allow replenishment of the tank contents without handling the chemical, accessing the bund, or manual handling of drums or pipework. Independent filling lines shall incorporate isolation valves and non-return valves to prevent spillage of chemicals during replenishment. All fill point connections shall be installed over the bund so that spillages during connection / disconnection of refill pipework are contained. Filling lines shall be sized to ensure that consequent filling velocities shall not be such that passivated layers formed on pipework of iron based material are not at risk of erosion during replenishment.
- **Overflow:** Each tank shall be provided with an overflow pipe that is located a suitable distance away from the inlet pipe and above 'high' tank fill alarm levels. The overflow pipe should be a sized accordingly

(80mm for tanks up to 1,000 litres, 100mm for tanks up to 5,000 litres, 150mm for tanks in excess of 5,000 litres) and discharge appropriately into the bunded area. Overflow pipes shall be positioned an appropriate distance above the top liquid level of the tank (100mm for tanks up to 1,000 litres, 200mm for tanks up to 5,000 litres, 350mm for tanks in excess of 5,000 litres).

- **Dosing Outlet:** Each tank should have an outlet connection which is elevated a sufficient distance above tank floor level (minimum 5% of total tank height) for mitigation against blockages arising from low lying sediment. The outlet connection should be valved appropriately and sized based on the dosing rate (50mm NB minimum). Diaphragm valves are unsuitable for this system.
- **Drain:** Each tank should have appropriately valved drain piping connected to the lowest point of the base.
- **Vent Pipe:** Each tank should have vent piping connected which is located above the overflow connection. Vent piping should be located at the top of the tank and rise vertically for discharge at a suitable location. The size of the piping should be chosen to prevent any build-up of pressure during delivery. Minimum acceptable dimensions for vent pipes shall be 2.5 times that of the largest liquid tank connection. The discharge point for interior tanks should always be outside the building and be protected against blockages from debris and the environment.

9.3.3 PIPEWORK AND CONNECTIONS FOR BATCHING TANKS

As the minimum volumes for batching / make-up tanks is 1000 litres, the following shall be applied to all batching / make up tanks proposed:

- **Dosing Outlet:** Each tank should have an outlet connection which is elevated a sufficient distance above tank floor level (minimum 5% of total tank height) for mitigation against blockages arising from low lying sediment. The outlet connection should be valved appropriately and sized based on the dosing rate (50mm NB minimum). Diaphragm valves are unsuitable for this system.
- **Drain:** Each tank should have drain piping connected to the lowest point of the base. The drainage pipework should be valved appropriately. Diaphragm valves are unsuitable for this system.
- **Potable Water Inlet:** Each batching / make-up tank shall include a valves water supply which passes through a flow meter with a localised digital display to allow the plant operator measure the exact quantity of water being used in each batch make up. The flow meter shall give a totalised value (not an instantaneous reading) and shall be resettable to zero after each use. In automated batching systems, an actuated valve shall be provided on this line, with the flow reading automatically resetting after each use.
- **Vent Pipe:** All enclosed batching tanks / make-up tanks shall have vent piping at roof level. The vent shall be sized appropriate to the size of the batching tank, the powder fill rate and the make-up water fill rate.
- **Overflow:** All enclosed batching tanks tank shall be provided with an overflow pipe that is located a suitable distance away from the inlet pipe and above 'high' tank fill alarm levels. The overflow pipe shall be sized appropriate to the size of the batching tank, the powder fill rate and the make-up water fill rate.

9.3.4 PIPEWORK AND CONNECTIONS FOR SILOS

As silos will typically be proposed only on plants with very high chemical demands, it is assumed they will generally all be large structures. Therefore the following pipework and connections shall apply for all silos proposed, regardless of capacity:

- **Filling Line:** Each individual silo shall be provided with an independent pneumatic silo filling line which will allow replenishment of the tank contents without handling the chemical, or climbing to the roof of the silo. Fill lines shall be sized appropriate to the size of the silo, and shall extend over the roof level of the silo in a long radius 180° bend. A lockable isolating valve, with keys held only by operational staff, shall be provided on each fill line to ensure that plant personnel be present during replenishment activities.
- **Outlet Connection:** For automated batching installations, the outlet of the silo shall discharge directly into a transfer auger, with no allowance of powder emission. The interface between the silo and the auger shall be isolatable by a knife gate valve which shall permit removal of the auger for inspection / maintenance, without loss of the silo contents.
- **Air Agitation Connection:** A connection of minimum 50mm NB shall be provided at the conical base of each silo to allow the installation of an air agitation system to loosen the contents of the tank if required.
- **Vent Pipe:** Each silo shall have vent piping at roof level which is routed through an air filtration system to prevent the emission of powdered chemical during replenishment. Minimum acceptable dimensions for vent pipes shall be 2.5 times that of the largest tank connection (typically the fill pipe).

9.4 TANK AND STORAGE ROOM VENTILATION

Venting systems shall be implemented on all enclosed bulk storage tanks, silos, and enclosed batching tanks, for pressure relief during filling / draining operations and for controlling the release of vapour / emissions during normal storage operations. For tanks installed indoors, all vents shall be routed to outside the building, but the designer shall take all necessary measures to prevent the ingress of moisture via externally mounted vent pipes. The following are Irish Water approved minimum standards for venting systems:

- Each tank should have vent piping connected which is located a minimum distance above the overflow connection. The size of the piping should be chosen to prevent any build-up of pressure during delivery, and at a minimum shall be 2.5 times the diameter of the filling line.
- The discharge point for interior tanks should always be outside the building and be protected against blockages from debris and the environment. Vents should be designed to minimise moisture ingress (drip lips should be considered).
- Vent piping should be located at the top of the tank and rise vertically for discharge at a suitable location. The discharge point should ideally be a minimum of 300mm above the tank or 5m above ground level.
- The minimum distance between vent discharge points and potential sources of ignition is 3.00m.
- Forced ventilation of the bulk tank may need to be provided for a number of chemicals, particularly dilute acids. This is due to the tendencies of these chemicals to generate hydrogen gas when in contact with carbon steel or a range of other materials. The General Risk Assessment, Chemical Compatibility Risk Assessment and PEAZ Assessment shall be used to assess whether natural ventilation or force ventilation should be provided at the storage location.

- All rooms which contain bulk storage or batching tanks shall incorporate a forced ventilation system which permits a minimum of 2 air changes per hour for the full volume of the storage room (with the exception of Class III segregated facilities which shall require a minimum of 10 air changes per hour). Storage room heating facilities shall be designed to maintain required storage temperatures despite this ventilation.

Chemical	Ventilation Requirements	Notes
Aluminium Sulphate	Forced ventilation of BST	For all BST > 1000 L. Passive otherwise.
Ferric Sulphate	Forced ventilation of BST	For all BST > 1000 L. Passive otherwise.
Ferric / Sodium Nitrate Mixture	Forced ventilation of BST	For all BST > 1000 L. Passive otherwise.
Hydrofluorosilicic Acid	Forced ventilation of BST	For all BST > 1000 L. Passive otherwise.
Orthophosphoric Acid	Forced ventilation of BST	For all BST > 1000 L. Passive otherwise.
Poly-Aluminium Chloride	Passive ventilation of BST	For all liquid storage tanks
Polyelectrolyte	n/a	May be batched in open make-up tanks
Potassium Permanganate	n/a	Batched at low concentrations.
Sodium Carbonate	n/a	Batched at low concentrations.
Sodium Hydrogen Phosphate	n/a	Batched at low concentrations.
Sodium Hydroxide	Forced ventilation of BST	For all BST > 1000 L. Passive otherwise.
Sodium Hypochlorite	Forced ventilation of BST	For all BST > 1000 L. Passive otherwise.
Sulphuric Acid	Forced Ventilation of BST	For all BST > 1000 L. Passive otherwise.

Table 22: General requirements storage room / tank ventilation. Check this table.

9.5 TANK ACCESS (MANWAYS AND INSPECTION HATCHES)

Manways and/or inspection hatches shall be provided on all enclosed bulk storage tanks to provide access for inspection, cleaning or maintenance purposes. This shall apply for liquid retaining bulk storage tanks, solid retaining bulk storage tanks, and enclosed batching tanks. All access manways and inspection hatches shall be lockable, with means of access only given to operational staff.

9.5.1 BULK STORAGE TANK (LIQUID)

The designer shall adhere to the following when determining requirements for access manways and / or inspections hatches for fully enclosed liquid retaining bulk storage tanks:

- Roof entry manways on liquid retaining bulk storage tanks shall be avoided wherever possible. Side entry manways are acceptable.
- Manways shall be sized at 900mm NB where possible, and permit access for a man wearing protective clothing and a breathing apparatus. This dimension may not be suitable for smaller tanks so therefore the largest possible manway shall be provided in accordance with the tank manufacturer's recommendations.
- Manway covers that weigh over 25 kg shall be hinged or provided with a davit.
- A 400mm NB inspection hatch should be provided on the roof of each tank where appropriate. Where this is not possible the largest diameter hatch will be provided. Hinged hatch covers should be provided if the cover weighs over 25kg.

- It may be necessary to provide permanent access routes if equipment and accessories cannot be accessed from ground level. The designer shall follow the recommendations of CIRIA Document C598 for all such facilities.

9.5.2 BULK STORAGE TANK (SOLID)

The designer shall adhere to the following when determining requirements for access manways and / or inspections hatches for fully enclosed solid retaining bulk storage tanks:

- All flat roofed bulk storage silo tanks shall be provided with both a roof manway and a side entry manway. Side entry manways on vertical side walls or inclined manways on conical base walls are acceptable. In the absence of a gantry crane over the roof manway, a lifting davit and socket shall be installed to facilitate evacuation in an emergency situation.
- Manways shall be sized at 900mm NB where possible, and permit access for a man wearing protective clothing and a breathing apparatus. This dimension may not be suitable for smaller tanks so therefore the largest possible manway shall be provided in accordance with the tank manufacturer's recommendations.
- Manway covers that weigh over 25 kg shall be hinged or provided with a davit.
- All conical roofed silos shall be provided with a hinged 400mm NB inspection hatch. The hatch should be positioned near the edge of the silo so that access to the roof is not required in order to look through the hatch.
- Flat silo roofs shall be provided with guard rails and an access stairway from ground level. Ladders shall not be permitted for use for silo roof access. Access to conical roof silos shall not be permitted or encouraged.
- Silo outlet cones shall be a minimum of 200mm diameter to simplify maintenance procedures should blockages occur.

9.5.3 MAKE-UP AND BATCHING TANKS

The designer shall adhere to the following when determining requirements for access manways and / or inspections hatches for fully enclosed chemical make-up or batching tanks:

- Access manways are generally not required on fully enclosed make-up batching tanks, as the volume is typically no larger than 2 – 3m^3. However the designer shall ensure, where the dimensions of the tank allow, that an inspection hatch which permits viewing of the entire inner contents of the make-up / batching tank with a hand held torch, is provided.
- Inspection hatches may be provided on make-up / batching tank roofs or sidewalls.
- Inspection hatch covers that weigh over 25 kg shall be hinged or provided with a davit.

9.6 TANK HEATING AND INSULATION

While certain chemicals will require storage within particular temperature ranges, in general, all indoor storage facilities for water treatment chemicals shall be capable of being maintained within a temperature range of 10°C to 20°C, therefore eliminating requirements for internal tank heating and insulation.

Maintenance within this temperature range shall be achievable despite all chemical storage room ventilation requirements necessary to maintain a safe working environment.

For all outdoor storage installations proposed, chemicals shall be capable of being maintained above their freezing / crystallization temperature in all climatic conditions of air temperatures ranging from -18°C to +30°C. This shall be achieved by the implementation of internal heating systems within the tank (where is it safe to do so), appropriately lagging the tank, and installation of heat tracing and lagging systems on all external pipework which may retain standing columns of liquid (overflow pipes, vent pipes, etc. need not be insulated and heat traced). Similarly, chemicals which may degrade in higher temperatures shall incorporate chilling systems in order to maintain their efficacy in outdoor storage installations.

In accordance with Table 19 of Section 7.1, outdoor installation of chemical storage facilities is permissible under the following circumstances:

- For a single chemical, with total storage volumes in excess of 12,000 litres (i.e. 2 No. bulk storage tanks, each in excess of 6,000 litres), provided it is practicable and safe to implement the installation of a internal tank heating and / or chilling system.
- For a single chemical, with total storage volumes in excess of 12,000 litres (i.e. 2 No. bulk storage tanks, each in excess of 6,000 litres) which have a freezing / crystallization temperature below - 18°C and does not suffer chemical degradation in ambient temperatures of up to 30°C.

In situations where it is deemed unsafe (due to material compatibility issues, ignition concerns, etc.) or impracticable to install internal heating systems in chemical storage tanks, then the designer shall ensure that allowance is made for such chemical storage facilities to be housed indoors, in adequately ventilated and temperature controlled environments where the required ambient temperature range of between 10°C to 20°C can be maintained.

For all outdoor chemical storage installations which incorporate internal heating / chilling facilities, as well as heat tracing and lagging systems on pipework, the designer shall implement the following mechanisms in order to effectively and efficiently control the system:

- A storage tank mounted thermostat or similar device shall be utilised to automatically activate the internal heating / chilling systems. The thermostat activation shall be based on liquid temperatures within the tank, with cut in and cut out temperatures appropriately set for each individual chemical in storage.
- An externally mounted thermostat which measures air temperature shall be used to activate heat tracing systems on pipework. Once the outside air temperature drops below 5°C, all heat tracing on pipework shall be activated, regardless of the chemical.
- The tank contents temperature sensor should be located so that it is fully immersed in the chemical in question despite the level within the storage tank.
- Heating / chilling systems shall only be activated when the heating coil is covered by a minimum of 150mm of the chemical.

- An independent electrical cut out should be provided as part of the system. This should be activated by unsuitable liquid levels in the tank for the heating / chilling system to be activated, the detection of high / low temperatures within the tank, and the generation of a heater failure alarm.
- Insulation should comply with the good practice guidelines listed in CIRIA Document C598.
- Insulation elements should be pre-formed and easily accessible if removal is required. Waterproof insulation should be provided for outdoor installations.

For each outdoor storage installation proposed, the designer shall at a minimum submit the following design information:

- Full details (specifications, SDS, etc.) of each chemical to be stored outdoors, including information regarding the freezing / crystallization temperature at the proposed storage concentration.
- Full details of how the tank contents, while in storage, will be maintained above the freezing / crystallization temperature across the full climatic temperature range noted above (i.e. details of internal heating systems, tank lagging, etc.).
- Full details of how an effective chemical pumping / conveying / transfer system shall be maintained across the full climatic temperature range noted above (i.e. details of lagging, heat tracing, etc.).
- Full details of how chemicals which are subject to degradation in elevated temperatures shall be maintained at their recommended storage temperatures across the climatic range noted above (i.e. details of internal chilling systems, lagging, etc.).

9.7 INSTRUMENTATION REQUIREMENTS

In addition to the instrumentation and control requirements for the accurate administration of chemical doses (i.e. flow proportional metering, residual trimming, etc.), the designer shall ensure that sufficient monitoring and control systems are implemented in order to facilitate safe storage management, continued and reliable dosing in all specified conditions, as well as maintenance of sufficient chemical inventory on each site at all times. All instrumentation proposed shall be fit for the purpose intended and give operational personnel adequate warning should certain situations arise. This section shall outline the minimum instrumentation requirements for the effective management of bulk liquid storage tanks, batching facilities, and dry powder storage facilities.

9.7.1 GENERAL INSTRUMENTATION REQUIREMENTS

The designer shall comply with all of the general instrumentation requirements as outlined below. While certain chemicals, or storage locations, will have specific instrumentation requirements (minimum requirements for these are outlined in subsequent sections), the following shall apply for the installation of all instruments, regardless of their function, or location of installation.

- All instruments and components installed shall be manufactured from materials which are compatible with the chemical to be stored and monitored. Irish Water or their representative may request written confirmation from equipment manufacturers to support the proposal of a particular instrument
- All instruments shall be located and / or valved so that removal for maintenance, service or replacement does not require draining / emptying of the storage tank.
- A continuous analogue indication of tank content level is required for all liquid, solid or batching installations. A real time reading of current volume in litres should be displayed on the system HMI (i.e. not weight or liquid level). Ultrasonic, radar and signal sensors are acceptable technologies for generating analogue signals, on the condition that they are deemed dependable and fit for purpose by Irish Water or their representative. Where foaming is likely to occur in the tank, radar sensors should be used. For solid storage, radar sensors or plumb bob devices shall be used.
- All silos which store bulk solids shall also incorporate a high and low digital point level device (e.g. diaphragm switches, rotary paddle switches, capacitance switches or vibratory probe switches) as a back up to the analogue system, as analogue signals may not be entirely accurate due to mounding / rat-holing.
- For all non-translucent tanks, filling operations shall be monitored by using a 'traffic light' type visual alarm system which shall be controlled by the analogue level sensors contained in each tank. A red light will indicate to plant operators that the tank is at less than 20% of its capacity and needs refilling. An amber light will indicate to delivery personnel that the tank is between 20% and 90% full. A flashing green light indicates that the tank is over 90% full and a solid green light indicates that the tank is 100% full and filling may cease.
- Strain gauges should be incorporated into installation of new tanks. These can be used to give an early indication of excessive strain in pressurised systems or due to fatigue or settlement.

9.7.2 INSTRUMENTATION REQUIREMENTS FOR MANUAL BATCHING SYSTEMS

At a minimum, the instruments outlined in Table 23 below shall be provided on all manual batching / make-up systems proposed. Note that additional process control instruments (i.e. chlorine analysers, streaming current monitors, pH monitors, process flowmeters, etc.) are not included in the below table as they are specific to the chemical being dosed. This table only accounts for instruments common to all manual batching / make-up tank installations. The designer shall allow for chemical specific process control instruments as required, and as outlined in other Irish Water Design Specifications (i.e. the IW-TEC-900 suite of documents).

Description	Instrument Type	Quantity Required	I/O Type	Function	Data Log
Batching / Make-up Tank Level	Continuous Level *(Ultrasonic)*	1 per tank	A	Stock level management, duty / standby tank changeover, mixer control	Remaining Volume
Batching / Make-up Tank Leak Detection	Point Level *(Conductivity probe, capacitance probe)*	1 per bund	D	Alarm.	-
Chemical Flow	Flowmeter	1 per dosing	A & D	Stock level management &	Trend

	(Electromagnetic FM)	delivery line		flow profile trend. Dosing pipework leakage alarm.	
Make-Up Water Flow	Flowmeter *(Electromagnetic FM)*	1 per delivery line	A & D	Accurate monitoring of make-up water quantity	Trend

Table 23: Minimum instrument requirements for manual batching / make-up systems.

9.7.3 INSTRUMENTATION REQUIREMENTS FOR AUTOMATIC BATCHING SYSTEMS

At a minimum, the instruments outlined in Table 24 below shall be provided on all automatic batching / make-up systems proposed. Note that additional process control instruments (i.e. chlorine analysers, streaming current monitors, pH monitors, process flowmeters, etc.) are not included in the below table as they are specific to the chemical being dosed. This table only accounts for instruments common to all automatic batching / make-up tank installations. The designer shall allow for chemical specific process control instruments as required, and as outlined in other Irish Water Design Specifications (i.e. the IW-TEC-900 suite of documents).

Description	Instrument Type	Quantity Required	I/O Type	Function	Data Log
Batching / Make-up Tank Level	Continuous Level *(Ultrasonic)*	1 per tank	A	Stock level management, duty / standby tank changeover, mixer control	Remaining Volume
Batching / Make-up Tank Leak Detection	Point Level *(Conductivity probe, capacitance probe)*	1 per bund	D	Alarm.	-
Chemical Flow	Flowmeter *(Electromagnetic FM)*	1 per dosing delivery line	A & D	Stock level management & flow profile trend. Dosing pipework leakage alarm.	Trend
Make-Up Water Flow	Flowmeter *(Electromagnetic FM)*	1 per delivery line	A & D	Accurate monitoring of make-up water quantity	Trend

Table 24: Minimum instrument requirements for automatic batching / make-up systems.

9.7.4 INSTRUMENTATION REQUIREMENTS FOR BULK STORAGE OF SOLIDS

At a minimum, the instruments outlined in Table 25 overleaf shall be provided on all silos used for storage of bulk solids. Note that additional process control instruments (i.e. chlorine analysers, streaming current monitors, pH monitors, process flowmeters, etc.) are not included in the below table as they are specific to the chemical being dosed. This table only accounts for instruments common to all silos used for the storage of bulk solids (i.e. powders, etc.). The designer shall allow for chemical specific process control instruments as required, and as outlined in other Irish Water Design Specifications (i.e. the IW-TEC-900 suite of documents).

Description	Instrument Type	Quantity Required	I/O Type	Function	Data Log
Silo Tank Level	Continuous *(Radar or Plumb Bob)*	1 per silo	A	Stock level management, duty / standby tank changeover.	Remaining Volume
Silo Tank Level	Point Level *(Diaphragm switch, vibratory probe, capacitance probe, rotary paddle)*	2 per silo (high / low)	D	Alarm.	-
Chemical Flow	Flowmeter *(Electromagnetic FM)*	1 per delivery line	A & D	Stock level management & flow profile trend. Dosing pipework leakage alarm.	Trend

Make-Up Water Flow	Flowmeter *(Electromagnetic FM)*	1 per delivery line	A & D	Accurate monitoring of make-up water quantity	Trend
Moisture Content	Continuous *(Moisture and temperature sensor)*	1 per silo	A	Alarm	-
Load Cells	Piezoelectric Load Cell	1 per silo leg	A & D	Alarm – overload of silo, high wind loading.	-

Table 25: Minimum instrument requirements for storage of bulk solids in silos.

9.7.5 INSTRUMENTATION REQUIREMENTS FOR BULK STORAGE OF LIQUIDS

At a minimum, the instruments outlined in Table 26 below shall be provided on all bulk storage tanks used for storing liquid chemicals. Note that additional process control instruments (i.e. chlorine analysers, streaming current monitors, pH monitors, process flowmeters, etc.) are not included in the below table as they are specific to the chemical being dosed. This table only accounts for instruments common to all tanks used for the storage of bulk liquids. The designer shall allow for chemical specific process control instruments as required, and as outlined in other Irish Water Design Specifications (i.e. the IW-TEC-900 suite of documents).

Description	Instrument Type	Quantity Required	I/O Type	Function	Data Log
Bulk Tank Level	Continuous *(Ultrasonic)*	1 per tank	A	Stock level management, duty / standby tank changeover, mixer control	Remaining Volume
Bulk Tank Leak Detection	Point Level *(Conductivity probe, capacitance probe)*	1 per bund	D	Alarm.	-
Day Tank Level *(if DT used)*	Continuous *(Ultrasonic)*	1 per tank	A	Control of chemical transfer, stock level mgmt.	Remaining Volume
Day Tank Leak Detection *(if DT used)*	Point Level *(Conductivity probe, capacitance probe)*	1 per bund	D	Alarm	-
Chemical Flow	Flowmeter *(Electromagnetic FM)*	1 per delivery line	A & D	Stock level management & flow profile trend. Dosing pipework leakage alarm.	Trend
Temperature *(outdoor tanks)*	Continuous *(insertion temp. sensor)*	1 per tank	A	Control of tank heating and / or chilling	Trend

Table 26: Minimum instrument requirements for storage of liquids in bulk storage tanks.

9.7.6 INSTRUMENTATION REQUIREMENTS FOR CHEMICAL STORAGE ROOMS

At a minimum, the instruments outlined in Table 27 below shall be provided for monitoring the environment in all indoor chemical storage rooms. Air temperature shall be monitored in all indoor facilities, and where more than one chemical storage / batching room exists onsite a digital temperature monitor shall be provided in each. Moisture content shall be monitored in all indoor facilities proposed for use for the storage of solid chemicals – this includes rooms which house silos and rooms where pallets of bagged chemicals are stored. Gas monitors shall be selected on the basis of the chemicals that are proposed for storage, but all indoor bulk liquid storage facilities shall at a minimum incorporate hydrogen and oxygen monitors. Further information on specific monitoring requirements for chemical storage facilities can be found in Section 9.8 of this document.

Description	Instrument Type	Quantity Required	I/O Type	Function	Data Log

Temperature	Continuous *(Air temperature monitor)*	1 per room	A	Alarm. Control of heating / cooling / ventilation systems.	Trend
Moisture Content	Continuous *(may incorporate temperature sensor)*	1 per solid chemical storage room	A	Alarm.	Trend
Gas Monitor	Continuous *(Chemical Specific)*	1 per room	A	Alarm.	Trend

Table 26: Minimum instrument requirements for storage of liquids in bulk storage tanks.

9.8 GAS MONITORING

Section 9.7.6 above outlines the minimum monitoring requirements for indoor chemical storage facilities. However an integral aspect maintaining a safe working environment in the presence of potentially hazardous chemicals is the effective monitoring of the composition of the atmosphere within the storage facility. The completion of the General Risk Assessment, Chemical Compatibility Risk Assessment and PEAZ Assessment, as described in Section 5 of this document, shall identify the potential gases which may be present in each chemical storage room, either as a result of chemical degradation, a reaction with storage materials, or a mixture of gases form a range of different sources. The designer shall allow for monitoring of all potential gases which may be generated in the chemical storage facility, but at a minimum, each chemical storage room shall incorporate a system which shall be capable of monitoring the gases outlined in Table 27 below.

Description of Storage Facility	Monitoring Required
All facilities which house bulk storage tanks for liquid chemicals	Oxygen levels, hydrogen levels
All facilities which house bulk storage tanks for sodium hypochlorite	Oxygen levels, hydrogen levels, chlorine gas levels
All facilities which house bulk storage tanks for hydrofluorosilicic acid	Oxygen levels, hydrogen levels, fluorine gas levels

Table 27: Minimum gas monitoring requirements for indoor storage of liquids in bulk storage tanks.

All gas monitoring systems shall be fixed devices (i.e. not portable), and mounted on the wall of the chemical storage room in a suitable location. A local visual display shall permit operational personnel to observe the levels of gas within the room. This visual display shall be mounted just inside the access door so that gas levels can be checked immediately upon entry to the storage area. The detected levels shall also be relayed to the control system PLC, which shall have the capability of generating alarms if set point maximum limits are exceeded.

9.9 SAFETY SHOWERS & EYEWASH

A minimum of one emergency shower and eyewash shall be provided at all chemical storage facilities, at a prominent location that can be easily and readily accessed, i.e. personnel shall not have to navigate obstacles, climb or descend steps, etc. in order to reach the showering facility. For chemical storage facilities (indoor or outdoor) which contain more than one chemical, an emergency shower shall be located no more than 10m from any item of equipment that stores or conveys dosing chemicals. Where the scale of installation does not permit this, more than one shower shall be provided. For storage facilities which contain one chemical only (i.e. chlorine dosing room, fluorine dosing room), an emergency shower shall be located no more than 5m from any item of equipment which stores or conveys the dosing chemicals. The designer shall ensure that showers are installed in locations where splashes or sprays do not pose a threat to the operation of electrical equipment (MCC panels in particular). Where the foot print of the storage room does not permit sufficient separation of showers and electrical equipment, then that equipment shall be suitably rated (IP66) to withstand powerful water jets.

Access routes to the emergency shower should be clear and unobstructed and should not present a trip or collision hazard to personnel that have impaired vision resulting from chemical contact with the facial area. The shower and eyewash shall be connected to a potable water supply which is capable of delivering a pressure of 2 – 3 bar at all times. Lower or higher pressures will not be accepted. Shower trays will not be permitted and as such drainage shall be provided by a floor sloping to a drainage point. If the shower is to be installed in a temperature controlled dosing room, then there shall be no requirement for insulation or heat tracing on the unit itself. However all externally installed shower and eye-washing facilities shall be sufficiently heat traced and lagged so that they can function normally in external air temperatures as low as -18°C. For both indoor and outdoor shower installations, the designer shall ensure that all piped supplies feeding the shower are appropriately protected to provide water for emergency washing purposes in conditions where external air temperatures drop as low as -18°C. This protection can be achieved by sufficient burial of the supply pipe, or alternatively, heat tracing and insulation to all sections of the pipe at risk from freezing temperatures.

9.10 SPILL KITS

Spill kits designed for storage on site are limited in size, and for all installations should be seen as a means of containing a hazard until a permanent resolution is put in place. Spill kits of different chemical compatibilities are available, and if there are different groupings of chemicals stored on site, then the designer shall ensure that there is a minimum of 1 spill kit provided for each chemical group. Each spill kit provided shall be clearly labelled as to which chemical group (or which individual chemicals) its use is intended for.

For each chemical group where the largest tank volume is ≤ 1000 litres, the chemical spill kit shall be sized to have the same sorbent capacity of the largest tank (i.e. if the largest tank within a chemical group is sized at 500 litres, then a 596 litre spill kit shall be provided). However, if another chemical group has storage tanks onsite on site which are > 1000 litres, then the spill kit provided shall have a maximum sorbent capacity of 1000 litres. The total number of spill kits provided is therefore a function of their compatibility with the chemicals in storage.

At a minimum, all spill kits shall include appropriately sized bins, and sufficient quantities of socks, cushions, sheets, rolls, plug rugs, plugging granules, shovels, hazard tapes and waste bags for containment and disposal.

10 CHEMICAL HANDLING DURING DELIVERY, BATCHING & TRANSFER

Provision of suitable infrastructure, as well as the implementation of correct procedures for chemical handling during delivery, batching and transfer operations can contribute significantly to the maintenance of a well-functioning chemical dosing system. It will also contribute to the provision of a safe workplace for all operational personnel and visitors to site, and will reduce the risk hazardous occurrences to the surrounding environment. Chemical handling procedures are largely dependent on the form that the chemical is delivered, which in the case of water and wastewater treatment chemicals in Ireland, can be typically categorised as follows:

- Drum / Carboy Liquid Deliveries
- Bulk Liquid Deliveries
- Bagged / Pallet Solid Deliveries
- Bulk Solid Deliveries

10.1 DRUM / CARBOY LIQUID DELIVERIES

This type of delivery system accounts for chemicals delivered in drums or carboys. Carboys typically have a capacity of up to 10 litres, with drums having a capacity of up to 25 litres. Multiple drums are typically delivered on a wrapped pallet with each pallet holding approximately 16 drums. Once delivered to site, all drums shall be transported by pallet truck or forklift to a dedicated room for drum storage, separate from all bulk storage, batching or dosing room facilities, where the pallet shall be unwrapped and each drum loaded onto a bunded pallet which will contain any spills while in storage. The drum storage area should be located close to the bulk storage, batching or dosing room facilities to reduce manual handling of the drums when replenishment is required. Transfer of the liquid from the drum to the bulk storage tank shall be completed using a 110V electric barrel pump which shall be provided by the contractor for each chemical where drum replenishment is proposed. Under no circumstances shall chemical replenishment be completed by pouring the contents of the drum into the bulk storage tank by hand. Note that replenishment from drum / carboy deliveries will not be acceptable for use for any chemical where the total volume of onsite bulk storage exceeds 250 litres.

10.1.1 CHEMICAL DELIVERY FACILITIES

The facilities for accepting deliveries of chemicals in drums or carboys shall be uncomplicated and designed to minimise manual labour for operators. The designer shall ensure that, at a minimum, the following is in place to ensure minimisation of manual handling associated with the receipt of chemicals delivered in drums.

- The provision of appropriate lifting / transfer equipment (forklift, pallet trucks or trolleys) and facilities to transfer the drums / carboys or pallets from the delivery vehicle to the storage areas.
- Ramps shall be incorporated where there are differences in floor level elevations (no steps).
- Allowance of offloading space close to storage room to minimise transfer distance from vehicle to storage.
- The provision of well-reasoned access routes and sufficient space to manoeuvre forklifts, pallet trucks, or trolleys within the storage area, even when fully stocked.
- The provision of bunded storage pallets upon which chemical drums will sit while in storage. Bunded pallets shall be manufactured from a material which is compatible with the chemical to be stored. Sufficient pallets shall be provided to accommodate the maximum number of drums expected to be stored on site at any one time.

10.1.2 ANCILLARY CHEMICAL TRANSFER / REPLENISHMENT EQUIPMENT

The designer shall ensure that the following equipment is provided to ensure minimisation of manual handling associated with chemical replenishment from drums. Such equipment shall also ensure that the plant operator does not have to risk contact with the chemical during replenishment operations.

- A two wheel hand truck shall be provided to transport chemical drums / carboys from the chemical storage room to the bulk storage tank room.
- A portable electronically operated 110V barrel pump shall be provided to facilitate the transfer of chemicals from drums / carboys to the bulk storage tank(s). One pump shall be provided for each chemical which is proposed for replenishment in this fashion, and the pump shall be selected so as to be compatible with the chemical for transfer.
- The barrel pump and connected flexible delivery pipes shall be constructed of non-corrosive material which is selected specifically for the associated chemical. The delivery hose shall be clamped in position to prevent movement during replenishment and it shall be of suitable length to facilitate operator ease when connecting between the drum / carboy and the bulk storage tank.
- The barrel pump shall be appropriately sized so that it is capable of transferring the chemical from the drum / carboy to the bulk storage tank within a reasonable period of time.
- The barrel pump shall incorporate an integrated non-return valve which will prevent backflow to the drum / carboy upon completion of pumping.
- Operators shall be provided with chemical resistive PPE at all times, which shall be appropriate to the chemical being transferred / stored.
- A venting system which is separate from the storage vent system should be provided at all filling / replenishment areas (adequate room ventilation in accordance with Section 9.4 shall fulfil this requirement).

10.2 BULK LIQUID DELIVERIES

This type of delivery system accounts for liquid chemicals delivered by tankers in a 'milk run' fashion. All chemicals with storage capacity on site in excess of 250 litres shall be delivered in this fashion. Each chemical tank will have a separate fill line to which the delivery hose from the tank shall connect. Fill lines shall be manufactured from materials which are compatible with the chemical to be conveyed, and shall incorporate isolation valves and non-return valves in order to minimise spillages during connection / disconnection. All connection points shall be located over the bunded area so that spillages can be contained. For indoor chemical storage installations, all connection points shall be located within the storage room, accessible only to plant operational personnel. For outdoor chemical storage installation, the isolation valves on each fill line shall be lockable, and accessible only by operational personnel. Operational staff must therefore be present during all replenishment activities, regardless of whether the storage facility is indoors or outdoors. Fill lines shall also be clearly labelled to ensure that the correct chemical is delivered to each storage tank. A filling panel at each fill point shall include a visual 'traffic light' system, controlled by the BST level sensor, which will allow delivery personnel to determine when the tank has been fully replenished. This shall also provide advance notice of when replenishment is required.

10.2.1 CHEMICAL DELIVERY FACILITIES

The installation of the bulk storage tank chemical replenishment system should ensure that no handling of the chemical is required by plant operational personnel or delivery staff. All filling points shall be accessible without requiring access to the bund, and all connections shall be installed over bunds so that spillages during connection / disconnection can be contained. Sufficient space shall be provided outside the chemical dosing room / area to allow access for the delivery vehicle and ensure that tanker hose extensions are not required. The following permanent infrastructure shall be put in place for all liquid chemical storage facilities in excess of 250 litres.

- The filling point shall be clearly labelled and identify which bulk storage tank it supplies, as well as the type of chemical to be stored.
- A separate fill line shall be supplied for each bulk storage tank in the facility. The filling line should be clearly labelled with the chemical type, and flow directional arrows.
- Chemical feed rates shall be dependent on the size of the fill line, and velocities in each fill line are not to exceed 1.6 m/s. Certain chemicals (particularly acids) which are replenished through unlined mild steel carbon steel pipework shall be pumped at lower velocities to prevent the erosion of the passivating iron layer which forms inside the pipe and offers protection against corrosion.
- A pressure relief valve should be provided on the filling line if a pump is incorporated into the line.
- The length of the filling line should be as short as possible, and shall have the minimum number of bends as is practicable. The bulk storage tank shall be visible from the filling point, and the distance from the tanker to the filling point should not require the use of a tanker hose extension.
- The filling line shall be constructed of non-corrosive material which is selected specifically for the associated chemical and shall be clamped against movement.
- The filling line shall enter the bulk storage tank from the top away from any ancillary equipment, instruments, vents, overflow pipe drains, etc.
- A drain valve (close to the filling point) and drop leg connection should be provided in the filling line to remove any remaining surplus chemical solution after filling.
- A filling panel should be provided at the filling point. This panel should primarily provide information on the tank contents level. An appropriate alarm system shall alert operators should specified undesirable contents level conditions arise.
- The visual element of this alarm shall take the form of a 'traffic light' system mounted over each of 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. This indicates that the tank contents level is low and needs replenishment. When the tank is above 20% of its capacity, an amber light shall be activated to show that the tank is filling. When the tank is at 90% of its capacity a flashing green light shall indicate that the tank is nearing its filled capacity. A solid green light shall indicate that the tank is 100% full and filling shall cease. Note that 100% of the tanks capacity should be at least 350mm below the overflow connection as specified in WIMES 8.02. Once the green light is activated, the audible alarm will also activate and remain on until muted at the filling 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.

10.2.2 ANCILLARY CHEMICAL TRANSFER / REPLENISHMENT EQUIPMENT

No specific transfer equipment shall be required for routine replenishment of bulk liquid chemicals, as all infrastructure shall be permanently in place to facilitate filling of the bulk tanks replenishment (as per Section 10.2.1). A bund pump shall however be provided in order to pump any spillages which may be contained within the bund. Bund pumps for indoor installations may be portable, and shall be selected so as to be compatible with the chemical to be pumped – therefore depending on the range of chemicals in storage, more than one pump may be required. For outdoor bulk storage facilities, permanent bund pumps will be installed in each bund, each of which shall be manufactured from materials compatible with the chemical in storage.

10.3 BAGGED / PALLET SOLID DELIVERIES

This type of delivery system accounts for solid chemicals such as kibbled aluminium sulphate, sodium carbonate, polyelectrolyte, etc. which is delivered in 25kg bags. Multiple bags are typically delivered on a wrapped pallet with each pallet holding approximately 40 bags (1000kg). Once delivered to site, all pallets shall be transported by pallet truck or forklift to a dedicated room for bagged chemical storage, which shall be separate from all liquid storage, bulk storage, batching or dosing room facilities. Bagged chemicals may be stored on the delivery pallet until their use is required, i.e. transfer to specialist bunded storage pallets shall not be required as per drum deliveries (see Section 10.1). The bagged solid storage room shall be located close to the make-up / batching room in order to reduce manual handling of the chemical when batching is required. There shall be no steps between the storage room and the batching room so that a trolley can be used to transport bags for batching. Where a difference in finished floor elevation is unavoidable, then a ramp shall be provided.

Manual handling of the chemical shall be minimised during batching operations, and operators should not have to lift 25kg bags into position over batching tanks in order to make a chemical up to the required concentration. Systems shall also be put in place to prevent emission of dust during batching activities. See section 10.3.1 below for further details on equipment required to ensure effective and ergonomic manual batching activities.

10.3.1 CHEMICAL DELIVERY FACILITIES

The facilities for accepting deliveries of solid bagged chemicals on pallets shall be uncomplicated and designed to minimise manual labour for operators. The designer shall ensure that, at a minimum, the following is in place to ensure minimisation of manual handling associated with the receipt of solid chemicals delivered on pallets.

- The provision of appropriate lifting / transfer equipment (forklift, pallet trucks or trolleys) and facilities to transfer the pallets / bags from the delivery vehicle to the storage areas.
- Ramps shall be incorporated where there are differences in floor level elevations (no steps).

- Allowance of offloading space close to storage room to minimise transfer distance from vehicle to storage.
- The provision of well-reasoned access routes and sufficient space to manoeuvre forklifts, pallet trucks, or trolleys within the storage area, even when fully stocked.
- All rooms proposed for use for the storage of solid chemicals in bags shall be shall be dry environments which can be maintained at a temperature of between 10°C and 20°C in all external climatic conditions between -18°C and +30°C.

10.3.2 ANCILLARY CHEMICAL TRANSFER / BATCHING EQUIPMENT

The designer shall ensure that the following equipment is provided to ensure minimisation of manual handling associated with manual batching / make-up of chemical solutions. Such equipment shall also ensure that the plant operator does not have to risk contact with the chemical during batching operations, and that chemical dust which may be released during batching operations is contained and extracted.

- A two wheel hand truck shall be provided to transport chemical drums / carboys from the chemical storage room to the bulk storage tank room.
- A pneu-vac lifting system by Beltyne (or equal approved) shall be provided which can lift bagged chemicals into position over the appropriate batching tanks in advance of bag cutting. If more than one batching tank is proposed, the pneu-vac arm shall be capable of reaching to each batching tank. The pneu-vac lifting system may be floor pillar mounted or wall mounted and shall be protected from dust ingress by an inline filter.
- A bag receptacle shall be mounted over each manual batching tank, into which the pneu-vac system shall deposit the lifted back. The receptacle shall be a fully sealed enclosure which will prevent the emission of dust during the bag cutting or the discharge of chemical to the batching tank. The platform upon which the bag will sit within the enclosure shall be of a mesh construction, with an automated bag cutting system incorporated.
- Once the bag receptacle is closed, the operator shall be able to activate the automatic cutting facility, and the contents of the bag will fall through the mesh platform, into a funnel from where it will be deposited to the batching tank. An electrical interlock shall prevent the bag cutting system from activating while the bag receptacle is open.
- The enclosed bag receptacle shall be air extracted to the batching / make-up room ventilation system.
- The water required for batching activities shall be supplied via a permanently fixed and metered pipe, where a visual flow totaliser will allow the plant operator to monitor the exact quantity of water used in each batch. The flow meter display shall be capable of being zeroed after each batching sequence.
- A floor mounted industrial weighing scales shall be provided with each installations to allow the refinement of chemical concentrations – i.e., sodium carbonate at 8% w/w in a 1000 litre batch will require 3 No. bags of powder totalling 75kg (deposited by the bag receptacle), plus an additional 5kg which may be weighed and added by hand.

- All batching / make-up tanks and bag receptacles shall be clearly labelled with the chemical it contains, and the required concentrations as determined by the process design or during the process commissioning.
- Operators shall be provided with chemical resistive PPE at all times, which shall be appropriate to the chemical being transferred / stored.
- All rooms proposed for batching / make-up purposes shall be dry environments which can be maintained at a temperature of between 10°C and 20°C in all external climatic conditions between -18°C and +30°C.
- All batching rooms and shall be provided with adequate ventilation to prevent the accumulation of dust from make-up activities (in accordance with Section 9.4 of this specification). Each individual bag receptacle shall also be linked to this ventilation system.

10.4 BULK SOLID DELIVERIES (SILO STORAGE)

This type of delivery system accounts for solid (powdered) chemicals delivered by tankers in a 'milk run' fashion, with powdered chemicals pneumatically pumped into each storage silo. Each silo will have a separate fill line, which will begin at ground level, and discharge to the top of the silo, via long radius bends. Fill lines shall be manufactured from materials which are compatible with the chemical to be conveyed. Connection points for fill lines may be located inside or outside the silo storage room, depending on the accessibility for the delivery truck, however if installed outside then connection points shall incorporate lockable isolation valves to prevent the delivery of incorrect chemical and also to prevent the ingress of moisture and vermin. Operational staff must therefore be present during all replenishment activities, regardless of whether the fill line connection point is indoors or outdoors. Fill lines shall also be clearly labelled to ensure that the correct chemical is delivered to each storage tank. A filling panel at each fill point shall include a visual 'traffic light' system, controlled by the silo tank level sensor, which will allow delivery personnel to determine when the tank has been fully replenished. This shall also provide advance notice of when replenishment is required. Note that silo storage tanks for powdered chemicals shall generally be installed indoors in temperature and moisture controlled environments. External silos shall only be permitted where the designer can demonstrate a system of controlling moisture ingress that is acceptable to Irish Water, or their representative.

10.4.1 CHEMICAL DELIVERY FACILITIES

The installation of the silo tank chemical replenishment system should ensure that no handling of the chemical is required by plant operational personnel or delivery staff. Sufficient space shall be provided outside the silo storage room to allow access for the delivery vehicle and ensure that tanker hose extensions are not required. At a minimum the following permanent infrastructure shall be put in place for all silo storage facilities proposed.

- The filling point shall be clearly labelled and identify which silo tank it supplies, as well as the type of chemical to be stored.
- A separate fill line shall be supplied for each silo tank in the facility. The filling line should be clearly labelled with the chemical type, and flow directional arrows.

- Chemical feed rates shall be dependent on the size of the fill line, and velocities in each fill line are not to exceed 1.6 m/s.
- The length of the filling line should be as short as possible, and shall have the minimum number of bends as is practicable.
- The filling line shall be constructed of non-corrosive material which is selected specifically for the associated chemical and shall be clamped against movement.
- The filling line shall enter the bulk storage tank from the top away from any ancillary equipment, instruments, etc.
- A dust collections system shall be mounted on top of the silo to collect and extract dust that arises during replenishment operations. An overhead gantry shall allow removal of the collections system and movement of other ancillary equipment within the silo storage room.
- A compressed air agitation system shall ensure that solidification of powdered chemical while in storage is prevented. The air compressor shall be mounted in a sound insulated kiosk within the silo storage room.
- A filling panel should be provided at the filling point. This panel should primarily provide information on the tank contents level. An appropriate alarm system shall alert operators should specified undesirable contents level conditions arise.
- The visual element of this alarm shall take the form of a 'traffic light' system mounted over each silo tank or alternatively on the filling panel (one traffic light system for each bulk tank). When the bulk tank is at 20% of its capacity, the red light shall be activated. This indicates that the tank contents level is low and needs replenishment. When the tank is above 20% of its capacity, an amber light shall be activated to show that the tank is filling. When the tank is at 90% of its capacity a flashing green light shall indicate that the tank is nearing its filled capacity. A solid green light shall indicate that the tank is 100% full and filling shall cease. Once the green light is activated, an audible alarm will also activate and remain on until muted at the filling 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.

10.4.2 ANCILLARY CHEMICAL TRANSFER / REPLENISHMENT EQUIPMENT

As the entire batching system associated with storage silos shall be fully automated in accordance with Section 7.8 of this specification, there shall be no requirement for specific ancillary transfer or replenishment equipment. A bund pump shall however be provided in order to pump any spillages which may be contained within the batching tank bund. The bund pumps may be portable and shall be selected so as to be compatible with the chemical to be pumped – therefore depending on the range of chemicals to be batched on site, more than one pump may be required.

11 INTEGRITY TESTING AND INSPECTION

Integrity testing of chemical storage tanks, piping systems and secondary containment systems (bunds) shall be completed by the Contractor prior to commissioning into service. In addition, regular inspections at appropriate time intervals shall be completed by the plant operator during the normal service of the system. While factory acceptance tests (FAT) and site acceptance tests (SAT) are critical to ensure a robust installation, they are not sufficient to predict the long term performance of the facility. This section therefore specifies the minimum test procedures to be completed by the contractor upon installation and during ongoing operation of chemical storage facilities. It shall outline the type of tests, the testing procedures and the frequency of testing necessary to ensure the integrity of the systems on a long term basis. In addition to the contents of this document, integrity testing should always be conducted in accordance with relevant guidance and standards as presented in the documents listed below. Note that all testing of chemical storage and conveying systems shall be completed by suitable trained personnel.

- EPA - *Guidance Note on Storage and Transfer of Materials for Scheduled Activities*
- CIRIA Document C598 – *Chemical Storage Tank Systems – Good Practice*
- CIRIA Report C736 – *Containment Systems for the Prevention of Pollution*

11.1 TESTING AND INSPECTION – GENERAL INFORMATION

It shall be the responsibility of the Contractor to adequately complete all tests as outlined in this document, or as instructed for completion by Irish Water or their representative, prior to commissioning of the chemical storage systems. Similarly, it shall be the responsibility of the plant operator (whom may also be the design build contractor) to complete all required tests during the operational stages of the works. It shall be the responsibility of the plant operator to ensure all components in the system are functionally sound and capable of carrying out their intended works. Testing of components should be carried out at the following times:

- Prior to commissioning of the component
- At regular time intervals, relative to each system component

- After significant modifications have been made to the system
- After decommissioning of the component

In addition, the following shall apply for all testing procedures:

- A risk assessment should always performed prior any integrity testing of a system.
- Testing should always be carried out at the maximum temperature and pressure (plus a factor of safety) likely to be experienced by the system.
- Internal inspection procedures should be empty-clean-inspect-test.
- Key areas of corrosion can include acid/air interfaces, oil/water interfaces, insulation attachment areas, bracket connection and fixing connections.
- Vents, valves and gauges should be regularly tested to ensure they are still functional.
- The integrity of associated electrical systems and earthing should be provided.
- Retesting should be carried out on any repairs or relining conducted.

11.2 TESTING AND INSPECTION FREQUENCY

Frequency of component testing shall be carried out based on the findings of the General Risk Assessment as described in Section 5 of this document, and shall take into account component age, materials of construction, compatibility of chemical in with storage / conveying material, storage duties, connections and history. The frequency of testing conducted on components should be based on the level of risk associated with each component – the higher the risk, the more frequent and extensive the testing. The contractor shall complete all tests required at the minimum time intervals outlined overleaf, as well as in accordance with the following documents:

- EEMUA Document 159 – *Users' Guide to the Maintenance and Inspection of Above Ground Vertical Cylindrical Steel Storage Tanks*
- EPA *Guidance Notes on Storage and Transfer of Materials for Scheduled Activities*

Where a conflict exists between the testing requirements outlined in the listed documents and this document, this specification shall take precedence. Where a tank manufacturer's recommendations are in conflict with the listed documents or this document, then the manufacturer's recommendations shall take precedence.

Bulk Liquid Storage Tanks: External visual inspections shall be completed once every three months.
Alarm generation tests (leak, gas, level, etc.) shall be completed every three months.
Hydraulic drop tests shall be completed once every six months.
Overfill protection test shall be completed every six months.
Internal visual inspection to be completed once every two years.
Weld tests shall be completed once every five years
Note: all the above tests to also be completed before tank is put into service.

Batching Tanks: External visual inspections shall be completed once every three months.

Alarm generation tests (leak, gas, level, etc.) shall be completed every three months.

Hydraulic drop tests shall be completed once every six months

Internal visual inspection to be completed once every year.

Weld tests shall be completed once every five years.

Note: all the above tests to also be completed before tank is put into service.

Solid Storage Silos: External visual inspections shall be completed once every three months.

Over fill protection test shall be completed every six months.

Internal visual inspection to be completed once every two years.

Weld tests shall be completed once every five years.

Note: all the above tests to also be completed before tank is put into service.

Containment Bunds: Visual inspections shall be completed once every three months.

Alarm generation tests (leak, gas, level, etc.) shall be completed every three months.

Hydraulic drop tests shall be completed once every year.

Note: all the above tests to also be completed before bund is put into service.

Pipework Systems: All above ground pipework shall be visually inspected once per month.

All above ground pipework shall be pressure tested every three years.

Underground piping systems shall be pressure tested once per year.

Secondary containment pipework shall be visually inspected once per month.

Secondary containment pipework shall be pressure tested once every three years.

Note: all the above tests to also be completed before pipework is put into service.

11.3 GENERAL DESCRIPTION OF TESTS

The tests as listed in Section 11.2 above are described in more detail in the following sections. The Contractor shall complete each test as required in accordance with this section of the specification. These tests should be carried out prior to commissioning and at regular time intervals as highlighted in the previous section. This section will provide the fundamental details for testing and testing procedures of chemical storage facilities.

11.3.1 HYDRAULIC TESTING

For the initial site acceptance test, each vessel shall be filled with water and the procedures below followed:

- Clean tank and close off all connections excluding the drain valve at the base.
- Establish the water disposal route and check that all valves and equipment will operate as expected during filling.
- Commence filling the tank in accordance with the design manuals and begin checking for leaks at appropriate locations such as the base and connection areas.

- When the tank has been filled in accordance with the design code, all valves should be closed so that the tank should contain all the contained liquid, and the level within the tank shall be noted by the level sensor and by manual measurement.
- The tank should be left for a minimum of 72 hours during which visual inspections for leaks should be carried out.
- The roof should be tested appropriately with water at the tank curb angle level. Roof connections are closed off prior to this test being conducted.
- As the tanks shall be enclosed there shall be no allowance made for rainfall or evaporation on outdoor tanks. Open topped tanks (batching tanks) shall only be permitted indoors where there shall also be no allowance made for evaporation or rainfall. *Note that this does not apply for outdoor bunds – a rain gauge / evaporation basin shall be used in this instance to complete the test.*
- Maximum allowable discrepancy between levels measured at the beginning of the test and levels measured after the test is 0.1%.
- After testing the tank should be drained via the drainage valve at the base. All roof connections must be reopened to prevent the formation of a vacuum. The tank shall be fully dried out using dehumidifiers before filling with the proposed chemical is permitted.
- A test completion certificate should be completed and submitted to Irish Water or their representative.

While water shall be used to complete the initial hydraulic drop tests of the storage tank, all 'in service' tests may be carried out by using the chemical being stored. The dual tank installations as specified elsewhere in this document shall permit dosing to continue from one tank while the other is being tested.

11.3.2 WELD TESTING

Weld testing should be carried out by specialist personnel. Non-destructive testing (NDT) techniques such as radiography or dye penetration should be provided. After baseplate welding of the tank has occurred, all weld seams should be vacuum box tested.

11.3.3 OVERFILL PROTECTION TESTING

This test focuses on testing the functionality of overfill safety equipment associated with storage tanks. This protection system shall incorporate an alarm generation system, as well as the 'traffic light' filling mechanism, both of which shall activated by the tank level sensor. Tests may be carried out at the same time as the initial hydraulic drop test, or for 'in-service' tests, during replenishment of the chemical. Overfill protection testing shall establish if;

- the level monitoring sensor is calibrated correctly
- every component in the system is working correctly. Alarms should be activated at the desired time.
- the time between alarm and overflow has been considered and tailored to accommodate possible filling rates.

11.3.4 TESTING OF PRESSURISED PIPEWORK SYSTEMS

This section relates primarily to pipework systems that operate under pressure such as pumped transfer systems, dosing lines and fill pipework. The following testing protocols shall be applied for pipes under pressure:

<u>Pressure Testing</u>

Testing shall be completed using a suitable fluid at 1.3 times the design pressure. The contractor shall follow the guidelines below in order to adequately complete the test.

- Conduct a general inspection of the pipework to ensure that the condition of the pipework is adequate to accommodate safe completion of the test.
- Survey all pipework components to ensure that it they are capable of withstanding the design pressure. Any components that cannot withstand the design pressure should be closed off prior to commencement of testing.
- The system should be flushed out to remove any debris and unwanted material from the system.
- Blind flanges should be used to seal of the section of pipework to be tested.
- Locate the test gauges at appropriate locations along the test section.
- For hydraulic tests, the system should first be filled with a suitable fluid. Air pockets can be reduced by leaving vents open until the liquid flows through them. The system should then be pressurised to the required test pressure. The pressure should be maintained in the system until leak inspection procedures have been conducted. The system should be completely drained and purged after test completion.
- For pneumatic testing, designers should consult Appendix G of EPA - *Guidance Note on Storage and Transfer of Materials for Scheduled Activities.*
- Testing should be documented by suitable personnel and any leaks/ defects repaired. Test should be repeated to ensure the integrity of the repairs.
- All test equipment such as gauges, blind flanges, blanks, etc. shall be removed after completion of testing.

<u>Non Destructive Testing (NDT)</u>

This type of testing may be carried out as an alternative to pressure testing if it is deemed unsuitable in certain circumstances. Testing shall be carried out at critical points on the piping system such as pipe elbows and connection locations. Due to the technical nature of NDT equipment, all NDT procedures should be performed by specially trained personnel and shall include:

- Ultrasonic and x-ray testing techniques.
- Dye penetration techniques to highlight surface defects
- Wall thickness measurement to determine system wear rate.

11.3.5 TESTING OF NON-PRESSURISED PIPEWORK SYSTEMS

This section relates primarily to non-pressurised pipework systems such as gravity transfer systems. The EPA have recommended the following relevant codes of practice for consideration in relation to the testing of non-pressurised systems:

- I.S. EN 752 parts 1-4 – *Drain and Sewer Systems Outside Buildings*
- BS 8301 - *Code of Practice for Building Drainage*
- I.S. EN 1610 - *Construction and Testing of Drains and Sewers*
- I.S. EN 1053 - *Plastic Piping Systems / Thermoplastic Piping Systems for Non-Pressure Applications. Test Methods for Water tightness*
- I.S. EN 13508 - *Establishment of the Condition of Drain and Sewer Systems Outside Buildings*

A number of tests are available for testing of non-pressurised systems. Operators should make informed decisions as to which testing procedure will provide the most reliable information and results. The following are permissible testing procedures for non-pressurised piping systems:

Visual Testing

Visual testing is a common test performed on non-pressurised systems and can identify defects and blockages in pipes which can then be repaired where necessary. The test shall involves conducting a CCTV survey as a means of visual inspection and any defects should be repaired, or the section of pipework replaced, as soon as is practicable. Trained personnel must complete and submit a report on the condition of the pipework based on their inspections. WRC *"Manual of Sewer Condition Classification"* sets out a method for compilation of this report and should be considered by the writer.

Leak Tightness Testing

Leak tightness testing is the most common test performed on non-pressurised systems. This test can identify leaks in pipes which can then be repaired where necessary. Leak tightness testing may be completed in two different ways for non-pressurised piping systems:

- Water Tightness Test
- Air Tightness Test

For a water tightness test, the section of pipeline shall be filled with water to a maximum pressure of 50kPa measured at the top of the pipe (a minimum pressure of 10kPa is recommended by the EPA). Testing should ideally begin approximately an hour after filling of the pipe section. The pressure in the pipe is maintained by topping up with water over a half hour time period.

For an Air tightness test, air is pumped into the pipeline so that a pressure of 1.1kPa is achieved. Airtight plugs or other appropriate mechanisms must be used at either end of the pipeline. The pressure is maintained for 5 minutes and then let to drop down to a 1kPa testing pressure. After another five minutes has passed the pipeline pressure is measured once again. If the pressure reading is less than 0.75kPa, then the pipeline has failed and remedial action must be adopted.

12 SAFETY AND HAZARD SIGNAGE

12.1 SAFETY SIGNAGE GENERAL INFORMATION

Health and Safety in the workplace is of paramount importance especially when dealing with hazardous chemicals. Through this specification, Irish Water aim to highlight best practice guidelines in terms of safety signage for chemical storage systems. Safety signage practice detailed in this specification will adhere to Chapter 1 of Part 7 (Regulations 158 to 162) and Schedule 9 of the Safety, Health and Welfare at Work Regulations 2007. Consideration is also made to CLP Regulations and information contained in Health and Safety (Safety Signs and Signals) Regulations 1996 produced by the HSE are also considered for good practice.

Safety signs should be clearly visible (illuminated where necessary) and should be maintained so that they are fit for the purpose intended. Provision should be made to ensure that the signs are of sufficient size to be understood correctly. Too many signs in close proximity is undesirable as it can result in confusion. Safety Signs should be displayed as close to the hazard as is practicable and should be provided where the risk to people cannot be avoided or reduced by other means. Containers, tanks and pipes which are used for dangerous substances must be supplied with the appropriate warning signs. Labels used on pipes should be positioned near possible risk points such as valves and joints and be repeated at suitable intervals. Signboards should be of the type, colour and shape specified in Schedule 9 of the Safety, Health and Welfare at Work Regulations 2007. Separate safety messages and supplementary text should be displayed on a separate signboard.

The following sections will give details of signs which are relevant specifically to chemical storage. Other signs such as Emergency escape, entry/ exit and firefighting signs should also be included in the design. These signs are not detailed in the following sections but are generally present in any place of work and should be located at appropriate locations within the plant. The chemicals which each sign should be considered for are also listed in adjacent tables in the following sections.

12.1.1 PROHIBITORY SIGNS

The following prohibitory signs shall be displayed at all access points to facilities which store the chemicals as listed in the following tables.

No Access for Unauthorised Persons			
Aluminium Sulphate	✓	Potassium Permanganate	✓
Ferric Sulphate	✓	Sodium Carbonate	✓
Ferric / Sodium Nitrate Mixture	✓	Sodium Hydrogen Phosphate	✓
Hydrofluorosilicic Acid	✓	Sodium Hydroxide	✓
Orthophosphoric Acid	✓	Sodium Hypochlorite	✓
Poly-aluminium Chloride	✓	Sulphuric Acid	✓
Polyelectrolyte	✓		

Table 28: ***No Access for Unauthorised Persons*** **signs to be displayed for chemicals indicated.**

Smoking and Naked Flames Forbidden			
Aluminium Sulphate	✓	Potassium Permanganate	✓
Ferric Sulphate	✓	Sodium Carbonate	✓
Ferric / Sodium Nitrate Mixture	✓	Sodium Hydrogen Phosphate	✓
Hydrofluorosilicic Acid	✓	Sodium Hydroxide	✓
Orthophosphoric Acid	✓	Sodium Hypochlorite	✓
Poly-aluminium Chloride	✓	Sulphuric Acid	✓
Polyelectrolyte	✓		

Table 29: ***Smoking and Naked Flames Forbidden*** **signs to be displayed for chemicals indicated.**

Do Not Extinguish With Water			
Aluminium Sulphate	✓	Potassium Permanganate	✓
Ferric Sulphate	✓	Sodium Carbonate	-
Ferric / Sodium Nitrate Mixture	✓	Sodium Hydrogen Phosphate	✓
Hydrofluorosilicic Acid	✓	Sodium Hydroxide	✓
Orthophosphoric Acid	✓	Sodium Hypochlorite	✓
Poly-aluminium Chloride	✓	Sulphuric Acid	✓

Polyelectrolyte	-		

Table 29: ***Do Not Extinguish with Water*** **signs to be displayed for chemicals indicated.**

Do Not Touch			
Aluminium Sulphate	✓	Potassium Permanganate	✓
Ferric Sulphate	✓	Sodium Carbonate	-
Ferric / Sodium Nitrate Mixture	✓	Sodium Hydrogen Phosphate	✓
Hydrofluorosilicic Acid	✓	Sodium Hydroxide	✓
Orthophosphoric Acid	✓	Sodium Hypochlorite	✓
Poly-aluminium Chloride	✓	Sulphuric Acid	✓
Polyelectrolyte	-		

Table 30: ***Do Not Touch*** **signs to be displayed for chemicals indicated.**

12.1.2 MANDATORY WARNING SIGNS

The following Mandatory Warning Signs shall be displayed at storage facilities for each of the chemicals as listed in the following tables. While the permanent design of each chemical storage system shall be configured to minimise hazards to operational personnel during routine activities, the safety equipment indicated must be worn when carrying out refilling, batching or maintenance activities on any chemical storage or dosing system where there is an elevated risk of the operator coming into direct contact with the chemical in question.

Eye Protection Must Be Worm			
Aluminium Sulphate	✓	Potassium Permanganate	✓
Ferric Sulphate	✓	Sodium Carbonate	✓
Ferric / Sodium Nitrate Mixture	✓	Sodium Hydrogen Phosphate	✓
Hydrofluorosilicic Acid	✓	Sodium Hydroxide	✓
Orthophosphoric Acid	✓	Sodium Hypochlorite	✓
Poly-aluminium Chloride	✓	Sulphuric Acid	✓
Polyelectrolyte	✓		

Table 31: ***Eye Protection Must be Worn*** **signs to be displayed for chemicals indicated.**

Respiratory Equipment Must be Worn			
Aluminium Sulphate		Potassium Permanganate	
Ferric Sulphate		Sodium Carbonate	
Ferric / Sodium Nitrate Mixture		Sodium Hydrogen Phosphate	
Hydrofluorosilicic Acid	✓	Sodium Hydroxide	✓
Orthophosphoric Acid		Sodium Hypochlorite	✓
Poly-aluminium Chloride		Sulphuric Acid	✓
Polyelectrolyte			

Table 32: ***Respiratory Equipment Must be Worn*** **signs to be displayed for chemicals indicated.**

Safety Gloves Must be Worn			
Aluminium Sulphate	✓	Potassium Permanganate	✓
Ferric Sulphate	✓	Sodium Carbonate	✓
Ferric / Sodium Nitrate Mixture	✓	Sodium Hydrogen Phosphate	✓
Hydrofluorosilicic Acid	✓	Sodium Hydroxide	✓
Orthophosphoric Acid	✓	Sodium Hypochlorite	✓
Poly-aluminium Chloride	✓	Sulphuric Acid	✓
Polyelectrolyte	✓		

Table 33: ***Safety Gloves Must be Worn*** **signs to be displayed for chemicals indicated.**

Safety Boots Must be Worn			
Aluminium Sulphate	✓	Potassium Permanganate	✓
Ferric Sulphate	✓	Sodium Carbonate	✓
Ferric / Sodium Nitrate Mixture	✓	Sodium Hydrogen Phosphate	✓
Hydrofluorosilicic Acid	✓	Sodium Hydroxide	✓
Orthophosphoric Acid	✓	Sodium Hypochlorite	✓
Poly-aluminium Chloride	✓	Sulphuric Acid	✓
Polyelectrolyte	✓		

Table 34: ***Safety Boots Must be Worn*** **signs to be displayed for chemicals indicated.**

Face Protection Must be Worn			
Aluminium Sulphate	✓	Potassium Permanganate	
Ferric Sulphate		Sodium Carbonate	
Ferric / Sodium Nitrate Mixture	✓	Sodium Hydrogen Phosphate	✓

Hydrofluorosilicic Acid	✓	Sodium Hydroxide	✓
Orthophosphoric Acid	✓	Sodium Hypochlorite	✓
Poly-aluminium Chloride	✓	Sulphuric Acid	✓
Polyelectrolyte			

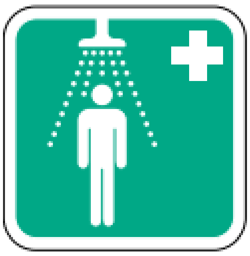
Table 35: *Face Protection Must be Worn* signs to be displayed for chemicals indicated.

Safety Overalls Must be Worn			
Aluminium Sulphate	✓	Potassium Permanganate	✓
Ferric Sulphate	✓	Sodium Carbonate	✓
Ferric / Sodium Nitrate Mixture	✓	Sodium Hydrogen Phosphate	✓
Hydrofluorosilicic Acid	✓	Sodium Hydroxide	✓
Orthophosphoric Acid	✓	Sodium Hypochlorite	✓
Poly-aluminium Chloride	✓	Sulphuric Acid	✓
Polyelectrolyte	✓		

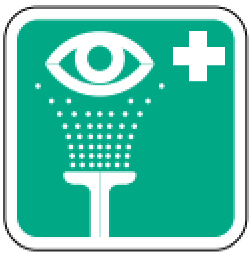
Table 36: *Safety Overalls Must be Worn* signs to be displayed for chemicals indicated.

12.1.3 FIRST AID SIGNS

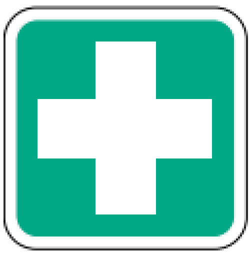
The following first aid signs shall be displayed at each emergency shower and eyewash installation and shall also be displayed to clearly indicate the location of the first air kit. This images shall be displayed at all emergency shower and first aid kit locations regardless of the type of chemicals in storage.



Safety shower



Eyewash



First-aid poster

12.2 LABELLING AND GHS HAZARD PICTOGRAMS

Labelling of containers and visible pipework/ accessories using hazard pictograms form part of the Globally Harmonized System of Classification and Labelling of Chemicals (GHS). Hazard pictograms are one of the features of labelling of containers along with a signal word, chemical identification and appropriate statements. Containers, tanks and vessels used in the workplace for hazardous chemical substances, and the visible pipes in the workplace containing or transporting hazardous materials, should be labelled with the relevant pictograms in accordance with the CLP Regulation.

Through this specification, Irish Water aim to highlight best practice guidelines in terms of labelling containers and pipework for chemical storage systems. Hazard pictograms detailed in this specification will adhere to the standards set by the GHS and CLP Regulations. The labelling of containers and pipework should be carried out so that the conveyed message is clear and fit for the purpose intended. The following section will give details of hazard pictograms which are relevant with respect to chemical storage. The chemicals which each pictogram should be considered for are also listed in adjacent tables below.

Gas Under Pressure			
Aluminium Sulphate	-	Potassium Permanganate	-

Ferric Sulphate	-	Sodium Carbonate	-
Ferric / Sodium Nitrate Mixture	-	Sodium Hydrogen Phosphate	-
Hydrofluorosilicic Acid	-	Sodium Hydroxide	-
Orthophosphoric Acid	-	Sodium Hypochlorite	-
Poly-aluminium Chloride	-	Sulphuric Acid	-
Polyelectrolyte	-		

Table 37: *Gas Under Pressure* signs to be displayed for chemicals indicated.

Explosive			
Aluminium Sulphate	-	Potassium Permanganate	-
Ferric Sulphate	-	Sodium Carbonate	-
Ferric / Sodium Nitrate Mixture	-	Sodium Hydrogen Phosphate	-
Hydrofluorosilicic Acid	-	Sodium Hydroxide	-
Orthophosphoric Acid	-	Sodium Hypochlorite	-
Poly-aluminium Chloride	-	Sulphuric Acid	-
Polyelectrolyte	-		

Table 38: *Explosive* signs to be displayed for chemicals indicated.

Oxidising			
Aluminium Sulphate	-	Potassium Permanganate	✓
Ferric Sulphate	-	Sodium Carbonate	-
Ferric / Sodium Nitrate Mixture	-	Sodium Hydrogen Phosphate	-
Hydrofluorosilicic Acid	-	Sodium Hydroxide	-
Orthophosphoric Acid	-	Sodium Hypochlorite	✓
Poly-aluminium Chloride	-	Sulphuric Acid	-
Polyelectrolyte	-		

Table 39: *Oxidising* signs to be displayed for chemicals indicated.

Flammable			
Aluminium Sulphate	-	Potassium Permanganate	-
Ferric Sulphate	-	Sodium Carbonate	-
Ferric / Sodium Nitrate Mixture	-	Sodium Hydrogen Phosphate	-
Hydrofluorosilicic Acid	-	Sodium Hydroxide	-
Orthophosphoric Acid	-	Sodium Hypochlorite	-
Poly-aluminium Chloride	-	Sulphuric Acid	-
Polyelectrolyte	-		

Table 40: *Flammable* signs to be displayed for chemicals indicated.

Corrosive			
Aluminium Sulphate	✓	Potassium Permanganate	✓
Ferric Sulphate	✓	Sodium Carbonate	-
Ferric / Sodium Nitrate Mixture	✓	Sodium Hydrogen Phosphate	-
Hydrofluorosilicic Acid	✓	Sodium Hydroxide	✓
Orthophosphoric Acid	✓	Sodium Hypochlorite	✓
Poly-aluminium Chloride	✓	Sulphuric Acid	✓
Polyelectrolyte	-		

Table 41: *Corrosive* signs to be displayed for chemicals indicated.

Health Hazard			
Aluminium Sulphate	✓	Potassium Permanganate	✓
Ferric Sulphate	✓	Sodium Carbonate	✓
Ferric / Sodium Nitrate Mixture	✓	Sodium Hydrogen Phosphate	✓
Hydrofluorosilicic Acid	✓	Sodium Hydroxide	✓
Orthophosphoric Acid	✓	Sodium Hypochlorite	✓
Poly-aluminium Chloride	✓	Sulphuric Acid	✓
Polyelectrolyte			

Table 42: *Health Hazard* signs to be displayed for chemicals indicated.

Acute Toxicity			
Aluminium Sulphate	-	Potassium Permanganate	-
Ferric Sulphate	-	Sodium Carbonate	-
Ferric / Sodium Nitrate Mixture	-	Sodium Hydrogen Phosphate	-
Hydrofluorosilicic Acid	-	Sodium Hydroxide	-
Orthophosphoric Acid	-	Sodium Hypochlorite	-
Poly-aluminium Chloride	-	Sulphuric Acid	-
Polyelectrolyte	-		

Table 43: *Acute Toxicity* signs to be displayed for chemicals indicated.

Hazardous to the Environment			
Aluminium Sulphate	✓	Potassium Permanganate	✓
Ferric Sulphate	✓	Sodium Carbonate	✓
Ferric / Sodium Nitrate Mixture	✓	Sodium Hydrogen Phosphate	✓
Hydrofluorosilicic Acid	✓	Sodium Hydroxide	✓
Orthophosphoric Acid	✓	Sodium Hypochlorite	✓
Poly-aluminium Chloride	✓	Sulphuric Acid	✓

Polyelectrolyte	-		

Table 44: ***Hazardous to the Environment*** **signs to be displayed for chemicals indicated.**

Serious and Prolonged Health Effects			
Aluminium Sulphate	-	Potassium Permanganate	✓
Ferric Sulphate	-	Sodium Carbonate	-
Ferric / Sodium Nitrate Mixture	-	Sodium Hydrogen Phosphate	-
Hydrofluorosilicic Acid	-	Sodium Hydroxide	-
Orthophosphoric Acid	-	Sodium Hypochlorite	-
Poly-aluminium Chloride	-	Sulphuric Acid	-
Polyelectrolyte	-		

Table 45: ***Serious and Prolonged Health Effects*** **signs to be displayed for chemicals indicated.**

12.3 SUPERCEDED EUROPEAN SYMBOLS

Since 2009 GHS international symbols have gradually been replacing European symbols. Irish Water recommend that the new GHS symbols should be adopted at all chemical storage facilities. It is nevertheless important that the designer recognise the old symbols so that they can be replaced if maintenance refurbishment or amendment of a chemical storage system takes place. Details of the old European symbols are contained in the figure below.

European symbols