Specification

seqwater WATER FOR LIFE

Engineering Standard B-SPE-STD-009 Liquid Chemical Storage and Dosing Systems

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Contents

1. Purpose

This document is part of a suite of Seqwater Engineering Standards which are in alignment with the Seqwater Quality Management System. Their purpose is to provide a consistent approach to the development, modification, and management of Seqwater infrastructure that is fit for purpose and safe so far as is reasonably practicable. Advice must be sought from Seqwater to clarify any ambiguities in relation to this document.

This Standard Specification provides the minimum requirements and recommendations for the design and construction of bulk liquid chemical unloading, storage and dosing systems used in drinking water treatment plants and drinking water quality management facilities.

This document must be used in conjunction with the documents it references to assist in ensuring a fit for purpose asset. This standard is not intended to be relied on solely for design, supply, and installation works; advice from specialist engineers and/or manufacturers may be required on a case-by-case basis.

This document provides specific information in relation to Seqwater's requirements and preferences for liquid chemical unloading, storage and dosing systems that have been obtained over years of experience.

This standard shall apply to chemicals that are delivered to Seqwater sites as liquids. Refer to Section 3 of this document for specific details of the chemicals this specification applies to, and their applications.

This standard specifically does not apply to chemicals that are delivered to Seqwater sites as compressed or refrigerated gaseous liquids, powders, solids, or slurries.

2. Scope

This Standard Specification applies to all Seqwater workers, as well as suppliers, contractors and consultants working for or on behalf of Seqwater unless otherwise stated. It applies to all new assets and to all existing assets undergoing refurbishment or modification. It must be used in conjunction with other relevant Seqwater Engineering Standards and project specific documents to define the technical requirements for infrastructure design and construction.

Where single or discrete components of an existing non-compliant chemical storage and dosing system (e.g. pipe, pump, tank or a skid) are to be replaced, refurbished or modified, this standard should not automatically be applied to the entire system or plant retrospectively (i.e. inclusive of all delivery, dosing, transfer and storage requirements). However, projects should consider the extent to which this standard should be applied in consultation with relevant stakeholders when refurbishing, modifying or upgrading a system.

Seqwater Engineering Standards detail Seqwater's minimum requirements and recommendations to provide infrastructure that will be fit for purpose, and safe to operate and maintain. However, compliance with these requirements and recommendations does not remove, and cannot be relied on as meeting, the designer's overarching responsibility for ensuring infrastructure designed is fit for purpose and safe to construct, operate, maintain, and demolish. The designer must exercise appropriate due diligence to identify and manage hazards so far as is reasonably practicable.

Designers must also ensure compliance with relevant Australian Legislation, Standards, Codes and Guidelines (including those produced by WSAA). Where no Australian Standard exists for a particular application, work must conform to the most current version of an industry accepted international standard.

Deviation from meeting the minimum requirements in this standard requires written agreement from Seqwater as per the deviation process detailed in Procedure X-PRO-STD-008 Asset Standards Management and Application. That process includes completion of an X-TMP-STD-022 Asset Standards Deviation Request Form and submission by the Seqwater Project Representative to the Seqwater Engineering Mailbox.

Where noted in this Standard Specification that Seqwater approval or acceptance shall/must be sought, approval or acceptance must be gained through the Seqwater Asset Standard Deviation process, as outlined above.

Responsibility for ensuring compliance with Seqwater Engineering Standards lies with those engaged in the management and execution of design, construction, and modification of Seqwater assets. This includes modifications to the functional design of the asset including technical changes made which would extend an asset outside of its design operating envelope and/or approved operation and maintenance practices.

In the case that it is identified that a specific requirement within this Engineering Standard does not meet the requirements of project specific documents, another Seqwater Engineering Standard or Australian Legislation, Standards, Codes or Guidelines, the conflict must be brought to the attention of the Seqwater Principal Engineering Standards and Assurance (or their delegate) via the Engineering Mailbox, and written agreement must be gained prior to application of the requirement.

Advice must be sought from the Seqwater Document Owner to clarify any ambiguities regarding this Engineering Standard.

Seqwater undertakes regular updates of its Engineering Standards. Before utilizing this Standard, the complete list of Seqwater Engineering Standards should be reviewed, to ensure currency and applicability of standards to be applied to the works.

3. Liquid Chemicals Used

This section provides a brief introduction to the bulk liquid chemicals most commonly used at Seqwater operating sites. The typical chemicals that this specification applies to are:

- Liquid Aluminium Sulfate (Alum)
- Aluminium Chlorohydrate (ACH)
- Polydiallyldimethylammonium Chloride (PolyDADMAC)
- Aqueous Ammonia
- Liquid Ammonium Sulfate (LAS)
- Sodium Hydroxide (Caustic Soda)
- Sodium Hypochlorite (Hypo)
- Sulfuric Acid
- Hydrochloric Acid
- Citric Acid
- Sodium Bisulfite

Additional liquid chemicals or concentrations as defined in the following sections may be considered or required for application. Approval shall be sought from Seqwater Principal Engineering Standards and Assurance for the validity and application of this standard in such circumstances.

For some key risks associated with these liquid chemicals, and for generic requirements and considerations including personal protective equipment requirements, refer to Seqwater PRO-00008 Hazardous Chemicals Procedure. Some details for each chemical can also be found in Appendix A.

An appropriate safety data sheet shall be used to provide guidance on toxicity and safe handling of all chemicals.

The following sections provide some key properties of each liquid chemical with chemical concentration and quality requirements, chemical incompatibilities and applicable governing Australian Standard for the storage and handling.

3.1. Liquid Aluminium Sulfate (Alum)

Liquid Aluminium sulfate (alum) is used at Seqwater Water Treatment Plants (WTPs) as its common primary coagulant. It is one of the most common liquid chemicals used in Seqwater.

When added to raw water, alum acts to neutralise the negative charge of suspended particles and organic matter in the water. Neutralisation of negative surface charges on particles prevents them from repelling one another, allowing them to agglomerate and form larger particles which may be more readily settled or floated out of suspension. During coagulation, rapid mixing is needed to disperse alum and initiate particle destabilisation.

Alum is commonly delivered in Seqwater sites as 47.2% (w/w) solution as $Al_2(SO_4).14H_2O$. Therefore, the liquid alum is specified as containing about 8.1% (w/w) of Al_2O_3, a common practice used in the industry to measure the alum strength other than actual aluminium (Al).

Alum is acidic and the alum solution delivered in Seqwater has a pH about 2.3 to 2.8 and is corrosive to many metals. When added into water, aluminium ion is hydrolysed to form insoluble aluminium hydroxide, the alkalinity is consumed and the pH of the dosed water drops. Alum is delivered to Seqwater sites by bulk trucks and the delivery temperature can be in the range of 20°C to 60°C.

Aluminium sulfate is not classified as dangerous goods in the Australian Dangerous Goods (ADG) Code. However, it is classified as a hazardous chemical in accordance with the criteria of Safe Work Australia - Globally Harmonised System (GHS). In addition, many countries and overseas chemical suppliers classify liquid aluminium sulfate under the category of corrosive Class 8. This standard considers liquid aluminium sulfate equivalent to ADG Class 8 chemicals following Seqwater current practice.

3.2. Aluminium Chlorohydrate (ACH)

Aluminium chlorohydrate ($Al_2(OH)_5Cl$) or ACH is another aluminium based coagulant used in small Seqwater treatment plants.

It has a high basicity due to its five OH^- molecules in its structure. The hydrolysis of ACH produces far less acid than the hydrolysis of aluminium sulfate due to the very high degree hydroxylation of the aluminium. As a result, ACH consumes less alkalinity, and the dosed water pH does not drop like it does with alum.

Liquid ACH is normally delivered to Seqwater sites in bulk containers of various sizes as ($Al_2(OH)_5Cl$). $3H_2O$ with 50% (w/w) solution which provide about 23% (w/w) of Al_2O_3. The delivered solution has a pH about 3 to 4 with 83% to 84% basicity.

3.3. Polydiallyldimethylammonium Chloride (PolyDADMAC)

PolyDADMAC is used as a secondary coagulant or coagulation aid in a small number of Seqwater treatment plants. It is commonly used in conjunction with Alum or ACH.

PolyDADMAC is a cationic polyelectrolyte with a high charge density which makes it suitable for coagulation and most effective for the removal of particulate materials and less effective for organics removal.

It is delivered at Seqwater sites as a liquid in 1000 L Intermediate Bulk Containers (IBCs) with the concentration in the range of 28% to 32% (w/w).

In addition of requirements specified in Section 3.13, European Standard for Chemicals Used for Treatment of Water Intended for Human Consumption – *Poly (diallyldimethylammonium chloride) - EN 1408* shall be applied on its use in drinking water treatment.

3.4. Aqueous Ammonia

Aqueous ammonia or ammonium hydroxide solution is used at Seqwater sites for secondary disinfection via the formation of monochloramine. Aqueous ammonia reacts more quickly than ammonium sulfate to form chloramines, due to immediate availability of free ammonia.

When dosed, ammonia dissolved in water will react with already dissolved free chlorine in the water from primary disinfection or added additional free chlorine to form monochloramine. Monochloramine is more stable than free chlorine and will persist longer in the water network than would free chlorine. However, monochloramine is a less potent disinfectant than free chlorine and requires far longer contact times to be effective. Monochloramine is therefore best suited to maintaining water in its disinfected state rather than providing the initial disinfection effect.

Aqueous ammonia is normally delivered to Seqwater sites at 25% (w/w) concentration [as NH_3]. At this concentration, it is very volatile and releases ammonia as a vapour. The solubility of ammonia is strongly affected by solution temperature, with decreasing solubility at higher temperatures. The boiling point of 25% (w/w) concentration is about 37.7°C. Aqueous ammonia is corrosive to many metals.

Ammonia vapour is very toxic by inhalation and can cause coughing, choking, lung damage, and in high concentrations, asphyxiation. Ammonia vapor is also flammable at concentrations of approximately 15%-28% by volume in air.

3.5. Liquid Ammonium Sulfate (LAS)

Liquid ammonium sulfate, $(NH_4)_2SO_4$ (LAS) is used as an alternative source of ammonia to react with free chlorine to form monochloramine for secondary disinfection.

LAS offers several advantages over aqueous ammonia; it is non-toxic, odorless, non-volatile, and chemically stable, making it significantly safer to store, handle, and transport — particularly in enclosed or urban environments. In contrast, aqueous ammonia poses notable health and safety risks due to potential toxic gas release and often requires additional capital investment for containment systems and hazardous area-rated electrical equipment.

LAS is typically supplied as a 40% (w/w) solution, equivalent to approximately 10.3% (w/w) ammonia [as NH_3], which is lower than the 25% (w/w) concentration of ammonia found in aqueous ammonia. As a result, larger dosing volumes are needed to deliver the same ammonia dose, impacting the design of storage, dosing, and pumping systems.

Chloramine formation with LAS is also slightly slower than with aqueous ammonia, as the ammonium ion (NH_4^+) must first shift to free ammonia (NH_3) via a pH-dependent equilibrium. In addition, LAS is slightly acidic and may require pH adjustment—typically with an alkali—when maintaining distribution system pH at 8 or above.

Despite these considerations, LAS's enhanced safety profile, chemical stability, simplified storage requirements, and lower regulatory burden make it an attractive and practical option for chloramination in drinking water treatment facilities.

3.6. Sodium Hydroxide (Caustic Soda)

Sodium hydroxide (NaOH), or caustic soda, is typically used at Seqwater treatment plants and supply systems for pH correction. It dissociates in water to produce a positively charged sodium ion, and a negatively charged hydroxide (OH^-), which results in an increase of pH. It may also be used in water softening and for corrosion control.

Sodium hydroxide at Seqwater sites is delivered at three different concentrations with 25%, 32% and 50% (w/w).

A 32% w/w solution of sodium hydroxide will freeze at approximately 5°C, while a 50% (w/w) solution will freeze at approximately 14°C. If a risk of freezing is considered likely, lower concentration of sodium hydroxide should first be considered.

3.7. Sodium Hypochlorite (Hypo)

Sodium hypochlorite (NaOCl) is one form of chlorine used as a primary disinfectant and the preferred chemical for disinfection at Seqwater sites.

The dissolution of sodium hypochlorite in water results in the formation of hypochlorous acid (HOCl), hypochlorite ions (OCl^-) and protons (H^+) depending on the pH of the water. It is the hypochlorous acid species that is considered the most effective disinfectant, although the hypochlorite ion also demonstrates some disinfection capacity.

Hypochlorous acid will predominate at lower pH (pH <7.5), thus it is preferable to maintain the water pH that favours hypochlorous acid formation. Therefore, as pH increases, the contact time necessary for effective disinfection will increase.

Sodium hypochlorite will react instantaneously with acids and release toxic chlorine gas. Sodium hypochlorite is highly corrosive and has potential to crystallise in the dosing line. It is known to degrade in storage and the degradation rate is dependent on initial sodium hypochlorite concentration, pH, temperature, age, exposure to UV light, and contact with metals and impurities that may exist in the bulk solution.

Because of the degradation, the chlorine content in the solution reduces and produces undesirable byproducts such as chlorate, chloride, and oxygen. There are some health concerns from the presence of byproduct chlorate in drinking water at an elevated level. The generation of oxygen bubbles or off-gas can create issues in the chemical dosing system due to potential vapor locking in pumps and pressure built up in the closed pipework section.

Sodium hypochlorite is normally delivered at Seqwater sites by bulk trucks at typical concentrations range 10%-11% (w/v).

3.8. Sulfuric Acid

Sulfuric acid (H_2SO_4) is used at Seqwater supply systems for pH correction. In addition, it is also likely to be used for pH correction prior to coagulation or chemical disinfection.

Sulfuric acid is a strong acid and releases protons (H^+) when dissolved in water resulting in a decrease in pH. Seqwater currently uses sulfuric acid at 70% (w/w) concentrations. However, experience shows corrosivity issues at this concentration, even when using exotic material choice such as Hastelloy variants. As per National Association of Corrosion Engineering (NACE), when Sulfuric acid concentration is below 70% the corrosion of carbon steel increases significantly, accompanied by a rapid evolution of hydrogen.

Increasing sulfuric acid concentration to 98% is expected to reduce the occurrence of chemical-induced failures. However, it should be considered that the sulfuric acid freezing point increases at higher concentration.

It is safe to dose to a water main for pH correction at a controlled rate. However, adding water to sulfuric acid or the uncontrolled addition of sulfuric acid to water may create an incredibly violent and a hazardous environment since the reaction between sulfuric acid and water is exothermic (heat-generating).

3.9. Hydrochloric Acid

Hydrochloric acid (HCl) is used at Seqwater sites only for descaling of piping and equipment for the calcium hydroxide (lime) system.

Hydrochloric acid is typically delivered at Seqwater sites with IBCs or in small drums (5-15 L) depending on the site's requirement with concentration of 32% (w/w). Where available, lower concentration should be considered to avoid dilution before using for cleaning. The specific requirements for hydrochloric acid batching or dilution system are covered in *B-SPE-STD-012 Lime Storage, Mixing and Dosing System* and therefore not included in this standard.

3.10. Citric Acid

Citric acid is used at Seqwater sites as Clean-In-Place (CIP) chemical for the membrane system. Like hydrochloric acid, it can also be used for descaling of piping and equipment for the lime system.

Citric acid is typically delivered at Seqwater sites in 200 L drums with concentration of 50% (w/w). Where available and needed, a lower concentration should be considered to avoid dilution before using for cleaning or descaling. The specific requirements for citric acid batching or dilution are covered in *B-SPE-STD-012 Lime Storage, Mixing and Dosing System* and are therefore not included in this standard.

3.11. Sodium Bisulfite

Sodium Bisulfite is used at Seqwater sites to neutralize free chlorine in solution before releasing water to the environment. It is also currently used in one of the treatment plants to neutralize sodium hypochlorite from the CIP waste stream before discharge to a sewer pump station.

Sodium Bisulfite is typically delivered at Seqwater sites in 200 L drums with concentration of 32% (w/w).

3.12. ADG Code and Governing Standard

Table 1 provides the classification of liquid chemicals included in this document following the Australian Dangerous Goods (ADG) Code for transport by Road and Rail. ADG code classification ultimately dictates the application of governing standard for the storage and handling of chemicals.

Table 1 ADG Code and Governing Standards

Chemical Name	ADG Code		Governing Australian Standard
	Class	Packaging Group	
Aluminium Sulfate	See Section 3.1		AS *3780* *The storage and handling of corrosive substances*
Aluminium Chlorohydrate (ACH)	See Note 1 below		
Polydiallyldimethylammonium Chloride (PolyDADMAC)			
Liquid Ammonium Sulfate (LAS)			
Aqueous Ammonia	Class 8	III	
Sodium Hydroxide		II	
Sodium Hypochlorite		III	
Sulfuric Acid		II	
Hydrochloric Acid		II	
Citric Acid		II	
Sodium Bisulfite		III	

Note 1: ACH, LAS and PolyDADMAC are not classified in ADG code. However, ACH and LAS are categorised as hazardous chemicals by Safe Work Australia. The volume of these chemicals used are relatively low in Seqwater. For consistency, the same requirement as applicable for Class 8 substances for the storage and handling of chemicals, is also applicable for them.

3.13. Chemical Quality and Concentration

Seqwater only uses bulk liquid chemicals it procures under contract to ensure that the quality of this product meets the required specifications. The overarching document PRO-02564 Drinking Water Treatment Chemicals - Specifications, Monitoring and Assessment Procedure provides Seqwater's chemical quality requirements for all liquid chemicals.

In addition of the Seqwater chemical quality specification, the Design shall consider that the quality of chemical meets the requirements of the Australian Drinking Water Guidelines (ADWG), the American Water Works Association Standards, and NSF International Standard / American National Standard/ National Standard of Canada for Drinking Water Treatment Chemicals – Health Effects (NSF/ANSI/CAN 60). Existing supply contracts should be used as a guide to chemical specification with the reference to REG-00250 Chemical Supplier Matrix.

Table 2 summarises preferred chemical concentrations to be applied in Seqwater plants as mentioned in earlier sections. The preferred chemical concentrations specified in are based on a combination of historical supply trends, availability of chemical from suppliers at the time of writing, and safety and chemical compatibility requirements.

The Design should consider reasonable and foreseeable deviations in the supplied chemical's concentration, quality or purity to ensure the facility can operate and respond in a safe manner or can be readily adapted to alternate supplies.

Table 2 Preferred liquid chemical concentrations delivered at Seqwater operating facilities.

Common Name	Chemical Name	Concentration	
		(%w/w)	(%w/v)
Alum	Aluminium Sulfate	8.1% as Al_2O_3	
ACH	Aluminium Chlorohydrate	23% as Al_2O_3	
PolyDADMAC	Polydiallyldimethylammonium Chloride	28% to 32%	
Aqueous Ammonia	Aqueous Ammonia	25% as NH_3	
LAS	Liquid Ammonium Sulfate	10.3% as NH_3	
[1]Caustic Soda	Sodium Hydroxide	25% 32% 50%	
Hypo	Sodium Hypochlorite		10-11%
Sulfuric Acid	Sulfuric Acid	70% [2]98%	
Hydrochloric Acid	Hydrochloric Acid	[3]32%	
Citric Acid	Citric Acid	[3]50%	
Sodium Bisulfite	Sodium Bisulfite	[4]32%	

Notes:

1. Lower caustic concentration should be considered at sites where there is a greater risk of freezing.

2. Sulfuric acid concentration to 98% should be considered for new sites as this concentration may reduce the occurrence of chemical induced corrosion if higher risk of freezing can be managed.
3. Not used for dosing. Applications for de-scaling of the lime system or membrane CIP solution. Where available, lower concentration should be considered to avoid dilution before applying as a cleaning solution.
4. Not used for dosing. Application for dechlorination.

3.14. Chemical Incompatibilites

The following types of chemicals shall not be allowed to come into contact with one another under any circumstance:

- Acids or alum with sodium hypochlorite - this may result in the formation of toxic chlorine gas.
- Sodium hypochlorite with aqueous ammonia/liquid ammonium sulfate – this may result rapid liberation of toxic ammonia gas and/or the formation of explosive concentrated trichloramine under favourable ratio.
- Acids or alum with sodium hydroxide.
- Liquid ammonium sulfate with sodium hydroxide.

4. General Requirements

This section provides several general requirements for the design and installation of the liquid chemical systems specified in this standard with reference to other applicable standards.

4.1. Safety in Design

In order to incorporate safety in design, Seqwater has a number of Engineering Standards that shall be used in the design and review of new assets and installations and modifications to existing systems:

i. *X-PRO-STD-009 Engineering Design, Construction, Operation and Maintenance*
ii. *X-PRO-STD-013 Engineering Technical Hazard Study*

These standards include discussion of the various risk assessments/reviews, studies, and management systems that must be in place/demonstrated and used in order to satisfy legislative and Seqwater requirements.

All designs and installations shall ensure due consideration of reliability, accessibility, maintainability, constructability, and operability are taken. This shall be demonstrated through auditable design documentation, reviews, communication, meetings, processes/procedures etc.

Design decisions and residual risks in design shall be supported, reviewed and accepted in accordance with FRA-00014 Enterprise Risk Management Framework.

For key risks associated with specific chemicals, refer to PRO-00008 Hazardous Chemicals, Safety Data Sheets (SDS) for specific chemicals and the rest of this specification. The details of chemicals provided in this specification are non-exhaustive and the designer shall consider industry and supplier expertise in the design, handling and management of chemicals and chemical systems.

4.1.1. Hazardous Areas

All hazardous areas at Seqwater sites must be identified and classified into specific zones in accordance with *AS/NZS 60079 (all parts) Explosive atmospheres*.

In relation to liquid chemical systems, aqueous ammonia installations in particular, including tanks and buildings, will require specific attention as ammonia vapour has the potential to form an explosive atmosphere. An example is included in *AS/NZS 60079.10.1* for the assessment of ammonia systems.

An appropriate hazardous area risk assessment shall be used to identify installations that may result in a hazardous area zoning, allowing appropriate mitigation strategies to be put in place.

Further information on hazardous area requirements and assessments may be found in PRO-00008 Hazardous Chemicals Procedure.

The design of the installation, the selection of equipment and the erection covered by *AS/NZS 60079* shall be carried out only by persons whose training has included instruction on the various types of protection and installation practices, relevant rules and regulations and on the general principles of area classification. The competency of the person shall be relevant to the type of work to be undertaken.

4.2. Engineering Units

Where not specified in this document, equipment and instrument units shall be in accordance with the requirements of *I-SPE-STD-013 Control Systems Design and Construction*.

4.3. Design Life

Table 3 provides the reference sources that define the required Seqwater asset design lives. Where a separate document does not provide this information, the required design life has been provided.

Table 3 Summary of references for asset design life.

Asset Class	Design Life
Chemical Dosing Skid Components: - Pumps - Valves - Pipework - Motors - Instrumentation - Electronics - Protective Coatings - Non-specified items	Refer M-SPE-STD-010 and relevant Asset Class Plans
Chemical Pipework	Refer M-SPE-STD-013
Concrete Structures (excl. pipes)	80 years
Electrical Installations / Assets	Refer E-SPE-STD-001
Field Devices (Instrumentation)	10 years
Flow Meters	Refer M-SPE-STD-001
General Mechanical Equipment	Refer M-SPE-STD-001
Metalwork and Structural Steel	Refer M-SPE-STD-001
Pipework (general & non-chemical)	Refer M-SPE-STD-001
Platforms, Walkways, Stairways Ladders	Refer M-SPE-STD-001
Protective Coatings	Refer M-SPE-STD-004 and WSA 201
Tanks: Steel, Plastic, FRP / GRP (with UV protection)	Refer M-SPE-STD-001 and Asset Class Plan (D15/111427)
Tank Liners	10 years
Valves	Refer M-SPE-STD-001

4.4. Site Conditions

Site Conditions is intended to mean any of the ambient conditions, process conditions, ground conditions and operating conditions that may be reasonably expected to occur during normal operation.

Ambient conditions for mechanical, electrical and control equipment shall be specified from the following documents:

i. *E-SPE-STD-001 Electrical Design and Construction*

ii. *I-SPE-STD-013 Control System Design and Construction*

iii. *M-SPE-STD-001 General Mechanical Specification*

iv. *M-SPE-STD-013 Chemical Dosing Piping*

Design and construction shall allow all assets to operate continuously and uninterrupted between the minimum and maximum Site Conditions specified.

If not defined by Seqwater, Ambient Conditions for design and construction of process equipment shall be determined by the Designer or Contractor and submitted to Seqwater for approval.

4.5. Materials

Materials selected in design for tanks, piping and equipment must be appropriate to the applications and appropriate for the selected chemical and vapor exposure for which they are intended.

Where stainless steel is used, passivation and pickling must be carried out correctly in accordance with *ASTM A380* to protect fabricated welded areas.

Where not specified, material requirements shall be sought from the following sources as a minimum:

a. Relevant Australian and industry standards and specifications for the material(s) selected.

b. Vendor and supplier recommendations and experience.

c. Safety Data Sheet (SDS).

d. M-SPE-STD-001 General Mechanical Specification.

e. M-SPE-STD-002 Platforms, Walkways, Stairways and Ladders.

f. M-SPE-STD-004 Protective Coatings.

g. M-SPE-STD-010 Chemical Dosing Skids.

h. M-SPE-STD-013 Chemical Dosing Piping.

i. D-SPE-STD-001 Water Supply Network Planning, Design and Construction.

Appendix B provides a guideline for the selection of materials for tanks which shall be used with the references included above.

Materials used in equipment, piping, coatings, joining and others which may come in contact with drinking water must have an appropriate certification to *AS/NZS 4020*. Refer to potable water compatibility section of *M-SPE-STD-001 General Mechanical* for further details.

4.6. Equipment Selection

In general, this Standard Specification does not specify the type and manufacturer of equipment (pumps, valves, instruments etc.) for a design. Where not specified, requirements shall be sought from the followings as a minimum:

i. *X-LST-STD-001 Seqwater Preferred Equipment*

ii. *M-SPE-STD-012 Chemical Dosing Pumps*

iii. *M-SPE-STD-009 Flow Meters*

iv. *M-SPE-STD-001 General Mechanical*

v. *I-LST-STD-001 Control System Prescribed Equipment*

Improved energy performance of new equipment shall be considered in the equipment selection process as specified in the following documents:

vi. *PLN-00452 Seqwater Corporate Energy Strategy*

vii. *E-GDE-STD-001 Energy Metering and Monitoring Guideline*

viii. *E-MAN-STD-001 Energy Efficiency Manual*

4.7. Colour and Coatings

Buildings, enclosures and shelters, pipes, tanks, fittings, fixtures, equipment, and surfaces shall be coloured / coated in accordance with:

i. *M-SPE-STD-001 General Mechanical*

ii. *M-SPE-STD-004 Protective Coatings*

iii. *WSA 201 Manual for Selection and Application of Protective Coatings*.

iv. *AS 2312.1 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings - Paint coatings*

v. *AS 2312.2 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings – Hot dip galvanizing*

vi. Other relevant legislation and Australian Standards, especially those referenced in the above documents.

4.8. Pipework, Valves, Fittings and Isolation

All pipework and fittings should comply with the requirements of the following standards, and the relevant industry and Australian standards referenced within:

a. M-SPE-STD-STD-001 General Mechanical

b. M-SPE-STD-003 Valves for Water Applications

c. M-SPE-STD-010 Liquid Chemical Dosing Skids

d. M-SPE-STD-013 Chemical Dosing Piping

Valves and actuators shall comply with the requirements of *M-SPE-STD-003*.

In chemical piping systems exceeding DN 50 mm, consideration should be given to the use of butterfly and diaphragm valves over ball valves. In general, diaphragm valves should be considered in preference to ball valves for chemicals which crystallise as crystallised chemicals may damage seals and seats in valves.

Mechanical isolation of piping and dosing systems shall be in accordance with M-SPE-STD-001.

Sections 4.8.2 to 4.8.4 provide requirements for specific chemicals.

4.8.1. Pipework sizing and line velocity

Suitable line velocities should be considered in all pipework to manage stagnation, settlement and degradation of chemical as well as maintain the integrity of assets. Line velocities requirement in Table-4 should be taken as a guideline unless deemed inappropriate by the designer for a particular application, specifically for small systems or low chemical dose rates or at lower plant production rates.

Table-4 Recommended Line Velocities

	Pipe Material	Maximum (No Fast Opening / Closing Valves)	Maximum (Fast Opening / Closing Valves)	Minimum Line Velocity
General	Plastic, GRP	2 m/s	1.5 m/s	0.5 m/s
	Metallic	2.5 m/s	2 m/s	0.5 m/s
Pump suction	All	1 – 1.5 m/s		0.5 m/s

4.8.2. Sodium Hypochlorite

Vented ball valves shall be used where ball valves are required in sodium hypochlorite systems. Sodium hypochlorite left in the cavity between a ball valve body and the ball may produce gas which can expand, increasing the pressure and damaging the valve.

4.8.3. Aqueous Ammonia

Vented ball valves shall be used where ball valves are required in aqueous ammonia systems. Due to the high vapour pressure of aqueous ammonia, when using ball valves, the liquid left in the cavity between a ball valve body and the ball may expand at higher temperatures increasing the pressure and damaging the valve.

4.8.4. Sodium Hydroxide

Sodium hydroxide has a tendency to crystallise. Crystallisation in ball valve bodies may lead to damage of valve seals. Consideration should be given to the use of diaphragm valves to limit this.

A 32% (w/w) solution of sodium hydroxide will freeze at approximately 5°C, while a 50% (w/w) solution will freeze at approximately 14°C. If a risk of freezing is considered likely, lower solution concentration (either 25% or 32% w/w) rather than 50% (w/w) should first be considered. Depending on the application and concentration, pipes may need to be insulated, and a heating system may be supplied. If a risk of freezing is still considered, ball valves should not be used.

4.9. Civil Works

Civil works shall comply with the requirements of WSA 03 *Water Supply Code of Australia, D-SPE-STD-001 Water Supply Network Planning, Design and Construction (Seqwater Supplementary Manual to WSAA Water Supply Code of Australia WSA03-2011 Version 3.2)*, and relevant Seqwater, Australian and industry Standards, Specifications and Codes.

All concrete shall be suitably finished and coated for the application and in accordance with *M-SPE-STD-004 Protective Coatings*.

4.10. Mechanical and Structural Works

Mechanical and metal structural design, construction and equipment selection shall be completed in accordance with the requirements of Seqwater's specifications, legislation, Australian and industry Codes, Specifications and requirements.

Refer to *M-SPE-STD-001 General Mechanical* for further guidance.

4.11. Electrical Works and Lighting

All electrical works, motors and variable speed drives (VSDs) shall comply with the requirements of *E-SPE-STD-001 Electrical Design and Construction*, the standards referenced within, and relevant Seqwater, Australian and industry Standards, Specifications and Codes.

Each dosing or transfer pump installed at Seqwater facilities shall be equipped with an individual locally-mounted power isolator switch – refer to *E-SPE-STD-001* for further details.

Lighting, of sufficient illuminance, must be provided for all markings, signs, instruments, valves, fittings, connections, roads, rooms and buildings related to chemical storage and dosing systems. Interior lighting luminance specification shall be as per *AS/NZS 1680.1 and AS/NZS 1680.2.4*.

4.12. Instrumentation Works

Instrumentation shall comply with the requirements of this standard specification, *E-SPE-STD-001 Electrical Design and* Construction, *I-SPE-STD-015 Instrumentation* and legislation, Seqwater, Australian and industry Codes, Specifications and requirements.

All instrumentation:

i. Shall be selected to prevent or minimise the potential of contact with any chemical as part of routine maintenance.
ii. Transmitters and control circuits shall comply with the voltage requirements of *E-SPE-STD-001 Electrical Design and Construction*.
iii. Safety devices or switches used for equipment protection, critical process safety, protection against environment release, or personal safety shall be hardwired and fail-safe in accordance with the requirements of *I-SPE-STD-013 Control Systems Design and Construction*.
iv. Flow meters shall comply with the requirements of *M-SPE-STD-009 Flow Meters and X-LST-STD-001 Seqwater Preferred Equipment* for the selection and installation. Flow switches may be used as a secondary means of flow identification.
v. Indicators shall comply with the requirements of the *Instrumentation Indicators* section of *E-SPE-STD-001*.
vi. Displays shall be digital and suitably weatherproof to the Site Conditions and shielded to prevent glare.

4.12.1. Level Sensors and Switches

i. Seqwater prefers the use of non-contact continuous level sensors in installations to limit exposure of personnel to chemicals during maintenance and commissioning activities. Non-contact radar type level sensors should always be given preference over ultrasonic sensors as chemical vapor or fume present in the tank head space may affect the accuracy of ultrasonic level measurement.

ii. If ultrasonic level sensors are selected for some applications, temperature compensation shall be installed in accordance with the manufacturer's recommendations, with consideration given to solar radiation.

iii. Where hydrostatic or differential pressure measurement sensors are used, the designer shall consider the influences of ambient and fluid conditions on instrument selection, calibration, temperature compensation, impulse line design and accuracy. Isolation and drain/vent valves as suitable for the chemical must be provided in the sensing lines for isolation, flushing, calibration and maintenance.

iv. Point level switches should be used in conjunction with continuous level transmitters as a secondary level control safety measure and shall be selected such that they minimise the risk of failure over time, or spurious trips. However, where another level sensor is selected instead of switches, it should be of a dissimilar technology to the primary level sensor.

v. Where available and suitable for the chemical and environment, high-high and low-low level switches should preferably be of non-contact or non-submersible type.

vi. Non-contact magnetic switches should be considered for high-high and low-low level switches where magnetic coupled level gauges connected to the side of tank has been selected for local level indication, provided that the switches are easily accessible for maintenance. Magnetic coupled level indicators and switches must be protected from external impacts either with shielding or practical placement.

vii. Non-contact capacitive level switches can also be considered for indoor polyethylene tanks following Seqwater's satisfactory experience. Its sensitivity in changing environmental conditions such as humidity, temperature etc. must be verified with the level switch vendor for any application to outdoor polyethylene tanks.

viii. Where contact level switches are selected, they should generally be of conductive or vibration fork types. Ball float switches shall not be used for chemical storage tanks to avoid failure and to prevent or minimise risk of contact with chemical during routine maintenance. Seqwater has experienced failures of ball float switches in chemical storage tanks on numerous occasions.

ix. Where level instruments are selected to be fitted to the top of the tanks, they should be fitted within arm's reach from the edge of the tank to provide maintainability without having to stand, climb or rest upon the top of the tank but rather from an access platform positioned at the side of a tank.

x. Where a level sensor is required to sit over media which is out of reach, a davit arm arrangement should be provided to swing the instrument back to a safe area where it can be maintained.

xi. Level instrument materials shall be compatible and resistant to corrosion from the chemicals and vapours with which they may be in contact.

xii. Refer to *I-SPE-STD-015 Instrumentation* for further details for the requirement of level instruments.

Level sensors shall have an accuracy of ±0.5% of span or better. Tank levels shall, as a minimum, be displayed in SCADA as both volume (L) and level (%).

See Section 6.1.7 for details of level set-points.

4.13. Telemetry and Control

This section provides Seqwater requirements on control systems for liquid chemical unloading, storage, and dosing facilities.

Control systems shall comply with the requirements of the key standards listed below:

I. *I-SPE-STD-005 High Priority Alarms & Interlocks Management*

II. *I-SPE-STD-009 Control Systems Architecture*

III. *I-SPE-STD-013 Control Systems Design and Construction*

Standards noted above are the key standards relevant to this section, but the standards noted within these key standards shall also apply and must be considered as part of the design.

Section 9 herein includes additional process control requirements for liquid chemical dosing systems.

4.14. Cyber Security

For all units associated with liquid chemical unloading, storage, transfer or dosing, whether supplied as a package unit or not, the vendor shall comply with Seqwater cyber security requirements as specified in the SPE-00502 Control Systems Cyber Security.

The vendor shall provide sufficient information as requested by Seqwater to allow the assessment of cyber security risks.

4.15. Safety Showers and Eyewashes

Safety shower and eye wash facilities shall be supplied with potable water and must comply with the requirements of *AS 4775 Emergency eyewash and shower equipment*. In addition, emergency eyewash, shower equipment, service water pipework and materials installed for use in supplying emergency showers and eyewashes shall:

i. Be installed out of direct sunlight, or

ii. Where not practicable to install out of direct sunlight, all associated pipework shall

   a. Be lagged with a suitable insulating material to prevent excessive water temperature of 38℃ and ensure the safety of personnel.

   b. Where in locations, due to high ambient temperatures, the lagging cannot ensure temperature below 38℃, a thermostatic relief valve shall be installed opening at 37℃ closing at 35℃. The valve shall be positioned in a way that any relief hot water stays away from the station piping, and from the concrete pad to minimise any potential algal growth and create a slip hazard. Such installations must ensure they do not trigger any flow alarm from the flow switch during hot water relief as described below.

Safety showers and eyewashes shall be fitted with a flow switch and the switch shall generate a flow alarm to SCADA. The flow alarm is to identify the activation of these devices when used by an individual who may be in an accident and need assistance from others monitoring the SCADA.

Safety showers, eye wash facilities and hose reels shall be provided at all levels within the chemical storage and dosing building, in each bund or each product transfer point or where product packages are opened. Hose reel may be of use for chemical wash down during spills, where appropriate.

The safety shower and eye-wash facilities shall be provided within 7 m, but not nearer than 2 m, to any product transfer point and where product packages are opened, in accordance with the requirements of *AS 3780*.

The safety shower shall be positioned in an accessible location that requires no greater than 10 seconds to reach. The shower shall be located on the same level as the hazard and bunds must be arranged to ensure a clear path free of trip hazards to use the equipment.

A green light shall be installed above the safety shower and eye-wash facilities at a suitable height to assist in locating them easily. Green light represents a medical/facility station. When the eyesight is compromised green is the last colour a person is able to differentiate, leading them to the life-saving safety shower and eyewash station. The light should be hardwired to the site electrical system with back-up by batteries.

Safety showers are to be appropriately illuminated and signed accordingly to *AS 1319 Safety Signs for the Occupational Environment.*

4.16. Signage, Tagging, Marking and Labelling

All equipment, instrumentation, and pipework shall be numbered and labelled, and include nameplates as required in accordance with:

i. *M-SPE-STD-001 General Mechanical*
ii. *E-SPE-STD-001 Electrical Design and Construction*
iii. *I-SPE-STD-010 Control System Tag Naming*
iv. *X-PRO-STD-006 Equipment Numbering and Naming Convention*
v. PRO-00008 Hazardous Chemicals Procedure.

Additional information and requirements regarding tanks and labelling are included in Section 6.1.3.

4.17. Design Philosophy

A high-level design philosophy for chemical unloading from trucks, storage and dosing systems as covered in this standard has been summarised in this section.

<u>Unloading and Storage System</u>

Each chemical storage tank shall have an individual fill line and Special Purpose Outlet (SPO) for the truck pump power supply to fill the tank. Unloading area shall be designed in a way that any spillage during unloading will be collected to a Chemical Spill Holding tank (CSHT) following the requirements of *AS 3780* and valving arrangement proposed in this standard. Incompatible chemicals must not share a common CSHT but can share the same unloading area with separate fill points and Local Control Panels (LCPs).

Key interlocks and alarms may include:

- Unloading area CSHT inlet and storm water valves interlock with tank SPOs.
- Bulk storage tank high level alarm and high-high level interlock with the tank SPO.
- SPO interlock or alarm from bulk storage bund sump or CSHT high-high level.
- SPO interlock from more than one tank fill line valve opened or storage bund valve opened (where applicable).

Storage tanks size, number, materials, and tank design standards shall be determined considering the criteria as stipulated in Section 6.1. Storage tanks must be installed in secondary containments in the form of bunds and each chemical must have a separate storage bund.

The bund capacity shall not be less than 110% of the capacity of the largest vessel located within the bund plus a freeboard above the design volume. Each bund must include a bund sump with suitable instruments, alarms and interlocks. Where a bund drain-valve is included to drain rainwater, the valve must have limit switches to alert operators if left open unintentionally. Where a bund area exceeds 25m^2, two points of access / egress must be provided into and out of the bund.

Dosing System

The design proposes to dose liquid chemical directly from a storage tank by incorporating several interlocks and alarms from electronic devices to overcome potential overdosing and underdosing scenarios. A dosing system shall normally include a dosing skid with positive displacement pumps and other necessary equipment and instruments as described in Section 7.2. External pressure relief valves shall be included near to the pump outlet for all positive displacement pumps to achieve protection against high pressure even for the pumps fitted with internal relief valves.

Chemical dosing control philosophy should be preferably based on the linear pump curve and chemical flowmeter feedback for trimming. Several other control mode options for the dosing are included in Section 9.1.

Dosing lines and transfer lines shall be double contained if not located in the bunded area and shall include a leak detection system. They shall include retractable dosing spears for dosing into pipes or spreader bars for equal distribution of chemical on surface waters under some scenarios. The lines should include actuated isolation valves near to the dosing point where syphoning need to be prevented when dosing lines are not used.

The design must ensure appropriate chemical mixing into water based on the application. Carrier water may be used at Seqwater facilities to improve transport characteristics of chemicals across distances, or to enhance mixing depending on the nature of chemical. However, all efforts should be made to avoid carrier water for sodium hypochlorite and sodium hydroxide as this may result in precipitation of calcium carbonate in piping and fittings. Where used, carrier should be added just before the dosing point with an appropriate dilution ratio.

Key interlocks and alarms for a dosing system should include:

- Tank low level alarms and low-low level interlock with the dosing pump.
- Water quality instrument interlocks and/or alarms from concentration and/or pH.
- Chemical flow discrepancy alarm from the flow meter.
- High pressure trip of the dosing pump (where needed).
- Alarms for higher daily chemical consumption than theoretical values from storage tanks draw down volume or from chemical flow meter totalizer values (where needed).

Dosing lines shall include suitable flushing/drain points at chemical dosing skids and near dosing points for flushing the lines, and collecting the flushed water rather than sending flushed water to the mains or basins.

An alternative design philosophy with ring main pumps and flow control valves should be used where dosing is required to several locations for one chemical as covered in Section 7.4 and not described in this section.

4.18. Asset Redundancy

This Standard Specification does not specify redundancy requirements for all essential equipment and dosing lines associated with chemical unloading, storage and dosing systems except the reference to duty/standby dosing pumps as commonly used in Seqwater sites.

The project shall determine redundancy requirements and the final number for equipment and dosing lines on a case-by-case basis considering the site's size, availability, criticality requirements, chemical supply chain risk, usage, site location and staffing, reliability, operability, maintainability, regulatory requirements, other Seqwater standard requirements and any other relevant issues.

5. Chemical Delivery and Unloading

Liquid chemicals may generally be delivered by bulk delivery road tankers or in intermediate bulk containers (IBCs). Chemical delivery by road tankers shall be the preferred mode of delivery.

Liquid chemical delivery by IBCs may be considered for some sites considering monthly chemical demand volume and suppliers' preference. Where this is the case, IBCs may be used as the storage vessel and should be transferred to a separate storage or day tank before dosing. Seqwater's preference is that empty IBCs are swapped out with a new IBC rather than transferring to an existing one.

The designer shall consider any downtime associated with IBC swapping or transfer activities and whether a duty/standby arrangement may be required to maintain operation. See Section 6.4 for further details about IBC storage and delivery system.

Irrespective of the delivery mechanism, operation of the plant and chemical systems shall not be adversely affected during chemical delivery and unloading.

The unloading system is considered to include the following:

- Unloading bay.
- Chemical spillage capture and drainage.
- Chemical filling point, transfer line and fill control.

Standard P&ID Drawings for chemical storage and dosing systems include unloading and delivery areas as referenced in Section 11.

5.1. Unloading Bay and Spillage Control

A chemical unloading bay shall be designed and constructed to provide safe arrival, parking, off-loading, vehicle turning and departure for chemical deliveries and road tankers.

The design shall consider specific chemical suppliers' requirements which may be obtained directly from chemical suppliers. Seqwater should be consulted with suppliers' requirements details.

Where possible, the reversing of chemical delivery road tankers should be avoided.

If reversing cannot be avoided, the arrangement of any unloading area shall allow the tanker driver to reverse into the unloading area and leave the site in a forward direction. The design should avoid the possibility of a tanker having to pass through a contained spill.

Entry to the unloading bays shall be clearly marked and signed, identifying entry / exit, and ensuring delivery vehicles are oriented such that truck hoses are the same side as the plant fill point.

Spillage control in unloading areas shall be provided for chemical deliveries and transfers which shall:

i. Divert all spillage to a sump measuring at least 600 x 600 x 600 mm with a drain. This drain shall divert to appropriate chemical spill holding tanks and a stormwater system via appropriate valving. See Section 5.2 for further information.

ii. Be graded to the sump sufficiently to prevent pooling or loss of containment. Graded surfaces shall be suitably finished with non-slip surfaces to provide protection to concrete structures and surfaces from chemical and mechanical damage.

iii. Include a protective galvanised steel sump grating sufficient to withstand the weight of any fully laden chemical delivery truck.

iv. Be located adjacent any Fill Points (See Section 5.3).

Drainage from an Unloading Area Sump shall be via gravity to a Chemical Spill Holding Tank (CSHT) (or similar structure) supplied normally for each chemical, see Section 5.2 for details. Valving providing diversion of spills from the sump to the appropriate CSHT shall be provided. Diversion via a separate valve shall also be provided to allow drainage of stormwater from the Unloading Area Sump. This arrangement is shown conceptually in Figure 1.

All diversion valves shall be positioned outside of the unloading area, in a valve pit allowing safe manual, above ground operation/actuation by an operator. Valves shall include local and SCADA position indication. The valve connected to CSHT shall be opened to divert any spillage to the appropriate CSHT during unloading procedures and closed at all other times. The valve connected to the storm water system shall be always opened except during the time of unloading. Automation of diversion valves should be considered if the chemical delivery frequency is relatively high and/or the valve pit shared by multiple chemicals. Operation of the valves should be preferably done locally adjacent to the valve pit. In this instance, a manual override function should be included for valves to be operated in the event of power failure.

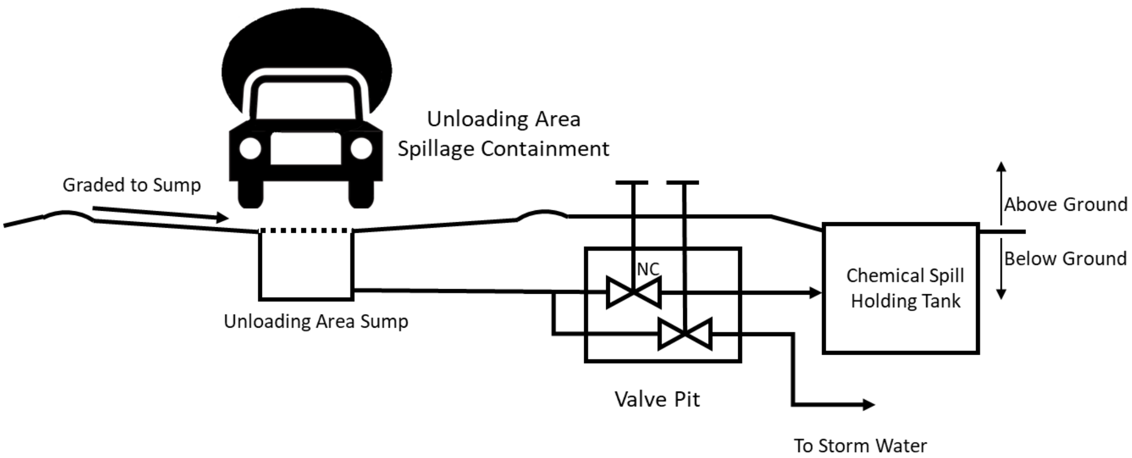

Figure 1 Section view showing unloading bay, sump, and drainage arrangement.

The Unloading Area and sump shall be capable of accommodating a spill volume such that it complies with the volume requirements in *AS 3780*. Additional allowances in accordance with *AS 3780* shall be made as necessary to provide for rain, clean-up or dilution water, or output from fire protection services. Allowances may include additional spillage volume, or protection from ingress of such sources (such as a shelter structure to protect from stormwater).

Consideration should be given to including unloading area shelters to prevent ingress of stormwater and provide protection to delivery personnel during unloading activities. Eliminating stormwater ingress will influence the capacity of spillage control infrastructure and associated assets in accordance with *AS 3780*.

A standard arrangement is shown with more details in the Standard P&ID Drawings, refer to Section 11 for a list of standard design drawings.

5.2. Chemical Spill Holding Tanks

The Chemical Spill Holding Tank is used to capture and hold spills from an unloading bund spill event, refer to Figure 1. This holding tank will allow the unloading area to drain to a safer location and prevent unloading truck and personnel standing in a spill.

The CSHT shall be sized to accommodate volumes as follows:

i. The capacity of the spillage control arrangement per the requirements of *AS 3780* including any rain requirements; plus;

ii. Additional volume to accommodate longer term containment of smaller but cumulative washdown and chemical neutralisation volumes arising from day-to-day operation and clean-up following typical chemical deliveries. This additional volume is intended to prevent the need to empty the CSHT after every small washdown event as part of routine maintenance and housekeeping.

Note: the volume of a significant spill (other than typical small splashes / spills which are cleaned up) would be emptied from a CSHT promptly.

Each Chemical Spill Holding Tank shall provide the following:

iii. The tank shall be double contained if not located within a bund.

iv. Gravity drainage from the spillage control sump.

v. Venting / breathing, and vent pipe should be directed to a safe location.

vi. Level sensor with local and SCADA reported level. A high-high tank level shall be interlocked with the chemical delivery and generates an alarm as a minimum.

vii. A means of emptying the CSHT by use of a vacuum truck:

   a. Above-ground drainage connection point with internal pipe extending to the tank base for drainage via a vacuum truck. This shall include a Mechanical coupling connection with lockable dust cover; or

   b. An alternate approved arrangement or methodology.

viii. A sample port / point to allow sampling of tank content. For buried tanks, a safe and ergonomically accessible sample port in the roof of the tank should be provided.

Where an unloading area's sump is used to service the unloading of multiple chemicals, a separate CSHT with a separate diversion valve shall be provided for each chemical to minimise the risk of incompatible chemicals coming into contact. However, based on the findings of a risk assessment, a CSHT may be shared for compatible chemicals.

Emptying of Chemical Spill Holding Tanks should be a manual operation by vacuum truck for offsite disposal. The inclusion of drain valves should be omitted to reduce the risk of environmental releases, subject to appropriate engineering reviews.

5.3. Transfer / Fill Points and Lines

The Fill or Transfer Point is the point at which a delivery hose from the tanker connects to the Bulk Storage Tank fill pipework.

Fill points shall be located adjacent the Unloading Area such that a tanker hose does not exceed 6m in accordance with *AS 3780* (although this length should be confirmed with chemical suppliers). They shall be positioned such that the tanker delivery personnel do not need to enter any spillage control containment.

Each bulk storage tank shall be filled individually, having its own fill line and fill connection point.

Fill points for different chemicals should be separated by a minimum of 5m.

Fill points shall:

i. Be clearly labelled, including a nameplate/identification plate above each filling point defining its name, grade and strength, and the tank into which it feeds.

ii. Include a mechanical coupling for connection to a tanker delivery hose which shall be:

   a. The fill point connection type shall be confirmed based on consultation with specific chemical suppliers and Seqwater.

   b. Fitted with a dust cap capable of being locked (via padlock) if necessary.

   c. Fixed to fill lines with a flanged connection to allow easy replacement if damaged.

iii. Positioned above ground level at a height per chemical suppliers' requirements. If not stipulated by the chemical supplier, or if unknown chemical supplier, between 800 – 1100mm above ground level at the point of connection to a tanker hose.

iv. Installed between 45° and 90° to the vertical (in a horizontal to downward orientation).

v. Where possible, be installed inside the lip of the chemical storage bund to capture any spills.

vi. Be designed such that only one tank (where multiple tanks of the same chemical exist) may be filled at a time.

vii. Include a drip tray under connection points to capture any residual chemical from connection, disconnection and filling of tanks. Drip trays shall:

   a. Drain via gravity to the respective CSHT or chemical storage bund (as discussed in Section 6.2), or storage bund sump, using whichever of these methods that is deemed most practical. If drain is connected to the CSHT, an isolation valve needs to be included in the drip tray drain line.

   b. Have their drains positioned to prevent chemical spilling onto valves, pumps, skids, instrumentation, pipe, pipe supports and cable trays.

   c. Be made of materials immune from corrosion or attack by the chemicals with which they may come into contact.

   d. Be sufficiently sized to capture spillage typical of connection/disconnection and drainage of fill lines.

   e. Not inhibit access requirements as stated in this document and in accordance with *AS 3780*.

The Designer should discuss alternative connection types with the chemical supplier and Seqwater. Final approval shall be sought from the Seqwater Principal Engineering Standards and Assurance.

Where multiple fill points for multiple tanks of the same chemical are installed in close proximity, they shall have a minimum separation distance of 400mm (outer edge of coupling, not centreline).

To prevent accidental filling of tanks with incorrect or incompatible chemicals, for each chemical type designers should consider incorporating one or more of the following:

viii. Use of an automatic chemical identification system (such as Orica's CoDé System®).

ix. Different size mechanical couplings for different chemicals.

x. Unique mechanical coupling type such as:

   a. Male vs female coupling connections; or

   b. Proprietary coupling technologies providing different connection shape for different chemicals.

xi. Fitting mechanical couplings with locks, with a different key for each chemical type.

xii. Fitting manual isolation valves (which include a position switch) with mechanical isolation (i.e. locks).

xiii. Colour coding mechanical couplings and connection points.

Safety showers and eyewashes complying with *AS 4755* shall be provided within 7 m from any Fill Points but not closer to 2 m in accordance with *AS 3780*. See Section 4.15 for further requirements about safety showers and eyewashes.

Each fill line from a fill point to the storage tank shall include a non-return valve, manual isolation valve with position switch and a drain line/valve before and after the non-return valve. These are described in further detail below.

Fill lines shall:

xiv. Be at least 50mm in diameter but sized to suit the expected tanker delivery rate based on delivery pressure and velocity.

xv. Be pressure rated as per guidelines in *M-SPE-STD-013 Chemical Dosing Piping*.

xvi. Made of suitable material, compatible with the chemical and sufficiently robust for the filling procedure.

xvii. Include a manual isolation valve with position switch:

   a. Ergonomically accessible to the tanker delivery personnel from outside the chemical storage bund.

   b. To isolate the LCP Special Purpose Outlet (SPO) when not in the open position to prevent inadvertent tanker pump operation and filling against a closed valve.

xviii. Include a non-return valve:

   a. Immediately downstream of the hose connection point to limit chemical spill upon disengagement.

b. Upstream of the Tee between the mainline and drain to ensure liquid downstream of the check valve can be drained.

xix. Include drain lines with valves before and after the non-return valve. This is to ensure the fill line and hose are completely drained prior to disconnecting the tanker hose. Drain lines shall be kept as short as possible and shall generally terminate in a drip tray, except in the case of aqueous ammonia. Drain line valves shall be:

a. At least 25mm NB.

b. Positioned to allow operators to drain the line without risk of contact with chemical spray.

xx. Rise vertically from the transfer connection point as quickly as possible and then slope toward the tank inlet.

xxi. Be installed to eliminate any pockets that could collect and hold chemical which cannot be drained from the fill point drain line.

Refer to Section 6.1.8 for additional information regarding the requirements for Fill Line connections to tanks and the tank internal requirements.

Clear signage identifying the chemical connection point must be provided for each fill point.

Power for the unloading pump shall be sourced from power outlets that are integrated with the unloading LCP arrangement. See Section 5.4 for additional information on LCPs.

A hose down facility shall be located adjacent to each fill point. This facility may be shared between multiple chemical fill points if the layout allows. A hose reel shall be provided for this purpose.

Additional information is provided in the following Section for the requirements of Aqueous Ammonia fill points due to the requirement of vapour return lines.

5.3.1. Aqueous Ammonia Fill Points and Lines

An additional 'vapour return' line shall be provided for aqueous ammonia bulk storage filling. This vapour return line shall:

i. Be provided as a distinct and separate line for each aqueous ammonia tank.

ii. Be made of the same material as the fill line.

iii. Not be fitted with a check valve.

iv. Include a manual isolation valve with position switch:

a. Ergonomically accessible to the tanker delivery personnel from outside the chemical bund.

b. The position switch to isolate the LCP and SPO when not in the open position to prevent inadvertent tanker pump operation or venting against a closed valve.

The aqueous ammonia vapour return line connection point shall:

v. Be installed adjacent to the aqueous ammonia fill line, and:

a. With a minimum separation of 400mm from any other fill point or vapour return line connection point.

b. Positioned above ground level at a height per chemical suppliers' requirements. If not stipulated by the chemical supplier, or if unknown chemical supplier, between 800 – 1100 mm above ground level at the point of connection to a tanker hose.

c. Installed between 45° and 90° to the vertical (in a horizontal to downward orientation)

vi. Include a mechanical coupling for connection to a tanker vapour return hose which shall be:

d. Of a different type or size to the fill line (e.g. male / female reversed) so as to prevent incorrection connection of lines – typically 80mm for return line but should be discussed with suppliers.

e. Clearly labelled and identified as "Ammonia Vapour Return"

f. Fitted with a lockable dust cap.

vii. Be designed such that only one tank (where multiple tanks of the same chemical exist) may be filled at a time.

viii. Include a nameplate/identification plate above each vapour return line connection point defining its name/function i.e. "Aqueous Ammonia Vapour Return" and tank number.

The drain lines from the fill lines and drip tray shall be directly connected to a chemical spill holding trap which is partially filled with water. If included, the spill holding trap should be located on the unloading area and fitted with a level gauge and a fill point. The designer shall provide a safe means of emptying or decanting this trap or may consider connecting to the CSHT.

The chemical supplier should be consulted for appropriate connection types and sizes for vapour return lines.

5.4. Local Control Panel

A Local Control Panel (LCP) shall be provided for each chemical fill location – multiple connection points for the same chemical (in the same bund) may share an LCP. Where multiple bulk storage tanks and fill points for a single chemical exist, a single LCP shall be provided for that chemical.

Safe fill level and normal fill level for each tank (described in more detail in Section 6.1.2) shall be clearly identifiable at / from the LCP (in Litres) for use by personnel during chemical deliveries, for each tank.

The LCP arrangement shall, as a minimum:

i. Be clearly labelled with the panel ID, chemical, all dials, buttons and displays clearly labelled as per Seqwater's labelling requirements.

ii. Include:

a. An On/Off switch to initiate the panel. The status shall be viewable remotely via SCADA.

b. A ready indicator – indicating all pre-requisites for fill are met.

c. A tank selection button for unloading (where applicable).

d. A running indicator (where possible).

e. An alarm test button.

f. A lamp test button.

iii. Include an integrated Special Purpose Outlet (SPO) per tank/fill line at each LCP to supply power to the unloading truck pump. SPOs shall:

a. Typically, be a three-phase and/or a single-phase power outlet with appropriate ampere rating, number of pins and pin types. This shall be at least IP56 rating with an interlock switch. The exact requirements shall be confirmed with the chemical delivery supplier and Seqwater based on power availability at site.

b. Be located away from the delivery hose connection point to prevent the risk of splashing by chemical and ensure personnel safety. Be resistant to the chemical and protected from UV degradation.

c. Be located within 7.5m of the delivery tank fill point (maximum allowable cable length to be used).

d. Include interlocks to cut off power to the SPO in the event of a tank high-high-level alarm (this will likely be a combination of level sensors and level switches in the bulk storage tank).

e. Be clearly labelled with the purpose.

f. Comply with the requirements of *E-SPE-STD-001 Electrical Design and Construction*.

iv. Include a local warning device providing visual and audio alert if the chemical delivery exceeds high level in the bulk storage tank, or bund high level is detected:

a. At least one amber beacon type warning light shall be attached to the top of the LCP. Additional beacons may be included in the chemical storage area based on the requirements of any risk assessments. Beacon light colour shall be as per *E-SPE-STD-001 and AS/NZS 4024*.

v. Include at least one Emergency Stop located in an accessible position near to the SPO (to cut power to the unloading truck's delivery pump). The emergency stop shall:

a. Be clearly labelled.

b. Trigger a local alarm (visual and audible) and telemetry alarm visible from the control room.

c. Be detailed with the functionality by the project specific design team. But, as a minimum, this shall isolate LCP SPOs and those of any other fill points in the bund.

d. Additional Emergency Stop buttons (or similar) should be considered in the area in accordance with relevant engineering risk assessments/reviews, HAZOPs and similar design processes, and chemical supplier requirements.

e. Emergency Stop category and design must comply with the requirements of *E-SPE-STD-001 Electrical Design and Construction* and related Australian Standards including *AS/NZS 4024 Safety of Machinery relevant series*.

vi. Be designed such that only one tank may be filled at a time.

vii. Be fitted with a test pushbutton to allow operators to check the audible and visual alarms.

viii. Include a digital readout of tank level providing a minimum of tank level (litres). Additional parameters may be provided and selectable as fill level (percentage), available working volume for fill (litres) (i.e. empty working volume). Displays shall:

a. Be fitted with a sunshade to provide protection and prevent glare.

b. Be sufficiently weatherproof to meet operational requirements and required design life.

c. Be visible and readable from at least 5m.

d. Where displays for multiple tanks are included on a single panel, be clearly labelled and identify which tank they apply to.

LCP operation shall include operator authorisation / enabling via SCADA with the selection of designated tank in addition to unloading start setting on the LCP. This SCADA enabling should be timed such that if an unloading activity is not initiated within that time period, the LCP operation is interlocked and requires re-initiation through SCADA.

It should be assumed that all chemical deliveries will be undertaken with supervision and attendance of a site operator as an additional layer of protection. Chemical unloading should be typically operated using the start/stop button on the truck panel.

Water Quality Management Facilities (WQMF) may require additional information be presented at the LCP to confirm valve position, status, chemical and spill tank levels. Designers shall ensure all necessary information is available to operators and delivery personnel during chemical deliveries.

6. Chemical Storage

This section describes the requirements for the design and construction of liquid chemical bulk storage systems including:

- Bulk Chemical Storage Tanks,
- Storage bunds,
- Access requirements,
- Chemical buildings, enclosures and shelters.

In addition, Section 6.4 includes some guidelines about IBC delivery and storage system.

6.1. Bulk Chemical Storage Tanks

Bulk storage tanks shall normally be used for the storage of liquid chemicals.

Bulk chemical storage tanks shall be above-ground, fixed, permanently positioned tanks that are filled and discharged in situ.

Secondary containment shall be provided for all chemical storage tanks. Refer to Section 6.2 for additional information. The requirement of tanks with integrated secondary containment or double-walled tanks have not been detailed in this document, refer to *AS 3780 The storage and handling of corrosive substances* for double-walled tank requirements.

Each bulk chemical storage tank that is filled via tanker or from any automated transfer system, excluding where filled by hand, shall include level control and protection as defined in Section 6.1.7.

All tanks shall be mounted on a purpose designed and built concrete plinth or tank stand so that the tank base is at least above the bund level of 110% of the capacity of the largest tank located within the same bund. This arrangement will facilitate to maintain a positive suction head on the inlet of the dosing pumps without excessive lowering of the pump skid and thus avoid inundation risk to the pump skid and electrical equipment from rainwater or chemical.

All tank equipment and instruments should be fitted such that they can be removed without draining the tank contents e.g., side-mounted pressure sensors should be fitted with an isolation valve.

6.1.1. Applicable Tank Standards

All bulk chemical storage tanks should be designed and constructed to the appropriate codes and standards, those of which are acceptable to Seqwater as listed below in Table 5.

Table 5 Approved standards for the design and construction of chemical storage tanks.

Operating Pressure	Material	Acceptable Standard(s)
Atmospheric[1]	Polyethylene (Rotationally Moulded)	AS/NZS 4766
Atmospheric	Polyethylene (Welded)	DVS 2205 series BS EN 12573 series
Atmospheric	GRP	AS 2634 BS EN 13121-3
<17.2 kPa(g)	Steel	AS 1692 API 620 API 650
17.2 – 35 kPa(g)	Steel	AS 1692 API 620
35 – 100 kPa(g)	Steel	API 620
>100 kPa(g)	Steel	AS 1210

In addition, *National Association of Corrosion Engineering (NACE) International Standards SP0294 and SP0391* should be considered for the design, fabrication, and selection of materials for sulfuric acid tanks and systems.

6.1.2. Tank Number, Size and System

Bulk chemical storage:

i. The tank number should be determined considering the site's availability and criticality requirements, the site's size, tank size, the stored chemical's properties and usage, site staffing, site location and access (e.g., in fair and poor weather), reliability, operability, chemical quality management, maintainability of tanks, tank instruments and tank other equipment.

ii. Storage tanks shall:

   a. Be capable of operating independently and as a combined storage volume.

   b. Include manual and automatic isolation valves on the tank outlets.

   c. Be provided with an ullage space in tank design to accommodate thermal expansion. Ullage shall be determined in accordance with the standards and specifications for the material, location, and contents of the tanks.

   d. Be vertically oriented unless instruction otherwise is given by Seqwater, or design requirements dictate a horizontal orientation.

   e. Be considered with customised sloped bottom where complete cleaning and drainage may be needed without the removal of top access. This may be applicable to manage off-

[1] Superimposed pressure above the maximum recommended fill level can be up to 2.5 kPa, but the standard applies to store chemicals at atmospheric pressure.

spec chemical like sodium hypochlorite as it may degrade over time, see Section 6.1.2.1 for more details. Fabricated High Density Polyethylene (HDPE) welded tanks may be considered with the sloped bottom for this application.

f. Be earthed in accordance with *E-SPE-STD-001 Electrical Design and Construction*, relevant codes and standards.

iii. Should provide a minimum demand or working volume which shall account for the influence of the raw water supply (i.e., run of river vs. dam storage) by sizing based on the greater of (except sodium hypochlorite which is covered in Section 6.1.2.1):

a. 14 days at maximum dose, average plant flow; or

b. 28 days at average dose, maximum plant flow.

Where there are significant variations in raw water quality, maximum dose rate shall be determined from 1-2 weeks of historical average dose data from multiple water quality events (where available) rather than using an instantaneous maximum dose rate.

Average and maximum plant production data, average dose rate data should be obtained from historical daily production data, historical average dose data and/or projected future planning data.

iv. A tank's design capacity shall consider the working volume/capacity from the requirements listed in point iii above, plus the requirements to achieve the level setpoints as defined in Section 6.1.7.

Specific considerations for sodium hypochlorite are discussed in the next section.

6.1.2.1. Sodium Hypochlorite Storage

Sodium hypochlorite tends to degrade over time forming chlorate ions (ClO_3^-) and others as mentioned in Section 3.7. When designing sodium hypochlorite storage, the designer should consider necessary steps to minimise ClO_3^- formation. The following may be considered as guidance when determining appropriate storage strategies:

i. The time it takes after manufacture to deliver sodium hypochlorite to bulk storage. Chlorate formation increases with time. Small and remote sites may receive bulk sodium hypochlorite several weeks after manufacture which will result in chlorate formation having already commenced. Larger sites may receive bulk sodium hypochlorite much sooner after manufacture.

ii. The storage temperature – the rate of chlorate formation increases with temperature.

iii. Storage concentration – while sodium hypochlorite solution will typically be delivered at 10-11% free available chlorine, dilution can significantly reduce the degradation rate. Dilution water should be demineralised or deionised to prevent catalysed degradation of sodium hypochlorite. Consideration should also be given to pH when diluting sodium hypochlorite, with optimum stability seen above pH 12 (approximately).

iv. At sites expected to operate with large turndown ratios, including an additional tank(s) which may be filled with bulk solution as required to buffer peak operating periods rather than relying on fewer larger bulk storage solutions may be considered.

v. Reducing the total stored volume to reduce ClO^{3-} formation may be considered. For sodium hypochlorite, storage tanks should be sized based on the demand volume of

- 14 days at maximum dose, average plant flow; or
- 14 days at average dose, maximum plant flow.

vi. Include a sample point on tanks or suction pipework for sampling and testing bulk chemical.

vii. Where more than one sodium hypochlorite tank is implemented, the arrangement shall allow one tank to be drawn from at a time to allow management of chlorate formation. Mixing of old hypochlorite solution with new is not recommended for chlorate management.

viii. Mixing or circulation of tank contents to prevent stagnant chemical and degraded stagnant or sediment layers at the bottom of the tank. If this option has been identified by the design as an optimum solution to maintain the chemical quality, a circulation pump may be considered preferably with the common suction line of the dosing system. This may help to:

   a. Reduce and manage off-gassing particularly during dosing start-up.

   b. Maintain a homogeneous chemical in the storage tank.

   Where considered, the pump should be supplied on a skid and incorporate the following:

   c. Fixed speed centrifugal pump.

   d. Flow switch and pressure gauge on the pump discharge.

   e. Flushing and draining capability.

   f. The pump and control system should be designed to run the pump intermittently at an interval and duration set by the operator.

   g. The design needs to ensure suitable location of the tank circulation return line to achieve the desired mixing without generation any fume hazards in the storage area.

ix. Shelters and UV protection as discussed in Section 6.3.

6.1.3. Tank Labelling

All tanks shall be labelled and placarded in accordance with PRO-00008 *WHS Hazardous Chemicals*, *Work Health and Safety Regulation 2011, Globally Harmonised System of Classification and Labelling of Chemicals (GHS), AS/NZS 60079 (all parts) Explosive Atmosphere*, *Australian Code for the Transport of Dangerous Goods by Road & Rail*, relevant tank standard and relevant legislative requirements.

Where multiple tanks of a single chemical are installed, each tank shall be labelled with the tank number for each specific chemical (i.e. Tank 1, Tank 2 etc.) such that it is clearly visible and readable from the tanker fill point.

Each tank shall include a name plate which will remain clearly legible for the design life of the tank and should be visible and legible from both within and outside of the secondary containment area where practicable. Each nameplate shall include the following information:

- Manufacturer
- Manufacturer’s details (name, address, contact number)
- Design Code or Standard
- Date of manufacture
- Serial Number
- Tank Number / Tag Number
- Materials of construction
- Product / content (including chemical name, formula, and strength in % w/w or %w/v).
- Design Volume / Capacity

- Design Life
- Nominal Height
- Diameter
- Design Liquid Level
- Overflow Level
- Design Temperature
- Design Pressure
- Maximum Specific Gravity (of liquid to be contained)
- Maximum mass in kilograms of stored chemical (when filled to overflow level)
- Test pressure (if applicable)
- Test temperature (if applicable)

The nameplate shall be printed, adhered to the tank following Seqwater *X-PRO-STD-006.Equipment Numbering and Naming Convention* and intended to remain in place and legible for the design life of the tank.

6.1.4. Design Pressure and Temperature

Liquid Bulk Chemical storage tanks shall be designed and constructed to operate for Site Conditions, Atmospheric Conditions and Process Conditions as defined in Section 4.4 of this document. PRO-02564 Drinking Water Treatment Chemicals – Specifications, Monitoring and Assessment Procedure shall be referred for the maximum and minimum chemical supply temperature.

The pressure or vacuum resulting from filling, emptying, thermal inbreathing and outbreathing, or atmospheric change shall not exceed the maximum design stresses of the tank.

Bulk storage chemical tanks shall be designed and constructed to operate at atmospheric pressure, with the exception of aqueous ammonia which is discussed below in Section 6.1.4.3.

The following Sections 6.1.4.1 to 6.1.4.4 discuss the requirements and considerations for aluminum sulfate, sodium hypochlorite, aqueous ammonia, and sodium hydroxide.

6.1.4.1. Aluminum Sulfate (Alum)

Alum can be delivered at Seqwater sites with temperature up to 60°C as per PRO-02564 Drinking Water Treatment Chemicals – Specifications, Monitoring and Assessment Procedure. The design shall ensure that selected materials and the tank design are suitable for the delivered temperature up to 60°C for the design life.

6.1.4.2. Sodium Hypochlorite

Sodium hypochlorite may be degraded through heat (See Section 6.1.2.1) and may off-gas in pipework and equipment. Regardless of installation location, sodium hypochlorite installations shall take into consideration the influence of temperature and direct solar irradiation.

The requirements for storage locations are discussed in Section 6.3.

6.1.4.3. Aqueous Ammonia

Aqueous ammonia (25% w/w as NH_3) tanks shall be designed to operate at a slight positive pressure due to its high vapor pressure using suitable pressure/vacuum valves, refer to Section 6.1.11.1 for more details.

Aqueous ammonia tanks shall be designed with consideration of the requirements for vapour return lines, venting and overflow control during filling.

Aqueous ammonia has a high vapour pressure which may require suitable management of pipework and equipment as the vapour is noxious. Regardless of installation location, aqueous ammonia installations shall take into consideration the influence of temperature and direct solar irradiation – especially onto pipes where stagnant fluid may lead to expansion and any piping leakage or mechanical failure.

Bulk stored aqueous ammonia shall be kept below boiling point under all Site Conditions.

The requirements for storage locations are discussed in Section 6.3.

6.1.4.4. Sodium Hydroxide

Tank arrangements for the storage of sodium hydroxide should consider the risk of freezing. While an unlikely risk in many of the regions where Seqwater operates, if Site Conditions suggest freezing may be possible, the design should consider any of the followings:

- Direct or indirect heaters with thermostat temperature control. If there is any risk of dangerous reaction between sodium hydroxide and the heating medium under any circumstances, direct heating shall not be used. Indirect heating shall always be given preference due to their distinct advantage of non-contact with the chemical and can be serviced without tank draining. Heater materials must be compatible with the chemical and environment.
- Lagging of the tank may be considered where night-time temperature is the primary cause of concern. Any additional risk of corrosion due to lagging must be managed.
- Lower concentration (i.e. 25% or 32%) should be considered instead of 50% concentration to manage freezing unless unmanageable larger volume storage tanks and frequent chemical delivery are needed for the application.

6.1.4.5. Sulfuric Acid

The risk of freezing should also be considered for tank arrangements for the storage of sulfuric acid with higher concentration (i.e. 98%) with the similar requirements covered in Section 6.1.4.4 for sodium hydroxide.

6.1.5. Tank Materials

Materials for tank construction shall ensure tanks and their fittings and attachments are suitable for use under Site Conditions. Where materials require additional protection as a result of Site Conditions, adequate protection, appropriate shelter, paint or coating, lining or other fit for purpose means shall be provided to ensure the required design life.

Materials for tank construction shall ensure tanks and their fittings and attachments that are likely to come into contact with chemicals are:

i. Substantially immune from attack by the chemicals under all service conditions; or

ii. Lined in a manner such as enables substantial immunity from attack by the chemicals under all service conditions.

A general guidance on typical tank materials for various liquid chemicals can be found in Appendix B – Materials Selection for Liquid Chemical Storage Tanks and shall only be used with the guidance provided in other Seqwater documents (where available) and relevant Australian and Industry standards and specifications.

Refer to *AS 3780* and relevant tank specific standards, chemical Safety Data Sheet (SDS) and Section 6.1.1 for further guidance to the selection of storage tank materials.

Where rotationally moulded polyethylene tanks are selected for liquid chemical storage, following the recommendations of *AS 3780*, they should be inspected frequently for cracking, leakage at connections and for becoming out of round due to load cycle and temperature variations. The inspection regime shall be based on the manufacturer's recommendations and a risk assessment including the following factors:

- Capacity of the tank,
- Melt flow compatibility of fittings and tank shell and weld,
- Properties of the chemical,
- Maximum chemical temperature and temperature cycling,
- Environmental impact (ambient conditions, UV exposure, vibration etc.).

6.1.5.1. Tank Liners

Plastic and GRP tanks shall not be lined or coated. However, GRP tanks shall generally include a corrosion resistant barrier comprised of an inner surface layer and interior layer as well as a structural layer.

In addition to coating, metal tanks may be lined where required to accommodate the contained chemical to prevent corrosion and damage to the metal tank. The design life of tank liners should be as per Section 4.3 of this specification. However, standard inspection intervals for liners should be allowed. Costs associated with the inspection and replacement of liners should be considered in the selection of lined metal tanks.

Provision for supply of alternative liners and suppliers during replacement shall be considered during the design stage.

Tank liners shall:

i. Be installed to enable removal and replacement without removal of the tank roof.
ii. Have sufficient strength and durability to accommodate two complete fill and drain cycles of the tank per day.
iii. Be fixed to the tank wall and supported around the full tank perimeter.
iv. Include a suitable geotextile fabric installed between the liner and the floor.

6.1.6. Tank Nozzles

All tank nozzles shall be flanged and adequately reinforced with minimum size of DN50.

Bulk Storage tanks should have nozzles for fill line, outlet line, overflow line, vent line, drain line, mechanical level gauges, level transmitters and level switches (as applicable).

Tanks may also require additional nozzles to accommodate:

- Return lines for commissioning purposes,
- Vapour return lines from the dosing skid,
- Pump discharge pressure relief valve return lines.

The designer shall account for such additional nozzles and ensure they are incorporated in tank fabrication. Section 7.2.10 has included some requirements of chemical return lines.

Standard P&ID Drawings for chemical storage and dosing systems as referenced in Section 11 include storage tanks with approximate locations of tank nozzles.

6.1.7. Level Device and Control

Each bulk chemical storage tank that is filled via tanker or from any automated transfer system, excluding where filled by hand, shall include level control and protection as defined here.

Tank level measurement and protection shall be achieved using:

i. A mechanical level indicating device, preferably magnetic coupled level gauge, with appropriate display to provide local level indication should be considered. Each magnetic coupled gauge must be connected to side tank connections with isolation valves. The float and float chamber materials must be compatible with the chemical. A float positive buoyancy must be ensured under all operating conditions for lowest possible chemical specific gravity.

   Where a magnetic coupled level display is chosen, magnetic high-high and low-low level switches should be considered for the functionality as covered below in point iii.

   The Safe Fill Level (SFL) of a tank shall be clearly marked on the level-indicating device and visible to the tank fill operator. It is also recommended to mark Normal Fill Level (NFL) on the device.

ii. A primary electronic level sensor to measure the tank level/quantity. The electronic level transmitter shall incorporate:

   a. Alarms – Level Alarm High (LAH) and Level Alarm High-High (LAHH). At LAHH, isolation of any Fill Point SPO shall occur during filling.

   b. Alarms – Level Alarm Low (LAL) and Level Alarm Low-Low (LALL). At LALL, closure of the tank outlet valve and trip of the chemical dosing pump shall occur.

   c. If the chemical draw-down rate within a 24-hour period exceeds the theoretical volume requirement considering average dose rate and maximum plant production or the rate of change for a tank level reduction exceeds any defined set value this may be indicative of leakage from the tank or line and an alarm should be included for this. Under this scenario, closure of the tank outlet valve and trip to the chemical dosing pump may be considered.

iii. Two separate and independent level devices (senor or switch) to identify and action level events at High-High and Low-Low levels as required by the design. These devices shall, as a minimum, trigger at LAHH (or LSHH) and LALL (or LSLL).

   a. At LAHH (or LSHH) measured on the High-High level device, isolation of any Fill Point SPO shall occur during filling procedures.

   b. At LALL (or LSLL) measured on the Low-Low level device, closure of the tank outlet valve and stoppage of the chemical dosing pump shall occur during dosing.

   c. Regardless of point (b) above, the designer may consider tripping the dosing pump only when both the level sensor and the level switch indicate a low-low alarm simultaneously. This approach helps prevent unnecessary trips caused by false alarms or faulty level switches. Additionally, the designer may implement a time delay in the dosing pump interlock, provided the pump can safely run dry for a limited time without immediate mechanical damage. However, the design must ensure that the time delay does not allow air or vapor to enter the dosing line.

iv. Electronic level sensors and switches must be suitable for Site Conditions and compatible with the chemical in service.

Tank level shall be readily viewable as an electronic digital readout for primary devices and, where applicable, backup devices. Tank level shall be viewable:

v. Local to the tank and viewable at ground level.

vi. Local to the tank LCP, and viewable near the LCP during filling operation as described in Section 5.4.

vii. Remotely.

A local and telemetry alarm shall be provided to indicate if tank level falls while the outlet pumps (if applicable) are not operating, or tank level rises while LCP SPO is not active.

Refer to Section 4.12.1 for recommendations of level instrument types and other related information.

6.1.7.1. Setpoints

Bulk storage tanks shall all be equipped with alarm setpoints, triggered by appropriate level transmitters and/or switches with appropriate prompts for operator-driven and automated actions as required by the design.

The following high-level setpoints shall be available for tank operation:

- **Operational High Level (OHL):** This operator settable setpoint provides no alarm. The process will continue to run with no action. Reaching this level will be recorded as an Event[2] only in SCADA.
- **High-level (LAH) Alarm:** At this level an Operator alarm shall be triggered requiring operator action to correct any issues if the trigger does not self-correct. The process shall continue to operate.
- **High-high level (LAHH) Alarm:** At this level a further alarm will be triggered, and the Operator notified. At this level Operator action has been unavailable or unable to correct the high-level event. The process should be interrupted, or further actions triggered.
- **Level Switch High-High (LSHH):** The high-high level setpoint designated where a switch is used. It will typically provide the same action as LAHH.

The following low-level setpoints shall be available:

- **Operational Low Level (OLL):** This operator settable setpoint provides no alarm. The process will continue to run with no action. Reaching this level will be recorded as an Event[2] only in SCADA. This may be used to allow autonomous duty tank changeover without triggering an alarm.
- **Low-level (LAL) Alarm:** At this level an Operator alarm shall be triggered requiring operator action to correct any issues if the trigger does not self-correct. The process shall continue to operate.
- **Low-low level (LALL) Alarm:** At this level a further alarm will be triggered, and the Operator notified. At this level Operator action has been unavailable or unable to correct the high-level event. The process should be interrupted, or further actions triggered.
- **Level Switch Low-Low (LSLL):** The low-low level setpoint designated where a switch is used. It will typically provide the same action as LALL.

[2] Events are a fifth priority alarm in the Seqwater alarm system as defined in *I-SPE-STD-006 Monitoring and Control System Alarm and Event Management.*

When sizing a tank and determining level alarm setpoints, designers should consider the response time, tank fill and draw-down rates, tank dimensions and other project considerations. The greatest tank fill rate or draw down rate that is likely to be experienced during operation shall be considered in response time calculation.

The response time allows an operator or control system to correct itself before an escalation in control system management is triggered. The level setpoint as a percentage of tank rated capacity or tank design capacity or total level can therefore be calculated from the response time. In addition, *AS 3780* and other relevant standards has included typical guideline values for the level set points which should be considered in the design and operation.

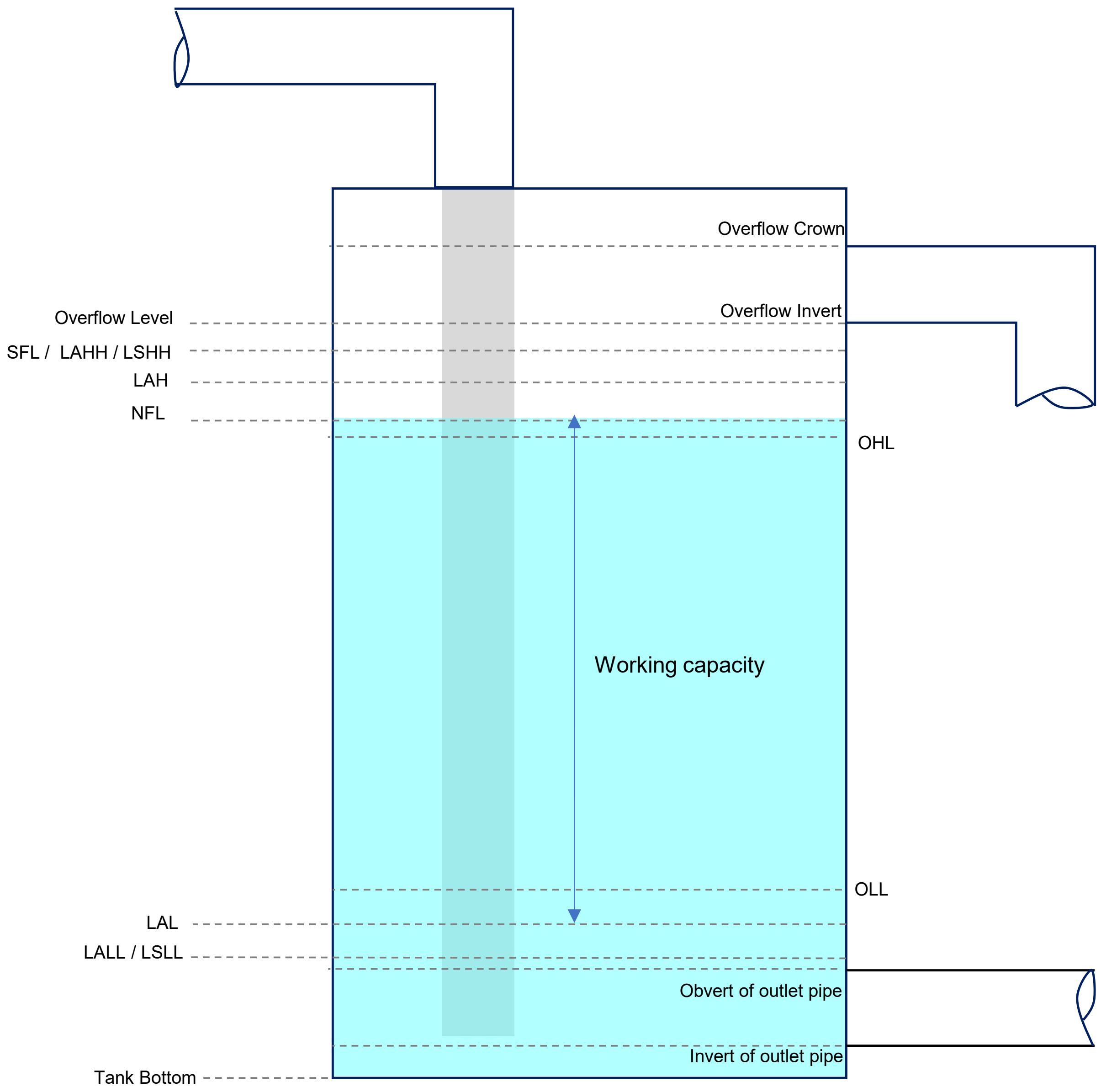

Figure 2 – Visual representation of level setpoints

Notes

1. *AS 3780* reports typical tank rated capacity or SFL at 100%. Tank rated capacity is often used as 97% to 98% of the tank design or maximum capacity.
2. LAHH and LSHH are recommended to set at SFL or tank rated capacity level.
3. NFL is typically set at 90-95% of the tank rated capacity.
4. OHL and OLL should be adjustable by operators.
5. OLL can be used to order a new delivery or tank changeover.
6. LALL / LSLL should typically be 10-30 mm above the outlet pipe obvert.
7. Obvert of outlet pipe is typically considered the minimum pumping level.

Guideline reference setpoints are provided in Figure 2 with some notes and recommended values as reported in relevant standards and typically practiced in the industry. In addition, Table 6 provides a guidance on response time as an alternative approach to determine level set points for the design to consider. However, this may vary considerably from site to site depending on the tank size, tank fill or draw down rate and other design requirements.

Specific design requirements and users' preference shall ultimately dictate the final level set points for the design and operation.

Table 6 Guideline response times for the determination of level setpoint.

Description	Shorthand	Approximate response Time (minutes)	Reference Level
Overflow level	OFL	≥ 2	From LAHH/LSHH
High-High Level Switch	LSHH	≥ 2	From LAH
High-High Level	LAHH	≥ 2	From LAH
High Level	LAH	≥ 2	From NFL
[3]Operational High Level	OHL	N/A	≤ NFL
[11]Operational Low Level	OLL	N/A	> LAL
Low Level	LAL	N/A	<OLL
Low-Low Level	LALL	≥ 60	From LAL
Low-Low Level Switch	LSLL	≥ 60	From LAL

The design should make empty working tank volume figure (i.e. available tank volume to be filled) to be displayed in liters on the HMI (i.e. LCP screen) and SCADA. This will enable operators to quickly know the volume in liters that may be transferred into a tank.

[3] OHL and OLL will be settable by operators and result in only an event being logged with no alarm.

6.1.7.2. Analogue Instrument Calibration and Setup

Tank analogue level instruments shall be calibrated to meet the design requirements. This can be such that:

i. 4 mA corresponds to 0% of tank level typically set at tank bottom level. Alternatively, the design may also consider setting 4mA at tank outlet pipe obvert or invert level depending on design specific requirements and users' preference.

ii. 20 mA typically aligns to the invert level of tank overflow pipe. The corresponding tank % level will need to be determined following the level set points meeting the design specific requirements and users' preference. The design may also consider setting 20 mA at overflow crown level.

A visual representation of the above calibration requirements is depicted in Figure 2.

6.1.8. Fill Lines

This section builds on the requirements of Fill Line discussed in Section 5.3, with the battery limit drawn from the flange connection at the tank nozzle to the tank internal. Tank fill lines, including the interface between fill lines and the tank shall:

i. Include a separate flanged nozzle/connection on the topside (roof) of each tank:

    a. A minimum of 50mm but matching the fill line diameter as discussed in Section 5.3.

ii. Enter the roof of the tank in a vertical orientation and above the overflow height.

iii. Provide a submerged inlet for bulk tank filling from tankers i.e. the fill line shall extend to the internal base of the tank. This is particularly important for chemicals that have a tendency to off-gas or readily form vapour or fume. Submerged inlets shall:

    a. Be made of materials suitable for submergence in the chemical tank.

    b. Extend to the base of the tank on the opposite side of the tank to any outlets to prevent air and vapour entrainment into outlets and dosing pumps.

    c. Include a mechanism to prevent siphoning the contents of the tank through the fill line, such as a siphon breaker or drilled hole at the top of the internal line above the maximum fill level.

iv. Include provisions for the complete and safe draining along with transfer hoses prior to decoupling them which should involve line purging after the completion of tank filling.

6.1.8.1. Aqueous Ammonia

Aqueous ammonia bulk storage tanks shall also have a vapour return line connected to a separate nozzle on the roof of the bulk storage tank. A pressure gauge should be installed on the vapour return line, directly visible to personnel involved in chemical deliveries.

See Section 5.3.1 for further details outside of the tank requirements.

6.1.9. Process Lines

Where multiple bulk storage tanks feed a dosing or transfer skid, a common skid manifold (fed from each tank) shall be provided. Each tank shall be manually and remotely isolatable from the manifold.

See Sections 7 and 8 for additional requirements for dosing systems and transfer systems, respectively.

6.1.10. Overflow Lines

Each tank shall have an overflow line installed which shall:

i. Be at least 1.5 times the diameter of the fill line.

ii. Be a minimum of 80mm regardless of point (i) above.

iii. Have no valves or restrictions and discharge above 200 mm above the bund ground level or where practicable into a sump or chemical drain except for aqueous ammonia and sulfuric acid.

iv. As far as is reasonably practicable, be installed in full view of the point of tank filling allowing any personnel involved in the filling procedure to witness any discharge. This may not be possible where multiple large tanks exist.

v. Be installed below the tank inlet line nozzle at side of the tank.

vi. Be fitted with a 2 mm aperture vermin mesh with mechanical fastening at the discharge point for outside tanks (where open to atmosphere). The mesh shall be weather proofed and mesh materials shall be compatible with the chemical. The design needs to size the overflow line appropriately considering the flow area reduction from the recommended aperture size.

vii. Comply with the relevant standards for the tank type, content, and material.

Sections 6.1.10.1 and 6.1.10.2 below include additional specific requirements for aqueous ammonia, sulfuric and hydrochloric acid systems.

6.1.10.1. Aqueous Ammonia Tanks

Overflow line for aqueous ammonia shall be allowed through to a water trap. A suitably design water trap may prove sufficient to capture ammonia vapor. The depth of water trap shall be determined during the design to limit the tank venting out through the overflow line particularly during tank filling, The operation of the water/oil trap needs to be confirmed during commissioning.

Where overflow pipes of aqueous ammonia systems discharge into a water trap, the overflow pipe or water trap should include an injection port (sealable via valve or other) to enable the controlled addition of a small amount of food-grade oil. Maintaining an oil layer of 1-3 mm on the water surface creates an impermeable barrier that effectively prevents ammonia vapor from escaping.

The water trap shall be connected to the site service water line and fitted with a float valve to maintain the required water level automatically. The water trap shall be fitted with the same size overflow line of the storage tank overflow line and a local level gauge. Where feasible, a low-level switch can be considered to know the low level of water in the trap. The site service water connection for the water trap shall need to be designed in accordance with AS/NZS 3500 to manage backflow risks.

6.1.10.2. Sulfuric and Hydrochloric Acid Tanks

Overflow lines for sulfuric and hydrochloric acid shall be allowed through to an oil seal pot (seal bend) to prevent fumes being released. Inert oil shall be used in the seal pot to prevent any reaction with acid fumes.

The fillable oil seal pot shall be fitted with the same size overflow line of the storage tank overflow line and has a visible sight tube with appropriate fittings. The system must be designed to limit acid fume venting out through the overflow line.

6.1.11. Vent Lines

Each bulk storage tank shall have its own vent in accordance with the relevant standard for the tank's construction.

Vents shall be sized appropriately to prevent excessive positive or negative pressures compromising the integrity of the tank structure taking into consideration the following:

i. Size of the inlet and outlet pipes.

ii. Maximum fill rate and / or drain down rate.

iii. Thermal inbreathing / outbreathing due to temperature changes.

iv. Allowance for adequate airflow during filling, dosing, and while the tank is being drained so as not to upset operation and not exceed the allowable stresses on the tank.

v. Shall be a minimum size of DN50 with a flanged nozzle regardless of point (i) to (iv) above.

vi. In absence of data for point (ii), the vent line shall be at least 2 times the diameter (four times the area) of the inlet or outlet line (whichever is greater).

vii. Vents shall be directed to a safe location with appropriate labelling where the chemical has an inhalation or aspiration risk particularly for acids and aqueous ammonia.

viii. Where installed outside, vents shall be directed downward with a 180^{o} bend with the opening toward the ground to prevent ingress of rainwater. The positioning of vents shall also ensure the risk of chemical dripping on personnel and the risk of chemical vapour condensing outside of the vent and damaging plant and equipment.

ix. The vent discharge point shall be weather proofed and fitted with a 2 mm aperture vermin mesh with mechanical fastening, and mesh materials shall be compatible with the chemical.

x. Where tanks are installed inside, vents must be directed outside of the building for aqueous ammonia, sulfuric acid. Where directed outside, vent lines shall be directed downward with the opening toward the ground to prevent ingress of water and 500 mm above the ground level to avoid the risk of any chemical dripping on a person.

xi. Vents directed outside of buildings should be preferably taken through the wall of a building rather than a roof or ceiling to minimise water ingress through seals.

xii. Where tank filling points are to be positioned above the height of tanks and tank vents, or if ventilation in the area is considered poor (e.g. in buildings), designers shall ensure the filling area remains safe to all personnel during filling operations.

xiii. A scrubber may be considered on the vent for noxious vapor taking into effect the vent velocity on the scrubbing efficacy. However, ideally, systems should be designed to limit off-gassing and release of vapour into the plant rather than manage vapours that are generated. The tanks holding fuming chemicals and those that produce noxious vapours should be fitted with a pressure/vacuum valve instead of free vent or with a scrubber.

The following sections include specific requirements for aqueous ammonia and sulfuric acid venting systems.

6.1.11.1. Aqueous Ammonia Tanks

Aqueous ammonia tanks shall be designed to withstand appropriate positive pressure and minimise the release of ammonia vapor under all operating conditions. Each tank shall be fitted with a pressure/vacuum valve and be sized appropriately to prevent excessive or negative pressure. The system design and pressure setting of pressure/vacuum valves shall consider the influence of vapour space pressure changes arising from tank filling and emptying conditions, tank vapor return line connection to the truck (pressure equalization line) and changes in temperature. This will allow the tank to operate at a positive pressure, minimising continuous off-gassing and preventing vacuum conditions. The design may also consider redundancy of such pressure/vacuum valves to achieve higher assurance on the integrity of the tank structure.

Aqueous ammonia tank overflow arrangements must need to minimise any constant vapour loss during filling operations e.g., providing sufficient water column height in water traps. Where a water trap is used in combination with a pressure/vacuum valve, this valve shall be set such that vapour and air are preferentially expelled/drawn through the pressure/vacuum valve rather than the water trap. The design shall assess the need for flame arrestors on the top of tanks as a flammable mixture may form inside the vapour space of aqueous ammonia bulk storage tanks.

The design may also consider designing the aqueous ammonia storage tank to operate as a closed system without any overflow line to limit any ammonia vapor release to the environment. To achieve this, the tank design pressure and the primary pressure/vacuum valve set pressure shall be sufficient to encounter pressure/vacuum arising from tank filling, emptying and changes in temperature. An additional pressure/vacuum valve with the higher-pressure settings than that of the primary pressure/vacuum valve must be provided.

6.1.11.2. Sulfuric Acid Tanks

Sulfuric acid tank vent shall be fitted with desiccant dryers (i.e. silica gel or similar) to prevent the ingress of moisture into the tank particularly for steel tanks. Any moisture entering into the steel tank will be absorbed by the hygroscopic nature of concentrated sulfuric acid and may create weak acid at the top layer due to dilution. The top layer weak acid may become more corrosive and corrode around the inside of the tank.

The desiccant dryer system and the vent pipe shall not create a high differential pressure that the tank design pressure and vacuum ratings are exceeded. The design shall consider the maximum fill-in and drain down rate for the vent pipe sizing and pressure drop calculations.

Where suitable and secure platform and ladder cannot be provided, the vent pipe shall be extended at ground level that the desiccant dryer can be easily checked and replaced.

6.1.12. Drains

Bulk storage tanks shall be capable of fully draining to empty. Each tank shall have a separate drain line facilitating tank drainage from the lowest point within the tank. Drain lines shall:

i. Where practicable, be diverted to the bund sump.
ii. Isolated via a drain valve, located as close to the tank body as possible.
iii. Be kept separate from overflow lines.
iv. Be adequately protected, sized and of suitable construction to prevent inadvertent damage resulting in tank drainage.

6.1.13. Tank Access

For a covered (roof) tank with a height of less than or equal to 3m, a minimum of one 600mm diameter access hatch shall be provided on the top of the tank.

For taller tanks (> 3m), an additional side access hatch of at least 600mm should be provided and hinged to the tank wall. Special attention is needed to ensure liquid tight of the seal of the side access, maintenance requirement and chemical compatibility of seal with the chemical.

Tank hatches shall be made from the same material as the tank, to be tamper proof and weigh no more than 15 kg. Where this cannot be practicably achieved, a lifting and support mechanism shall be supplied and mounted to the tank to facilitate access.

All access hatches shall comply with this standard and the relevant requirements of the codes and standards for specific tank classes.

6.1.14. Additional Requirements

All tanks shall:

i. Be installed such that they will not float in the event of a loss of containment.

ii. Where installed outside, or in a shelter with open sides, be anchored to the plinth using hold down bolts. Hold down bolts should not be tightened until the tank has been filled. Seqwater has experienced stress-induced failure of tanks as a result of flexing during filling/emptying as a result of the use of hold down bolts. The design and installation procedure for hold down bolts must consider and account for this active flexing.

iii. Constructed to prevent vortexing within the tank and at any outlets.

iv. Include the ability to sample each tank's contents, independently, for testing purposes. Where fixing a nozzle directly to the tank is not viable or mechanically suitable, an alternate means of providing chemical sample shall be provided. This may include providing a sample point in the suction line immediate downstream of the tank isolation valve.

Particular care should be taken to protect tank outlets nozzles, pipe and valves and especially non-metallic components to prevent accidental damage and tank draining.

6.1.15. Duty Rotation

Bulk storage tanks shall be provided with duty rotation in accordance with *I-SPE-STD-013 Control Systems Design and Construction.*

6.2. Bund Arrangement

Secondary containment shall be provided for all bulk storage tanks in the form of a bund. Each chemical storage tank shall be installed in a separate bund. Storage bunds shall:

i. Comply with the requirements of this standard specification and *AS 3780*.

ii. Provide a minimum separation distance between tanks in a single bund of 0.6m, and between bund walls and each tank a minimum 1.0 m.

iii. Ensure a Crest Locus limit (θ as defined in *AS 3780)* of 26.5°.

iv. Be designed to withstand the instantaneous dynamic loading effects created by tank failure assuming a tank was full at the time of failure.

v. Be provided with access such that entry and exit by personnel under both normal and emergency conditions shall be ergonomically safe and shall comply with *M-SPE-STD-002 Fixed Platforms, Walkways, Stairways and Ladders* and *AS 1657*. Additional requirements for access are provided in Section 6.3.1 below.

vi. Be preferably a concrete bund, but a HDPE bund is acceptable for small tanks.

vii. Include wall and floor coatings in accordance with *M-SPE-STD-004 Protective Coatings* and *WSA 201*. If the system is designed to return rainwater into the head of the plant, then wall and floor coatings shall need to be AS/NZS 4020 compliant.

viii. Include a Bund Sump. Refer to Section 6.2.2 below.

ix. Include open channel collection gutters with grating covers connected to the bund sump for the collection of wash down water, spills, overflow, and scours.

x. Be designed to prevent pooling of chemical or water by providing a suitably finished surface with a gradient toward the Bund Sump of 1:75.

xi. Safety showers, eye wash facilities complying with *AS 4775 Emergency Eyewash and Shower Equipment* shall be provided in each chemical storage bund. Relevant general requirements about this have been included in Section 4.15.

Storage bunds preferably should be covered where not installed indoors, with more specific guidance provided in Section 6.3.

Every effort should be made to avoid casting pipes through bund walls as this may affect the future leak prevention capability. In addition, the life of a bund is likely considered greater than that of pipes. If casting through bunds is required, particular care should be taken to ensure the lifetime integrity of the asset.

Pipes shall not be cast through the base/floor of a bund.

Any high-volume service water lines or others fed from outside of the bund shall not pass though the storage bund to avoid potential chances of bund flooding from pipe burst. This shall be limited to smaller diameter potable water lines to supply eye wash and safety shower facilities.

All equipment and structures within the bund must be suitably protected and resistant to degradation due to applicable chemical attack. This is particularly important for items which may be located close to the bund floor, such as platform feet / legs and pipework. Where possible metallic assets should be raised above the bund floor level, so that minor spills do not contact these assets.

6.2.1. Bund Capacity

In accordance with *AS 3780*, for corrosive substances other than classified as Packaging Group I under the ADG Code, the bund capacity shall be not less than 110% of the capacity of the largest tank or 25% of the total capacity of all tanks within the same bund, whichever is greater. If multiple tanks share a common point of failure; such as operating in series, functioning as a combined volume, or discharging through a common manifold without adequate control and isolation valves, the bund capacity shall be not less than 110% of the total storage capacity of all such tanks.

Where bunds are constructed outside and subject to filling with rain, bund capacity must take rainfall events into account to maintain effective containment.

Where storage tanks are installed inside or outside under a shelter, bund walls should generally be sized to include a freeboard of at least 100 mm above the design fill volume and at least 250 mm where storage tanks installed outside without a shelter.

6.2.2. Bund Sumps

A low point Bund Sump shall be provided in each bund, to:

- Provide a point of collection for rainwater, spillage or tank overflow.
- A point of extraction.
- A point of measurement for increased level and detection of chemical.

Bund sumps should be a minimum of 600 (long) x 400 (wide) x 300 (deep) mm.

The Bund Sump shall:

i. Include a Fibreglass Reinforced Plastic (FRP) grating or other chemical-compatible material sufficient to withstand any weight reasonably expected to be applied during construction, maintenance and operations activities.

ii. Include provision to fit a portable sump pump with an appropriate GPO and IP rating for pump connection in accordance with *E-SPE-STD-001 Electrical Design and Construction*. Where a bund is not covered, the designer should consider including a permanent sump pump as part of the design.

iii. Include instrumentation for level measurement and identification of spills and rainwater. See Section 6.2.3 below for further detail.

The design shall take into consideration and clearly define:

- How a filled bund will be drained in the event of a chemical spill; this must be in-line with site Emergency Response Plan. And
- The drainage destination for stormwater using a sump pump, and how this will be achieved.

Consideration may be given to including a drainage pipe for connection to a vacuum truck. This drainage pipe would be expected to extend from the base of the sump to above the bund wall, with a mechanical coupling connection allowing connection to a vacuum truck.

If a bulk chemical storage bund is not protected from the ingress of rainfall (by shelter or other – refer to Section 6.3), then the following shall apply:

iv. Bund sumps should include drainage pipework allowing manual diversion of stormwater to a safe location. Pipework shall:

   a. Divert stormwater to a safe location (after testing).

   b. Be designed with consideration of safely draining chemical in the event of a spill. This may need to consider whether a sump pump is able to recover all chemical, or if a diversion to a CSHT is required to capture residual chemical in a pipe.

   c. Include an isolation valve with a limit switch:

      1. The isolation valve shall be installed in a valve pit outside of the bund, manually actuated from a safe location and from above ground level.

2. The limit switch shall provide an alarm to alert operators if it is in the open position.
3. The limit switch shall provide an interlock to prevent operation of the fill point SPO if the valve is not in the closed position. It will also alert operators with an alarm if the valve is in the open position more than a defined period.
4. The design shall consider the risk of spilled chemical passing the isolation valve and ensure materials and valve type are selected accordingly.

6.2.3. Bund Instrumentation

Chemical storage Bund Sumps shall include as a minimum:

i. A high-level switch (LSH) (conductivity, ball float or similar) used to generate a high-level alarm (LAH). The switch shall:
   a. Provide an alarm to SCADA to alert the operator of a high chemical or water level in the bund sump. The design should also consider a dial-out alarm to the operator for indoor storage tanks where a facility is not manned for 24 hrs.
   b. Trigger an audible and/or visual local alarm at the LCP during filling operation (i.e when SPO is energised) if the storage bund under a shelter and ingress of rainwater into the bund prevented.

At sites where clear visibility of the entire bund may not be available to chemical delivery personnel, or a risk assessment determines an unavoidable risk to personnel, equipment, or the environment, the following additional requirements should be considered:

ii. A high-high-level switch (LSHH):
   a. Used to generate a high-high-level alarm (LAHH).
   b. Used to shut down the tank filling process and provide an interlock to any further tank filling operation (including LCP SPO interlock).
   c. Be set to activate at the lowest reasonable level in the sump to avoid spurious trips but still detect valid spills or volumes of rainwater.

The design needs to assess the impact of bund sump level interlock during unloading activities under rain if a storage tank bund installed without a shelter or the ingress of rainwater into the bund not adequately prevented. An alternative design should be considered to address this issue.

Where bulk storage tanks located outside, an additional conductivity probe should be installed in the bund sump to distinguish between rainwater and chemical with suitable alarms in SCADA. The conductivity probe shall be selected such that it can be left dry and does not need frequent calibration.

6.2.4. Bund Access

Where a chemical bund exceeds 300 mm in height, a suitable access structure shall be provided for safe access in the form of stairs.

Access stairs shall:

i. Be installed on both the inside and outside of the bund or on the one side in excess of height.

ii. Comply with the requirements of *M-SPE-STD-001 General Mechanical*, *M-SPE-STD-002 Fixed Platforms, Walkways, Stairways and Ladders*

iii. Be constructed from materials suitably compatible with the environment in which they will be installed.

Consideration should be given to the corrosivity of chemicals stored in a bund and the likelihood of damage to access installations.

Where a bund area exceeds 25m^2, two points of access / egress shall be provided into and out of the bund. Bund areas of this size or smaller should include access platforms/grating to allow safe access in the event of chemical spills. Such platforms shall be installed at a level that exceeds the maximum fill level of the bund. Larger bunds may also be considered for access grating installation.

The minimum clearance distance between any neighbouring equipment shall not be less than 0.6m for general maintenance access. A minimum of 1m clearance shall be maintained in evacuation routes.

Where access is required to the roof of a tank for maintenance and operational purposes, an appropriate access structure shall be provided to facilitate such access which complies with the requirements of *M-SPE-STD-002 Fixed platforms, walkways, stairways and ladders*. Design shall seek to minimise the use of portable ladders for maintenance.

The roof of tanks shall be capable of bearing the load of personnel and equipment reasonably required to complete maintenance and operational activities, or an appropriate platform shall be provided.

Where needed, a walking platform should be considered inside the bund to reach critical instruments and equipment.

Where pipes are run across the floor of a bund, suitable access and trip prevention shall be provided. Running pipes under a step, platform or similar installation may achieve this requirement.

6.3. Chemical Enclosures, Buildings and Shelters

Bulk chemical storage systems may be installed inside a building, outdoors with or without a shelter, or in a kiosk as chemical and process requirements dictate.

Where not installed indoors, storage bunds shall be installed under a shelter to prevent ingress of rain and filling with stormwater. An exception to this requirement may be applied where the arrangement of the bund would make the design and construction of a shelter infeasible or impracticable. In this circumstance, additional bund sump requirements apply – refer to 6.2.2.

Shelters may be used as a means of preventing rain ingress and providing protection from UV radiation. Structures shall be designed in accordance with relevant Australian Building Codes, legislation, Industry Standards. Roof sheeting extension form the bund wall edge should be considered to prevent rainwater ingress.

Seqwater's preference is for fuming chemicals such as acids and aqueous ammonia to be installed outside under a shelter with open walls in order to provide natural ventilation for vapour.

Penetrations through enclosure, building and shelter roofs should be avoided in favour of penetrations through walls to minimise the ingress of rainwater.

Particular care should be taken if installing more than one chemical in an enclosed building. Some chemical vapours in addition to the liquid chemicals may be incompatible and lead to explosive or toxic combinations forming.

Where in bushfire-prone areas, the requirements of *AS 3959* shall be addressed.

Requirements relating specifically to aqueous ammonia and sodium hypochlorite are discussed in Section 6.3.3 and 6.3.4, respectively.

6.3.1. Access

Access and layout (internal and external) of structures, including buildings, enclosures and shelters shall consider the requirements for maintenance and replacement of related assets, especially those which may have lifespans shorter than that of the structures. Designs shall clearly address such future requirements.

If access doors are insufficiently large or internal arrangement does not provide sufficient space; buildings, enclosures and shelters shall be designed and constructed to enable the installation, replacement and maintenance of tanks or other equipment. This can be done either through the removable sidewall of the structure or having a roof specially designed with a lift-out section such that the roof section can be removed without damaging the integrity of the structure.

The distance between the top of any tanks should be a minimum of 1.2 m from the roof of any structures in all circumstances. Notwithstanding the previous statement, there shall be sufficient space provided between the top of any tanks and the ceiling of any structures or buildings to allow ergonomic access for expected maintenance to take place. If an access platform is required on top of the tank, a minimum clearance of 2.4 m should apply between platforms and building ceilings.

If chemical storage tanks and dosing systems are installed inside a building or kiosk, all doors shall open outward and be fitted with panic release bars.

6.3.2. Ventilation

Structures / buildings, kiosks, shelters for chemical storage area layouts shall be designed using suitable natural or forced ventilation to:

- Prevent the accumulation of chemical fumes, mists, or vapours.
- Prevent condensation build up.
- Ensure a safe operating atmosphere at a level determined in the hazard identification, assessment, and control process.

Building ventilation systems shall be designed in accordance with relevant Australian Building Codes, legislation, Industry Standards. In addition, the guidelines provided in *AS 1668.2 Mechanical ventilation in buildings* and *AS 1668.4 Natural ventilation of buildings* shall be followed.

Where applicable, any hazardous area ventilation requirement as specified in *AS/NZS 60079 (all parts) Explosive atmospheres* must be followed.

Routine air monitoring shall be conducted to determine the level of air contamination where an inhalation hazard of chemical fume, mist or vapour exist.

6.3.3. Aqueous Ammonia Installations

Seqwater's preference is for aqueous ammonia installations to be installed under a shelter with open walls to balance hazardous area and ventilation requirements. However, the requirements for security and safety of installations shall be considered when finalising this decision.

If a building or enclosure is used for the storage of ammonia systems, particular attention shall be required in design to ensure appropriate ventilation and hazardous area zoning is maintained.

Also refer to Section 6.1.4.3 for details relating to thermal influences on aqueous ammonia.

All aqueous ammonia installations shall require gas monitoring to alert operators and nearby personnel of potential unsafe ammonia vapour concentrations. Monitors shall be suitable for detecting across a 0-100 ppm range. Monitors shall be positioned appropriately to reflect the concentration of vapour that may be breathed in by personnel. The designer should determine whether any trips are necessary because of high gas/vapour concentrations being detected.

Ammonia detectors shall be visible in SCADA and include visual and audible alarming. Where the design includes an alarm mute option by operator intervention, it shall automatically be unlatched itself after a defined period which is "non-configurable" by an operator.

6.3.4. Sulfuric Acid Installations

Where sulfuric acid storage tanks are installed inside, mechanical ventilation with an exhaust fan must be provided to remove any potential acid fumes. The additional requirements of the system are:

i. The location of the exhaust fan and room vents shall be chosen to maximise cross flow ventilation of the room.

ii. The exhaust fans and ducts must be acid-fume resistant.

iii. The system shall be designed for continuous operation.

iv. The fan must be vented away from areas that may be accessed outside the room.

v. The mechanical ventilation system shall comply with the requirements of *AS 1668.2 Mechanical ventilations in buildings*.

6.3.5. Sodium Hypochlorite Installations

Sodium hypochlorite storage tanks should be installed inside a building or at least under a shelter providing protection to tanks and pipework from the influences of solar UV irradiation and heat to prevent chemical quality and strength degradation.

Where tanks are installed inside, in addition to natural ventilation, the design needs to assess the need for mechanical ventilation to manage sodium hypochlorite fumes following the requirements provided in *AS 1668.2 Mechanical ventilations in buildings*.

6.4. IBC Delivery and Storage System

Preference for liquid chemical delivery method shall be decided in consultation with chemical suppliers considering a sites monthly chemical demand and location. Intermediate Bulk Containers (IBCs) can be considered instead of tanker delivery for small to medium size plants. However, where possible chemical delivery with IBCs should be avoided due to the need for manual handling for IBC storage, set-up, and connection to transfer or dosing line.

If IBCs are selected for the delivery of liquid chemicals, the storage and dosing system shall include the following requirements:

i. Liquid chemicals should not be dosed directly from an IBC and must be transferred to a bulk storage tank or a day tank for dosing. The provision of a bulk storage tank or a day tank for IBCs should be considered to accommodate appropriate level instruments and interlocks for the control of chemical dosing and to minimise the frequency of IBC handling. The storage tank system for IBCs shall be designed as described in Section 6.1.

ii. Where selected, the storage tank for IBCs should have a minimum storage size with equivalent volume of two (2) IBCs (usually each 1000 L). At any given time, only one IBC shall be connected to the bulk storage tank.

iii. The total demand volume of liquid chemical in the IBCs and tanks should follow the guideline provided in Section 6.1.2. The final storage size should be determined considering the available IBC in the market, supply arrangement, supply chain risk for the site and chemical shelf life.

iv. The IBC must comply with construction, testing, inspection, transportation, marking and other requirements within the ADG code.

v. The IBC shall be made from materials compatible with liquid chemicals with suitable support stand and a cap on the top to loosen easily for venting.

vi. The IBC must include a bottom discharge valve, be secured against accidental opening and the open or closed position must be readily apparent. A secondary means of sealing the discharge aperture by a blank flange or equivalent device must be provided.

vii. Consideration should be given to including a tote scale in the IBC to measure the weight of the contents and be the only mode of monitoring and control parameter for the operation. It should have the following requirements:

    a. Be mounted along with weighing modules, junction box and a transmitter to send the weight signal to PLC.

    b. Be capable of reading the tank weight empty and full within ±0.1% accuracy.

    c. Include a low weight setpoint and an alarm to notify operators and automatically trigger shutdown of the chemical transfer pump.

    d. The IBC weight shall be on display as an electronic digital readout local to the IBC and viewable locally at ground level and remotely at SCADA.

    e. Chemical transfer operation from an IBC to a bulk storage tank should be designed to perform from an LCP.

    f. Electrostatic charges must be discharged to the ground without crossing the scales. Earthing shall be provided according to the requirements in *I-SPE-STD-015 Instrumentation*.

viii. The transfer line to transfer the chemical solution from an IBC to a bulk storage tank shall:

    a. Be fitted with a dry break coupling for connecting IBC to the transfer line.

    b. Be fitted with a manual isolation valve and a solenoid valve to open/close automatically when initiated the transfer.

c. Be fitted with a drain line to enable complete and safe draining of transfer hose prior to decoupling.

d. Be in a bunded area with the requirements that any spillage shall be directed to the storage tank bund sump.

e. Be fitted with a vent/degassing line installed at the highest point to vent to atmosphere in a safe location. It shall include an isolation valve with a mechanism to lock open and be easily accessible.

f. Be fitted with a non-return valve upstream of the bulk storage tank to prevent back flow.

ix. Gravity transfer is not recommended where it may require an elevated support stand for the IBC and increases manual handling. Where suitable, a transfer pump should be installed when gravity transfer is not practical with the following requirements:

a. Depending on the transfer frequency, one (1) fixed speed drive transfer pump may be considered with a spare pump in the workshop.

b. An air driven diaphragm pump may be considered where compressed air supply is available and the chemical transfer is not frequent. However, other pumps appropriate for the chemical transfer should also be considered. When an air diaphragm pump is used, the air inlet line shall:

1. Be fitted with a solenoid valve to open/close the compressed air supply and a pump interlock from high air pressure.

2. Be fitted with a pressure regulating valve to maintain the required air operating pressure for the pump and a manual isolation for positive isolation.

c. Provide flanged connection at both inlet and discharge ends.

d. Consider including a pressure indicating device at pump discharge.

e. Comply with Engineering Standard *M-SPE-STD-012 Chemical Dosing Pumps*.

x. An alternative compact package design with an IBC installed on top of a day tank can also be considered for small sites with an automated chemical transfer provided that all interlocks and functionalities illustrated in this document can be achieved without any additional risks and manual handling.

7. Dosing System

Liquid chemical dosing systems include the following:

- Dosing skid and control.
- Dosing line point and chemical mixing.
- As required, chemical dosing tank, containment and bunding.

The following two types of dosing system may be considered for Seqwater liquid chemical dosing systems:

1) Positive Displacement Pump in each dosing line: This dosing arrangement should be used in most circumstances. Dosing systems shall use positive displacement type pumps with 100% duty/standby capability. This method of dosing is discussed in Section 7.2.
2) Pressurised Ring Main Dosing Arrangements: This system may be considered where dosing is required to multiple locations separated over a large distance, which would otherwise require excessive numbers of positive displacement pumps. It is most likely to be employed in coagulation systems where a treatment plant has more than one clarification/sedimentation unit. This arrangement is discussed in Section 7.2.15.

Standard P&ID drawings arrangement including the chemical dosing system is referenced in Section 11.

7.1. Dosing Tanks

Seqwater's preference is to use bulk chemical storage tanks as dosing tanks rather than having separate day or dose tanks – refer to Section 6. Circumstances may require a separate dosing tank be supplied for chemicals where:

- Dosing occurs at a location a significant distance from the bulk storage.
- A single chemical is required in multiple systems.
- Dosing may be susceptible to fluctuations or effects in a large bulk storage tank.
- Batching or dilution of chemical prior to dosing is required.

General requirements for tanks, including dosing tanks, are provided in Section 6.1.

Where separate dosing tanks are required, the dosing tank(s) should provide at least 12 hours capacity at average flow and average dose, however, the final volume and dosing tank number should be determined based on process needs.

A chemical transfer system shall be provided to fill the dosing tank from the bulk storage tank. This requirement is discussed in Section 8.

7.2. Dosing System with Positive Displacement Dosing Pumps

Systems employing dosing with positive displacement pumps shall include the following (refer to the subsequent sections for more detail on each item):

i. A manual and actuated isolation valve on the outlet of each tank.
ii. Where multiple tanks are used, a combined inlet manifold to the dosing pump skid.
iii. A dosing skid including the following as a minimum, in order of upstream to downstream relative to the standard P&ID drawings as referenced in Section 11.

a. Suction-side Y-strainers
b. Suction-side calibration cylinder.
c. Suction-side manual isolation valve for each pump.
d. Suction-side pulsation dampener, only if required or recommended by pump manufacturer.
e. Suction side flushing and drainage points for skids and ancillary pipework.
f. Duty / standby positive displacement pumps to dose chemical.
g. Pressure relief valve for each pump, preferably returning to tank (in addition to any pump internal pressure relief valves).
h. Discharge-side pulsation dampener for each pump, if required or recommended by the vendor. Normally needed for diaphragm pumps.
i. Pressure gauge / indicator – installed before each pressure-sustaining valve (see point 'k' below).
j. Discharge side flushing and drainage points for skids and ancillary pipework.
k. Discharge side pressure sustaining / backpressure valve, if required or recommended by the vendor. Normally needed for diaphragm pumps.
l. Pump discharge non-return valve.
m. Discharge-side manual isolation valve for each pump – discharge isolation valve downstream of non-return valve.
n. An optional pressure transmitter on the combined outlet manifold for recording or monitoring pressure online and achieve high pressure cut-off from PLC.
o. Flowmeter on the combined outlet manifold.
p. For sodium hypochlorite and aqueous ammonia systems, a degassing arrangement shall be provided, including a suction side (as a minimum) vapour vent returning to the top of the chemical tank. (Anti-siphon prevention shall be included).
q. A testing and commissioning return line into the tank (to be used for dosing skid commissioning and pump calibration).
r. A non-return valve in the dosing skid boundary, only if carrier water used.
s. A manual isolation valve at the skid boundary.
t. Inclusion of carrier water may be required for dosing some chemicals in low concentrations or low flows or to improve mixing of some chemicals – refer to Section 7.2.11 for further detail.

iv. Dosing line for each dosing point fitted with additional pressure sustaining valve, actuated valve, dosing spears, line leak detection system, containment and flushing capability, refer to Section 7.2.12 for details.

v. Chemical mixing device or arrangement.

Refer to *M-SPE-STD-010 Chemical Dosing Skids* for some detailed requirements of the chemical dosing skid and its skid components as identified above. The Chemical Dosing Skid must be designed and installed such that dosing pumps and other electrical components are above the bund 110% full line.

M-SPE-STD-012 Chemical Dosing Pumps and *M-SPE-STD-013 Chemical Dosing Piping* shall also be used in the design and installation of chemical dosing systems. The remainder of Section 7.2 shall be used to identify any further requirements.

7.2.1. Suction Lines

The suction line supplies chemical from each tank to the duty dosing pump(s).

i. Suction line to the dosing pump shall be kept as short as possible.
ii. The design shall ensure flooded suction to the pump centerline under all process conditions for all chemicals.
iii. Refer Section 4.8.1 for suction line sizing and velocity recommendations. The diameter of the suction line shall be at least equal or larger than the pump suction port diameters.
iv. Suction lines shall minimise or eliminate the use of right-angle bends and where needed include bellows/flexible joints to minimise stresses on the polyethylene tank joints.
v. Include both a manual and actuated isolation valve just next to the tank.
vi. Include Y-strainers with a maximum of 0.5mm mesh:
    a. A duty and standby arrangement shall be provided.
    b. Strainers shall be made from suitable transparent material.
vii. The piping design and material selection must prevent any cracking or failure to tank joints due to changes in tank liquid level and/or ambient temperature.

7.2.2. Calibration Cylinders

Designer should consider the installation of calibration cylinders when it is practical considering the maximum design flow rate.

Where installed, a suitably protected, capped, graduated, transparent and calibrated cylinder should be provided on the suction side of the pumps for pump calibration. This is particularly important for a system where the pump curve needs to be calibrated at periodic intervals in the absence of a flowmeter or where a flowmeter may deviate from accuracy. Appropriate isolation valves shall be provided to allow the calibration of each pump The calibration cylinder shall be fitted with a vent line, an overflow outlet line with an isolation valve and returned into the top of the dosing tank.

Refer to *M-SPE-STD-010 Chemical Dosing Skids* for further detail on calibration cylinder requirements.

7.2.3. Positive Displacement Dosing Pumps

A minimum of one (1) duty and one (1) standby pump shall be provided in all circumstances for a dosing system. Standby capability shall ensure 100% of the duty arrangement can be achieved. To minimise the risk of chemical overdosing, the control system shall prevent the simultaneous operation of both pumps under all scenarios.

The design should consider using one pump for each dosing line where duty/standby dosing lines have been included in the design.

Suitable positive displacement dosing pump types shall be selected from the X-LST-STD-001 Seqwater Preferred Equipment List based on chemical properties, turn down ratio, current Seqwater practice and experience, and following the guidance and requirements included in *M-SPE-STD-012 Chemical Dosing Pumps*.

The pump capacity and pressure rating must be suitable for the whole dosing range, with a strict avoidance of prolonged operation within undesirable operating zones to maximise the pump design life. Where available, the pumps should generally be selected with the maximum capacity which does not exceed about 10% of the required maximum design flow rate, this is to minimise any potential chemical overdosing scenarios.

Seqwater prefers the application of digital positive displacement dosing pumps where suitable for the design flow envelope and the pumps that do not require manual stroke length adjustment in the field.

Dosing pumping systems shall be designed to provide duty rotation which shall comply with the requirements detailed in *I-SPE-STD-013 Control Systems Design and Construction*.

SCADA shall be capable of displaying each pump's speed (Hz), stroke, and derived flow.

7.2.4. Pressure Relief Valves

External pressure relief valves shall be included on the discharge line for all positive displacement pumps, positioned near to the pump outlet to achieve protection against high pressure.

This requirement also applies to positive displacement pumps with integral pressure relief valves. This is intended to prevent short circuiting of liquid chemical from the discharge port of positive displacement pumps, immediately to a suction port by internal relief valves in case of a blocked discharge. In addition, internal relief valves may not provide adequate protection to dosing lines due to the existence of check valves in certain types of pumps like diaphragm pumps (where applicable).

An external pressure relief valve also gives operational flexibility to set and test the relief valve pressure according to the system need whereas internal relief valves may often be required to test using the pressure set by the pump manufacturer.

Pressure relief valves shall:

i. Be installed immediately downstream of the pump discharge and shall not include any isolation valve between the pump and the relief valve.

ii. Include provision for the attachment of a hand-held pressure gauge to test the valves operation.

iii. Be set to relieve pressure:

    a. At approximately 100 kPa below the pump internal pressure relief valve.

    b. Regardless of the point above, be set about 10% below the pressure rating (after any design de-rating for Site Conditions) of the lowest pressure rated fitting or item in the system.

    c. Designers should ensure there is sufficient margin between the pressure relief setpoint of pressure relief valves and the set pressure of pressure sustaining valves (where used) to ensure pressure relief valves are not subjected to 'chatter'.

iv. Include the set pressure recorded on a valve tag attached to the valve. This tag shall be separate from the naming tag.

v. Discharge to the dosing tank. Where a return line to the storage tank may be an excessive length, introduces a process or safety risk, or inhibits safe access, return to the pump suction side will be acceptable if it does not create unacceptable back pressure from tank head.

vi. Where the discharge line is returned to the dosing tank, it is recommended to connect the discharge line to the outlet of the calibration cylinder (where available) to identify a leak or relief of the pressure relief valve (i.e., liquid accumulation in the calibration cylinder will confirm a leak or relief from the pressure relief valve).

vii. If needed, consider including a flow switch in the discharge line to identity a relief event or leak from the relief valve.

viii. Be sized for the full flow relief.

ix. Be lockable (e.g., locking nut) such that the setpoint pressure cannot accidentally be changed e.g., by vibration in pipelines.

7.2.5. Pulsation Dampeners

Where required, as per the pump manufacturers' recommendations, a suitably sized pulsation dampener shall be provided inline or on a branch line from the suction or discharge sides of dosing pumps to reduce pressure fluctuations. A pulsation dampener is normally needed for diaphragm and peristaltic pumps.

Refer to *M-SPE-STD-010 Chemical Dosing Skids* and pump manufacturers' recommendations for further detail on pulsation dampener requirements.

7.2.6. Pressure Indication

Pressure gauges shall:

i. Be installed on the discharge line of each pump.

ii. Be installed upstream of pressure sustaining or back pressure valves.

iii. Include diaphragm seals to allow easy replacement and maintenance.

Installation of pressure gauges as close as possible to dosing points should also be considered to allow identification of leaks in long dosing lines.

Where the design identifies the need to monitor the dosing system pressure online and record pressure trends due to frequent pressure fluctuations in the dosing location or variations due to the potential built-up of pressure in the dosing line from scaling or crystallisation, a pressure transmitter should be installed. Pressure transmitter should

i. Be installed preferably on combined discharge line, as appropriate, to monitor pressure in the dosing line.

ii. Be installed upstream of pressure sustaining or back pressure valves, where available.

iii. Include double block and bleed valve arrangement to allow easy replacement, calibration and maintenance.

iv. Include a chemical barrier diaphragm seal (gauge guard) to protect the transmitter.

v. Be provided with high-high pressure alarm for dosing pump interlock (where necessary).

7.2.7. Vent Lines (Degassing Arrangement)

Vent / degassing lines shall be provided on the suction lines of the dosing pumps as part of a degassing arrangement for sodium hypochlorite and aqueous ammonia systems. Relying solely on an integrated pump degassing valve for these two chemicals shall not be accepted.

Vent lines shall:

i. Be at least 25mm nominal pipe diameter (to reduce the risk of siphoning).

ii. Be installed at the high point of suction lines and discharge lines.

iii. Return to the top of the vapour space of the tank – returning at least 500mm above the top of the tank to prevent siphoning.

iv. Include an isolation valve with mechanism to lock open. Valve shall be positioned near to the skid and easily accessible.

v. (Should) Include a transparent section at the inlet point to the tank to identify if liquid is transferring through the line.

A de-gassing valve and vent line (complying with the above requirements) should be considered on the pump discharge. This de-gassing valve can:

vi. Be a manual or an automatic valve. For automatic option, [4]solenoid-operated valves should not be used.

vii. Be set to open on start-up and at pre-set intervals (operator adjustable manually or remotely depending on the design need).

viii. Preferably be a vented manual or actuated ball valve, unless an alternate equivalent or better method can be demonstrated.

7.2.8. Pressure Sustaining Valve / Back Pressure Valve

In systems using diaphragm pumps, a pressure sustaining valve (also known as back pressure valve or loading valve) is used to provide a minimum backpressure for effective pump operation and control, and to assist in providing accurate flow meter readings. For other types of positive displacement pumps, the pump manufacturer's recommendation shall be followed for the requirement of a pressure sustaining valve in the dosing skid.

Pressure sustaining valves shall:

i. Be set in accordance with the Designer or suppliers' recommendations or requirements. Where this is not provided, or is unclear, these valves should:

    a. Typically, be set at 100 kPa above the normal operating pressure of the process line.

    b. Be set at a minimum of 200 kPa regardless of point (a) above. Pump supplier recommendations should always be followed.

ii. Be operator adjustable while in operation.

iii. Be selected with types suitable for the design minimum and maximum flow rates.

iv. Include a pressure gauge or transmitter installed upstream to verify operation.

v. Be installed in accordance with and comply with *M-SPE-STD-010 Chemical Dosing Skids*.

An additional pressure sustaining valve along with an upstream pressure gauge should be installed near to the dosing point particularly for the longer dosing lines to encounter pressure and flow fluctuations in the main process line and provide steady chemical flow. This valve may also provide backpressure to the flow meter to

[4] Industry experience has demonstrated sodium hypochlorite crystal formation leads to short lifespan of such valves.

achieve uniform flow under all operating conditions. Generally, this pressure sustaining valve should be set to approximately 50 kPa above the normal operating pressure of the main process line.

7.2.9. Flow Meter

Flow meters shall be installed in the dosing skid preferably in the common discharge line and be part of the chemical dosing pump feedback control loop. Flow meters should be installed upstream of the pressure sustaining valve (where available in the common discharge line) to achieve uniform flows under all operation conditions.

Flow meters shall raise a discrepancy alarm comparing with the set point flow rate. In addition, flow meters should raise high-high and low-low flow alarms. Where needed, the design may consider interlocking the dosing pump from these alarms after assessing the benefits.

A redundant flowmeter may be considered for critical chemicals on a case-by-case basis. Where considered, the second flow meter preferably installed near to the dosing point unless the installation does incur significant additional cost due to extra electrical and control cables or create maintenance issue. The secondary flow meter can raise discrepancy alarms between two flow meter readings and may provide indication of a failed dosing line. Instead of the additional flowmeter, if needed, the design may consider installing a flow switch at the dosing point to identify a failed dosing line.

The design must provide special attention to ensure dosing accuracy with suitable flowmeter sizes particularly for small flow rates. Any potential scale build-up or crystallisation on small bore flowmeters especially for sodium hypochlorite or sodium hydroxide systems shall be managed by routine monitoring and maintenance.

Flow meters shall be installed in accordance with *M-SPE-STD-010 Chemical Dosing Skids,* comply with the requirements of flow meter suppliers' and *M-SPE-STD-009 Flow Meters* including upstream and downstream straight piping requirements.

7.2.10. Chemical Return Line

Chemical return line to the dosing/storage tank shall be included to accommodate chemical return from the pump discharge during commissioning, calibration cylinder and pressure relief valve discharge.

When installed, the chemical return line should:

i. Include a separate flanged nozzle/connection on the topside (roof) of each tank.
ii. Enter the roof of the tank in a vertical orientation and above the overflow crown height.
iii. Be minimum of pipe size DN 25 mm to prevent blockage.
iv. Chemical return lines should avoid low points and, if possible, transfer upward then with a single slight decline into the tank. For additional specific requirements, please refer to Section 7.2.4 (vi) and standard specification *M-SPE-STD-010 Chemical Dosing Skids*.
v. Include a section of removable spool to facilitate tank maintenance.
vi. Include a flushing/draining point to flush/drain the line.

7.2.11. Carrier Water

Carrier water may be used at Seqwater facilities to improve transport characteristics of chemicals across distances, or to enhance mixing.

Where used to improve transfer characteristics, or to increase transfer velocity, carrier water should connect into the chemical dosing line at the end limit of the chemical dosing skid.

Where used for dilution to improve mixing, carrier water should be introduced near the dosing point to minimise any potential build-up area for scaling or precipitation in the dosing lines.

Carrier water systems must have water quality which is equal to or better than that into which chemical is being dosed. Carrier water systems may use potable water or plant water or other suitable water source depending on the application location. Plant water is considered to be a source that has undergone conventional treatment (or similar) to a minimum of sand/media filtration. If used for chemical disinfection or after chemical disinfection, the water source selected must not deleteriously affect treatment or pose an unacceptable risk to treated water.

Careful assessment must be conducted as to whether the selected chemical can be dosed using carrier water. Where carrier water is considered, an appropriate dilution ratio shall be selected to avoid any potential hazards, operational or maintenance issues.

Sulfuric acid must not be dosed using carrier water as it will result in significant heat evolution due to exothermic reactions. Mixing sodium hydroxide with water will also result exothermic reactions. Any rigorous reaction and heat evolution must be considered when designing chemical dosing systems either during mixing or line flushing to ensure personnel safety and material and equipment integrity is maintained.

Seqwater prefers chemicals delivered with high pH such as sodium hypochlorite, sodium hydroxide and aqueous ammonia to be dosed neat to the injection point if desired mixing can be achieved. Mixing these chemicals with carrier water may result in precipitation of calcium carbonate in dosing lines and fittings depending on the carrier water calcium content and dilution ratio.

Where using carrier water is the only option to achieve dilution and mixing for sodium hypochlorite, sodium hydroxide or aqueous ammonia, the benefits of higher dilution ratio with preferable residence time to reduce the calcium precipitation potential must be assessed. If carrier water is needed to achieve mixing in sedimentation basins, basin submersible pumps should be considered to achieve higher dilution ratio (in the order of 100:1 or above) with suitable velocity and residence time to reduce the precipitation opportunity without softening the water.

Careful assessment must also be undertaken for the dosing of liquid ammonium sulfate, liquid aluminium sulfate(alum) or other coagulants using carrier water. If carrier water is selected for alum dosing for mixing, a higher dilution ratio may start hydrolysis reaction thus forming aluminium hydroxide flocs which can cause blockage and reduce the efficiency of the coagulation process.

Where other alternative means are not feasible, carrier water should be softened to a total hardness of about 10 mg/L $CaCO_3$ to reduce the calcium carbonate precipitation potential

The design must address all maintenance and operational issues related with the water softener system including regeneration frequency, regeneration chemical handling, regeneration solution disposal, additional equipment required for the automation and continuous operation of the softener system.

A pressurised ring main should be considered for carrier water source. This should preferably be treated water taken upstream of a chemical disinfection stage and used within the plant.

Where used, carrier water lines shall:

i. Be fitted with manual isolation valves:
   i. One upstream of all fittings after the water off-take.
   ii. One downstream of all fittings to allow maintenance.
   iii. A third valve at the point of connection to any dosing pump discharge line.
ii. (Where needed) be fitted with a Y-strainer with minimum mesh of 0.5mm.
iii. Be fitted with an automatic actuated isolation valve or solenoid valve.
iv. Be fitted with a pressure sustaining valve to ensure consistent feed pressure to the dosing system including upstream and downstream pressure indication.
v. Be fitted with a flow measurement device.
vi. Be fitted with low and high flow switches and alarms which shall only be active when system dosing is active.
vii. Be fitted with an additional non-return valve prior to connection to the chemical dosing line.
viii. Be supplied with a booster pump if the site service water pressure system cannot achieve the necessary pressure and dilution ratio. Booster pumps should consider duty/standby arrangement or a spare pump in the shelf.
ix. Should be capable of providing a minimum dilution ratio of 10:1 of carrier water to dosing chemical as standard. The actual dilution ratio will be dictated by the design.

In addition to the above requirements, where a potable water system is used to supply carrier water it must be fitted with a double layer of backflow protection between the chemical dosing system and the potable water system using:

x. A reduced pressure zone (RPZ) valve shall be used for this – only proprietary back flow prevention devices shall be used.
xi. Double check valves are not considered adequate double layer protection.
xii. Arrangement must comply with the Queensland Plumbing and Wastewater Code and AS/NZS 3500 Plumbing and Drainage Set.

7.2.12. Dosing Lines

Dosing lines refer to pipework transferring liquid chemical from the dosing skid to the dosing point. Dosing lines shall comply with the requirements of *M-SPE-STD-013 Chemical Dosing Piping*.

Dosing lines shall:

i. Be kept as short as possible.
ii. Be double contained from the outside of dosing skid boundary to the dosing point. At the lowest point, the outer covering should be fitted with a sight glass with level indication or connected to a leak detection pit or preferably to the chemical dosing skid bund or other suitable mechanism to identity any potential leak.

iii. Be suitably pressure rated and made of materials immune from chemical corrosion in accordance with *M-SPE-STD-013 Chemical Dosing Piping.*

iv. Include a non-return valve installed immediately upstream of the dosing point.

v. Be installed to minimise the risk of excess dosing occurring because of:

   a. Gravity / siphoning effects

   b. Control valve passing

vi. Include a pressure sustaining valve near the injection point to provide dosing stability for pressure fluctuations in the main process line particularly for long dosing lines. Refer to Section 7.2.8 for guidance in setting pressure of such pressure sustaining valves. Installation of a pressure gauge near the dosing point should be considered to allow pressure monitoring and identification of leaks from dosing lines.

vii. Include an actuated isolation valve positioned as near as possible to the dosing point for automated isolation of the dosing line only where potential siphoning has been assessed when dosing is stopped. This shall comprise the following requirements:

   a. Be upstream of the non-return valve.

   b. Be fitted with open and close position switches.

   c. Be designed with a suitable fail to safe mode for the application.

   d. Appropriate valve opening and closing times need to be considered to start and stop the dosing pump. And the dosing pump shall not start without the valve opening signal.

   e. The design shall assess any potential pressure increase in a section of piping from trapped liquid chemical from gasification or thermal expansion due to the closing of actuated valve and diurnal temperature change. Where needed, the design shall include pressure relief arrangements for such scenarios.

viii. Include retractable dosing spear(s) for dosing into the main with manual isolation valve upstream of and downstream of the non-return valve to allow maintenance of individual lines/spears without affecting dosing capability.

ix. Include the ability to flush and drain the lines.

x. Assess and include appropriate arrangements to contain any foreseeable chemical spills during operations and maintenance of the valves and instruments installed outside the chemical skid near to the dosing points. If the dosing equipment is located inside an enclosure or in a covered dry pit, then a level switch within the enclosure or pit shall be used. This shall be used to identify a chemical leak and shut down the dosing pump.

xi. Be designed to address any potential chemical freezing issue from low ambient temperature and located to provide protection from any potential bushfire issue following the guidelines included in *M-SPE-STD-013 Chemical Dosing Piping.*

Dosing lines should:

xii. Be sized following the velocity requirements provided in 4.8.1, where feasible.

xiii. Consider (where needed) installing a second flowmeter or flow switch near the dosing point as mentioned in 7.2.9 Section.

7.2.12.1. Leak Detection Pit

A leak detection pit or catch pot shall be installed at a low point for a double contained dosing line, unless:

- where chemical dosing skid or dosing pit is located at the lowest point, the dosing skid bund or dosing pit shall be used as a leak detection pit. Where the chemical dosing skid bund is not located at the lowest point, if the selected line type is suitable, it should be assessed to use with the opposite end annular space closed and the dosing skid end opened to the bund for leak detection using the bund sump level switch, or
- the dosing line works under capillary action for leak detection and is equipped with a proprietary mechanism that can generate electrical signals upon detection of leaks.

Where a separate leak detection pit is selected for the design, the double contained dosing line must be ended/drained to the pit for the leak identification and collection of leaked chemicals.

Leak detection pit shall:

i. Include a level switch to indicate presence of chemicals and be installed as low as possible to identify any presence of chemical. Leak detection shall be considered to shut down the chemical dosing system or at least trigger an alarm.

ii. Be made of suitable materials compatible with the chemical and environment. If the pit is in underground, similar conditions stipulated for the dosing pit as per Section 7.2.13.2 shall be applied.

iii. Be sealed to watertight to prevent ingress of rainwater or ground water.

iv. Be sized appropriately for the collection of leaked chemicals considering the line size and length and be able to accommodate a small submersible pump or similar for draining, or an alternate means of draining.

v. Be readily accessible to operators and maintenance personnel as required for inspection and maintenance.

7.2.12.2. Dosing Quills

A retractable dosing quill or spear shall be used for each dosing line to dose liquid chemicals where they are injected into the pipes. The requirement of duty/standby dosing quill should be assessed for maintenance for a single line critical chemical dosing system particularly where there is a potential of scale build-up in quill nozzles.

A dosing quill shall:

i. Include adequate protection with safety chains from being ejected from the pipeline during operation and extraction.

ii. Be retractable / removable from a pressurised process line. The dosing quill shall pass through an integrated ball valve that allows the process line to remain operational while the dosing quill is removed for maintenance.

iii. Be fitted with a check valve, preferably a spring-loaded valve.

iv. Be installed penetrating 25% to 50% of the internal diameter of the line being dosed, measured from the pipe wall.

v. Not be installed immediately downstream of an isolation or modulating valve that may create significant stresses to the assembly during the valve operation.

vi. Have open ended discharge to reduce the chance of blockage from scaling (where applicable).

vii. Be constructed of materials suitable for chemicals, operating conditions, and installation locations. In addition, the design needs to ensure suitable main pipe materials for chemicals to the mixing location where the chemical is dosed.

viii. Be installed at a suitable location with protection, where necessary, to avoid any debris accumulation when used for raw water applications.

ix. Be typically installed upstream or directly on the static mixer, following the static mixer vendor's recommendations, to ensure even dispersion of chemicals as they pass through. However, chemicals that are prone to causing scaling within the static mixer, dosing quills should be installed downstream of the mixer, provided that the mixer design allows it and the mixer vendor recommends it, to maintain effective mixing and prevent build up.

x. Be adequately supported for longer quills or quills in high flow lines to reduce vibration and mechanical stress.

xi. Be installed at a location with no access issues, ensuring easy maintenance, inspection, and replacement. Adequate clearance must be provided for retractable quills when the quill is fully withdrawn.

xii. Be included in the list of periodic cleaning to remove scaling.

Where dosing quills are used in horizontal pipes and mains that may not always be fully flooded while in operation:

xiii. Dosing quills should be installed in the lower half of the pipe, preferably at a 45-degree angle from the bottom part of the pipe, protruding 25% to 50% of the internal diameter of the pipe.

When dosing is not injected into pipes or channels, provision should be made to use spray bar or other methods to provide adequate mixing into process water. If additional mixing is necessary, mixing options as provided in Section 7.2.15 shall be considered.

Separation of dosing quills for chloramine formation

To ensure safe and effective chloramine formation, an appropriate separation distance must be maintained between the dosing quills for sodium hypochlorite (or chlorine gas) and aqueous ammonia (or liquid ammonium sulfate). Direct contact between these chemicals can result in the formation of volatile and toxic chloramine gases, particularly dichloramine and trichloramine. When a static mixer is present, a spacing of 3 to 5 pipe diameters is generally recommended to prevent localised reactions. However, this distance should be carefully optimised based on site-specific operating conditions and the sequence of chemical addition to ensure the timely and efficient formation of monochloramine, which is critical for reliable and consistent secondary disinfection.

7.2.13. Buried Pipes and Dose Pits

The requirements for above ground assets are covered above in this standard and the standards referenced within. Further consideration of below ground assets, including buried pipes and dose pits is discussed in the following two sections.

7.2.13.1. Buried Pipes

All chemical dosing pipework required to be installed below ground shall:

i. Be buried for the minimum distance necessary to minimise the risk of identifying and finding leaks.

ii. Be double contained. Any double containment pipe or system shall be suitable for burying.

iii. Minimise the use of joins as far as practicable to mitigate the potential for leaking.

iv. Eliminate low points in the chemical pipe as well as dual containment pipe to prevent chemical pooling (where possible).

v. Drain to a sump or pit or the dosing skid / chemical storage bund. Pipes shall be run such that dual containment and buried chemical pipes run to a sump or pit or bund and can be freely drained at this location. Refer to Section 7.2.12.1 for the design requirements of a sump or pit.

vi. Where non-metallic pipe is used, include a continuous detectable metal tape placed in the trench on top of the pipe, installed in accordance with the manufacturer's guidance and relevant piping standards. The tape should indicate the pipe content whether by printing the chemical name on the tape or using an agreed colour coding.

7.2.13.2. Dosing Pits

Dosing Pits shall refer to pits used for dosing into or sampling from any buried pipes.

Where possible, an alternative design to a dosing pit using a vertical riser pipe from the underground main to the ground surface should be considered. This alternative design may provide a cost-effective option and eliminate the creation of a confined space.

The riser pipe of the alternative design to encapsulate the retractable dosing quill and associated dosing line shall be fitted with a level switch to detect any chemical leak. The design must ensure reliable provisions to contain any leaked chemical for this arrangement. The design needs to allow for appropriate operation and maintenance activities without imposing any additional load to the main for the riser pipe design. The design also needs to ensure easy removal of dosing pipework and enable backfill around the riser pipe to be easily removed if excavation is required.

Where selected, dosing pits shall:

i. Be made of concrete (pre-cast or formed in situ), and sealed to provide chemical protection, leak tightness, and water tightness.

ii. Be readily accessible to operators and maintenance personnel as required for normal operation.

iii. Include a level switch to indicate ingress of liquid from stormwater or leaking assets. Level switches shall:

    a. Be installed as low as possible to indicate ingress of liquid.

    b. An additional high-high level switch shall be necessary to trigger a shutdown at remote sites, or where submersion of the pit equipment, dosing/sampling points and instrument connection points would lead to damage of equipment, contamination of water, or an environmental release.

iv. Consider designing the edge of the pit above the normal level of the ground to eliminate the chance of any rainwater ingress.

v. Be included with appropriate signage with any potential risk of chemical vapour or fume.

Where sampling from a dosing pit is required, Seqwater's preference is to use an off-take tube or sampling pump to pass process water to an external analyser. This is to reduce access requirements to dosing pits as far as practicable. Where this would result in excessive sample time delay, instruments may be installed in the Dosing Pit. All analysers and transmitters shall be installed outside of dosing pits in appropriate shelters, kiosks, or buildings.

7.2.14. Flushing and Draining

The design shall include provisions of flushing with water (where appropriate for the chemical) using suitable line velocity for chemical dosing skids, dosing lines and tank return lines in preparation of maintenance or equipment removal. The provision shall include flushing dosing lines both from the suction and discharge sides of chemical dosing pumps. Flushing or drainage points shall be provided at various locations and shall be designed to collect dosing lines flushed water near to dosing points for disposal, as the flushed water must not be directed to the mains or basins due to adverse impact to water quality. Normally, each flushing and draining point are fitted with an isolation valve and a camlock fitting.

The design should consider flushing the line using the dosing pumps. The maximum pressure built-up in the piping during flushing must be considered in the design. Set points of pressure relief valves and pressure sustaining valves, and other pressure set points along with the site service water maximum pressure must be considered in the development of the flushing procedure.

Service water or site water used for flushing shall be equipped with appropriate isolation valves, pressure regulators, pressure, and flow devices, as appropriate for the design. The design needs to ensure a double layer of backflow protection system upstream of flushed water connection points where potable water is used similar to the requirements provided in Section 7.2.11 for carrier water.

Check valves on the dosing pump suction lines are normally not recommended as a means to prevent inadvertent service water flow back to chemical dosing tanks during flushing. This is to avoid any additional head loss in the suction line for normal dosing operation. Where check valves are considered, the pump manufacturer must be consulted for suitable check valve types. If selected, the check valves shall include low pressure springs to reduce pump suction side pressure losses. The spring opening pressure should generally be within the range of 0.1 to 0.2 bar.

The design shall assess the need to keep provisions of chemical cleaning for the dosing line from any potential scaling considering long term applications.

A risk assessment must be conducted involving each step of the adopted flushing procedure to avoid any inadvertent consequence from line flushing. Sulfuric acid or hydrochloric acid or sodium hydroxide mixing with water during flushing can provide exothermic reactions resulting in heat evolution and may create a significant hazard. Rapid heat evolution must be considered for each flushing scenario and must be prevented this in the design and operations of dosing systems to ensure personnel safety and the integrity of material and equipment.

The other requirements for draining and flushing shall comply with *M-SPE-STD-010 Chemical Dosing Skids* and *M-SPE-STD-013 Chemical Dosing Piping.*

7.2.15. Chemical Mixing

Good mixing is critical for chemical dosing in water treatment plants because it ensures that the added chemicals interact efficiently and uniformly with the water being treated. Poor mixing leads to inefficient treatment, potential operational and water quality issues, and chemical waste.

This section refers to the various modes of mixing employed to ensure uniform dispersion of dosed chemicals in water. This standard does not discuss modes of mixing for flocculation.

The following primary modes of mixing apply to existing Seqwater sites:

i. Channel Mixing

ii. Static Mixing
iii. Recirculation / Jet Mixing
iv. Mechanical Mixing
v. Spreader Bars.

The Designer should carefully evaluate and select the most appropriate mixing mode for each specific application considering a range of factors including supplier guidance, technical performance data, process requirements, and the full range of operational conditions the system will encounter.

The selected mixing strategy must ensure effective and reliable performance across the entire range of plant flows, including both peak and minimum turndown scenarios, to maintain consistent process outcomes.

All mixer installations should be designed to achieve effective mixing within a short distance downstream of the injection point. All modes of mixing should generally achieve a coefficient of variation (CoV) of 0.05 or less within five pipe or channel diameters downstream of the mixer. The CoV is a statistical measure of mixing uniformity, with lower values indicating better homogeneity of chemical or physical dispersion.

Alternatively, or in addition, the mixing system may be designed based on mixing energy, commonly expressed as the G-value (velocity gradient, in s^{-1}). This parameter is especially useful in the design and control of mixing intensity for different process objectives. For example, coagulation processes require rapid or high-energy mixing (high G-values, typically 700–1000 s^{-1}) to ensure immediate dispersion of coagulant chemicals and effective destabilisation of suspended particles. In contrast, flocculation requires gentle, low-energy mixing (low G-values, typically 20–80 s^{-1}) to promote the aggregation of particles without breaking apart the forming flocs.

7.2.15.1. Channel Mixing

Channel mixing may include:

i. Flume or weir used to produce a standing wave
ii. Static mixer installed in a channel

Flume / Weir (Hydraulic Jump)

Mixing in a channel may be achieved through either local restriction (e.g. flume / weir) and change in floor level to achieve a supercritical flow (via hydraulic jump).

A hydraulic jump and standing wave must exist at all times under all flow conditions. A Froude Number (Fr) of at least 2.5 should be achieved for all flow conditions.

The dosing point should be into the base of the weir where plunging water flows enter the receiving volume.

If the weir width exceeds 500 mm, a sparger with multiple dosing points along the width of the weir may be required.

Static Mixer (Channel)

Channel mixing may be improved or achieved over a shorter distance if a static mixer is installed in the channel. A CoV of 0.05 or better should be achieved within five channel widths downstream of the mixer.

Advice should be sought from the supplier for sizing, spacing and design requirements.

Static channel mixers should only be used if the design guarantees debris and blockage of the mixer can be prevented.

7.2.15.2. Static Mixing (Pipe)

Static mixing shall be the preferred method of chemical dosing for dosing systems into pipes.

Static mixers shall:

i. Be installed in accordance with the manufacturer/supplier's requirements for upstream and downstream diameter clearances from injection points and other fixings to achieve the required mixing. Proprietary integrated dosing points are acceptable. See further information about dosing quills in Section 7.2.12.2.
ii. Be designed to achieve a coefficient of variation (CoV) of at least 0.05 at the mixer outlet (where applicable) across the required process operating range.
iii. Be designed to minimise head loss across the mixer.
iv. Include flanged connections to facilitate easy removal and maintenance or replacement.

Care should be taken to ensure good dispersion and rapid mixing is achieved when mixing alkalis in (e.g. sodium hydroxide) where alkalinity may exceed 10mg/L as $CaCO_3$. This may result in calcium carbonate scale forming on the mixer vanes.

Seqwater has a history of aluminium hydroxide and aluminium sulfate deposition in static mixers affecting performance. Ferric salts may also result in hydroxide precipitation on the elements. Static mixers shall therefore include provision for visual monitoring of pressure drop across the static mixer body. Monitoring of pressure drop shall be visible locally, and consideration should be given to making pressure drop visible remotely. The provided delta pressure methodology shall not negatively influence the operation of the static mixer.

The selection of large static mixers should consider the inclusion of nozzles for a maintenance clean in place arrangement to be used for removal of scale and fouling. Physical removal and access for cranes, cradles or similar may be difficult or introduce unnecessary manual handling.

Static mixer suppliers should be consulted for guidance and selection of appropriate mixers

Static mixers may not be suitable for pipes with extremely high turndown ratios. The Designer shall take this into consideration and may consider alternate mixing methodologies, parallel streams, or the use of carrier water. Where appropriate, Computational Fluid Dynamics (CFD) modelling should be undertaken to assess chemical mixing effectiveness under all anticipated flow conditions, taking into consideration the mixer type and dosing quill locations, and operational parameters.

Refer to *M-SPE-STD-001 General Mechanical Specification* and *M-SPE-STD-013 Chemical Dosing Pipe Specification* for additional detail on fitting requirements.

7.2.15.3. Recirculation / Jet mixing

This mode of mixing relies on taking a small percentage of the plant flow returning it to process stream at a defined point. This may be achieved in open channel processes by returning the flow via a pipe through an orifice and onto a plate in the mixing chamber or directing it against the feed flow to create turbulence.

Where a plate is used, the plate shall be removable for cleaning and maintenance.

Mixing may be achieved in a pipe by taking the upstream or downstream flow, dosing into the off-take line, and returning the off-take downstream or upstream respectively of the mixing pump into the process line.

Recycle ratios returning downstream flow usually fall somewhere in the vicinity of 2-8%. Literature identifies a range of figures, more typically 4-7%.

If jet mixing is used in a channel, the jet should be sized using a momentum flux ratio of 0.5 – 1 (ratio of the momentum flux of the channel / momentum flux of the jet).

The system including jet pump suction line and pump position shall be selected to avoid entrainment of air into the jet stream.

Reinforcement at the point of jet injection (e.g. a steel plate) shall be provided if necessary, to prevent erosion of channels or pipes.

The mixing may be achieved by either gravity flow or pumping depending on site hydraulics.

If a pump is used, the jet mixing pump:

i. Should be provided with duty/standby capability or with a spare pump in the shelf.
ii. Where necessary, should be controlled using a control valve or a variable speed drive for mixing optimization over the full range of flow rates.
iii. Should be capable of isolating the pump from the main process stream if mixing is not required.
iv. Shall include a non-return valve on the pump discharge.
v. Shall be protected from low pressure/flow or no flow with suitable instruments.
vi. May be submersible or above ground.

Static mixing is preferred over jet mixing where practicable due to the reduced maintenance and operational requirement of the pump.

7.2.15.4. Mechanical Mixing

Here mechanical mixing is used to refer to a vertical type of mixer with motor, possibly a gearbox, shaft and propeller. Mechanical mixers shall generally not to be applied at Seqwater sites in liquid chemical dosing systems for the purpose of dosing chemicals.

Mechanical mixers may be used for maintaining a homogenous chemical in bulk storage or dosing tanks. They may also be used in batching systems. Where used, installations shall be designed to provide sufficient residence time in the mixing chamber, minimizing dead zones, and preventing inconsistent chemical quality.

Mixers shall not be mounted to tank roofs unless the structure is specifically designed to support the mixer, it's weight, and any forces generated. Mixers shall be removable from tanks without the need to remove the roof in its entirety.

Mixer blades shall be designed to provide uniform velocity across the full diameter and operate without cavitation. Blades shall be of one-piece construction, connected to the shaft via a keyway or a welded hub, and retained via mechanical means that prevents detachment or loosening due to rotation and vibration.

Wetted and non-wetted components shall be suitable for contact with the process chemicals, and the environment resulting from containment of the chemicals.

Mechanical mixers shall be capable of delivering varied shear rates to the fluid by way of variable speed drive, or stepwise speed adjustment. Mixing speed shall be operator adjustable.

7.2.15.5. Spreader Bars

Spreader bars are used to provide an even distribution of chemical to an open surface of water. They have typically been used by Seqwater in the application of chemicals used for flocculation aids, pre-gravity filter liquid chemicals of sodium hypochlorite and sodium hydroxide dosing in sedimentation basins. They should not be considered as a preferred method of chemical dosing.

Due to the hazards that may be introduced because of spraying chemicals, the designer shall consider measures with suitable injection nozzle/pipe design, appropriate dilution to mitigate and manage these risks and ensure the safety of personnel, plant, and the environment.

Spreader bars and associated balance of plant should include the followings:

i. A continuous, isolatable, and removable pipe manifold installed along the width of the water body, with perforations of multiple short, branched lines to allow diluted chemical to be sprayed onto the surface of the water. The spreader bar should be removable in manageable sections.

ii. A fixed speed carrier water pump is to deliver dilution / carrier water to the manifold. Due to the large volume of carrier water that may be required, clarified raw water or settled water should be considered as the source, delivered using a basin submersible pump. Where possible, the design should aim to reach the favourable resultant solution pH with appropriate dilution to reduce/eliminate the driving force for calcium carbonate precipitation for high pH chemicals of sodium hypochlorite and sodium hydroxide. Otherwise, requirements per Section 7.2.11 should apply.

iii. A flow meter or flow switch at the pump discharge with low flow alarms.

iv. Where necessary, a backpressure valve, installed at the pump discharge.

v. A pressure gauge at the beginning of the spreader bar prior to any nozzle to validate operation.

vi. A dosing pump and dosing line arrangement to deliver bulk chemical to the spreader bar assembly. Injection quills are typically not required in this instance.

vii. A throttling valve and/or orifice plate in each branched line to ensure equal distribution of flow rates. Each branched line may have multiple injection points.

viii. Each branched line is recommended to have open ended discharge with 8-10 mm size to reduce the chance of blockage from scaling.

The designer should consider scale formation because of high pH chemicals addition to carrier water and how it can be mitigated, such as ensuring a suitable high velocity and low residence time in the spreader bar, but without compromising appropriate mixing within the spreader bar. Spreader bars and injection manifolds should be designed with disassembly and maintenance in mind to facilitate safe and easy removal/reinstatement for manual and chemical cleaning.

The selected pipe materials used shall be rigid, compatible with the chemicals used, and suitable for removal and cleaning on a regular basis by maintenance personnel.

7.3. Chemical Analyser

As appropriate, at least one chemical or pH analyser shall be installed downstream of the dosing point where adequate mixing has been taken place. The chemical analysers shall be used to raise alarms or interlocked with the dosing pump as a safeguard against overdosing or underdosing scenarios.

Where needed, depending on the process criticality of the concerned chemical, a second analyser should be considered to monitor and control the performance of the dosing system.

A feedback trim for chemical dosing instead of direct feedback control from the dosing point downstream analyser is generally recommended.

This Standard Specification does not specify the type of analyser for each liquid chemical. For the design and construction of analyser sample water line and sample hut, refer to *I-SPE-STD-015 Instrumentation, Water Quality Analyser Standard P&ID drawings B-DWG-STD-00041 to B-DWG-STD-00045,* and other relevant Seqwater Standard Specifications.

The design must include HACCP alarms from analysers following recommendations provided in *SPE-00320 WTP and Supply System Process Validation Standard*.

7.4. Pressurised Ring Main Dosing Arrangements

This dosing arrangement should only be considered where dosing is required to multiple locations separated by long distances where excessive numbers and multiple sized positive displacement pumps may be required.

A Standard P&ID drawing arrangement including the ring main chemical dosing system is referenced in Section 11.

Systems employing dosing with a pressurised ring main shall include:

i. Where multiple tanks are used, a combined inlet manifold to the dosing pumps.

ii. A combined pump outlet manifold.

iii. A pump skid including:

   a. Duty / standby centrifugal pumps to maintain a constant ring main pressure.

   b. Suction-side Y-strainers

      1. Duty / standby arrangement with a bypass line

      2. Minimum of 0.5mm mesh size.

   c. Pump discharge non-return valve.

   d. A pressure transmitter and a pressure gauge with chemical barrier diaphragm.

   e. A suction-side and discharge-side manual isolation valve for each pump – discharge isolation valve downstream of non-return valve.

iv. A common return / recycle line returning to bulk storage fitted with an orifice to allow constant recirculation and to maintain the minimum flow for the selected pumps and prevent the system stagnating when there is a low dosing demand. The return tank(s) shall be operator selectable from among all bulk storage tanks.

v. Each dosing line should include:

   a. A single dosing point and withdrawable dosing spear/quill (where suitable).

b. A flow control valve.

c. A flowmeter.

d. Manual isolation valves.

e. A backpressure valve / pressure regulating valve near to the dosing point to ensure smooth dosing to encounter fluctuations in main pressure and flows.

f. An actuated isolation valve, where siphoning may occur after the stoppage of dosing.

g. An optional low flow switch near the dosing point may be considered to assist in identifying a failed dosing line or blocked dosing quill (where used) for long dosing lines.

vi. A non-return valve installed immediately upstream of the dosing point.

vii. Chemical mixing device or arrangement.

Refer to Section 7.2 for details regarding specific components of dosing systems. Where pressurised ring main components differ, they are discussed in the following sub-sections.

7.4.1. Centrifugal Recirculation Dosing Pumps

A minimum of 1 duty and 1 standby pump shall be provided in all circumstances. Due to the operation of a ring main system, plant availability and criticality requirements shall be used to determine the total number of standby pumps. Dosing pumping systems shall be capable of achieving:

i. 100% duty/standby.

ii. The pump maximum flow at least 110% of the Instantaneous Maximum Dose requirement at Instantaneous Maximum Plant Design Flow plus the tank recirculation/return flow.

iii. The pump minimum flow at 90% of the Instantaneous Minimum Dose requirement at Minimum Plant Design Flow or simply the tank recirculation/return flow, as appropriate.

Centrifugal pumps shall:

iv. Include variable speed drives (VSDs) for variable control of ring main pressure or flows.

v. Be selected to avoid chemical damage to pump components and avoid spills.

Dosing pumping systems shall be designed to provide duty rotation which shall comply with the requirements detailed in *I-SPE-STD-013 Control Systems Design and Construction*.

7.4.2. Control Valves

Control valves will be used for controlling pressurised ring main dose rates.

A minimum of 1 control valve shall be provided per dosing line. Standby capability shall ensure 100% of the duty arrangement can be achieved when combined with duty/standby dosing lines, if included by the design.

Control valves shall be:

i. Selected to allow smooth flow control over the dose range.

ii. Installed downstream of dosing flow meters to minimise flow disturbances that could affect readings.

7.5. Emergency Stop (E-Stop)

Designers should consider whether E-stops are required on the dosing system via application of an appropriate engineering-based risk assessment and reference to *AS/NZS 4024 Safety of Machinery relevant series*. The location of such devices shall be determined by the designer, considering the identified risks and access constraints. Emergency Stop performance category and design must comply with the requirements of *E-SPE-STD-001 Electrical Design and Construction and relevant Australian Standards*.

8. Liquid Chemical Transfer System

Chemical Transfer System refers here to a system in place to transfer chemical from bulk storage to another storage tank, batch tank, day tank or dosing tank. Seqwater prefers dosing of liquid chemicals directly from bulk storage tanks.

Chemical transfer may be achieved via gravity or pumping. Where gravity transfer can be achieved, this shall be the preferred method. The transfer system must be installed within a skid like chemical dosing skid.

Only requirements specific to Transfer Systems are included in this section.

Standard P&ID Drawing arrangement including the liquid chemical transfer system is referenced in Section 11.

8.1. General Requirements

Transfer systems shall include the following.

i. Where multiple bulk storage tanks are available, a combined pump skid inlet manifold.

ii. Where transfer can be achieved via gravity:

   a. Suction-side Y-strainers

   b. Manual isolation valves near the bulk storage tank(s) outlets, and near the receiving tank inlet.

   c. An actuated valve near the delivery tank's outlet.

   d. An actuated valve positioned near the receiving tank inlet.

   e. A flow meter for metering of transferred fluid.

   f. A degassing or venting arrangement for systems transferring sodium hypochlorite or aqueous ammonia.

   g. Flush / drain lines and connection points.

iii. Where transfer cannot be achieved via gravity, a transfer pumping skid, including:

   a. Suction-side Y-strainers:

   b. Duty / standby centrifugal transfer pumps.

   c. Discharge and suction side pump isolation valves.

   d. Pump discharge non-return valve for each pump.

   e. Discharge side pressure indication (e.g. pressure gauge).

   f. A suction-side and discharge-side manual isolation valve for each pump – discharge isolation valve downstream of non-return valve.

   g. A flow meter for metering of transferred fluid.

   h. A degassing or venting arrangement for systems transferring sodium hypochlorite or aqueous ammonia.

   i. Flush / drain lines and connection points.

j. If required, a pressure relief valve (unlikely to be required in a centrifugal pumping arrangement).

iv. Automated operation, including instrumentation required to initiate and stop chemical transfer. Refer to Section 9.2.4 for detail.

Except where the content of Section 8 of this document describes otherwise, the requirements of any components of pumped transfer systems shall generally meet those stipulated in Section 7.2 for Dosing Systems.

Where more than one destination tank for transferred chemical exists, only one tank shall be transferred to at a time.

Whether transferring via gravity or pump, the design shall consider the effects of surge and pressure waves. Slow acting valves may be necessary to prevent surge events occurring, particularly with fixed speed pumps.

The chemical transfer skid must be designed and installed such that transfer pumps (if used) and other electrical components are above the bund 110% full line as per this standard and *M-SPE-STD-010 Chemical Dosing Skids*.

Refer to *M-SPE-STD-010 Chemical Dosing Skids* for detailed requirements of the skid and its skid components as identified above.

8.1.1. Suction Lines

Suctions lines shall generally comply with the requirements of Section 7.2.1, except:

i. Y-strainers need only include 1-2 mm aperture mesh for pump protection.

8.1.2. Transfer Lines

Transfer lines shall comply with the requirements of *M-SPE-STD-013 Chemical Dosing Piping*.

The transfer line should consider including a return line to the bulk chemical storage tank(s) to allow stagnant chemical to be circulated (where needed), and to facilitate commissioning activities.

8.1.3. Transfer Pumps

Transfer pump systems shall provide 100% duty / standby pumping capability.

Transfer pumps should:

i. Be centrifugal type pumps with the feature to minimise the risk of chemical leaks and damage to pumps.

ii. Be capable of completing their transfer task in 1 to 2 hours.

iii. Operate at fixed speed unless there is sufficient reason to install them with soft start, VSD, or similar.

iv. Be selected such that they cannot exceed the rated pressure of the lowest pressure rated pipe or fitting in the system, even when pumping against a closed system

v. Include duty rotation in accordance with the requirements detailed in *I-SPE-STD-013 Control Systems Design and Construction.*

8.1.4. Emergency Stop (E-Stop)

Refer to Section 7.5 for this requirement.

9. Process Control Requirements

I-SPE-STD-013 Control Systems Design and Construction provides the minimum technical requirements for the procurement, design, installation & construction of control systems inclusive of PLCs, SCADA, communications and ancillary equipment.

A Functional Description for the Unloading, Storage, Transfer and Chemical Dosing System(s) shall be developed to cover control requirements in detail. Functional Descriptions shall use the following standards and templates as necessary:

- B-SPE-STD-005: Functional Description Documentation
- I-TMP-STD-001: Functional Description Part A
- I-TMP-STD-005: Functional Description Part B
- I-SPE-STD-013: Control Systems Design and Construction

Equipment Control Modes, Process and Start Permissives, Trip Interlocks, and Hardware/Hardwired Interlocks as discussed in the following sections are defined in *I-SPE-STD-013 Control Systems Design and Construction*.

9.1. Control Modes

Control systems shall support Equipment Control Modes and Dosing Control Modes.

Equipment control modes are defined as:

i. Local – plant may only be operated in the field independent of the control system. In this mode, only hardware/hardwired interlocks remain active.

ii. Remote Manual – plant may only be operated manually from HMI under control of the MCS. In this mode, hardware/hardwired and trip interlocks remain active.

iii. Remote Automatic – plant is controlled by the control system. In this mode, hardware/hardwired and trip interlocks, process and start permissives remain active.

The standard Dosing Control Modes to be considered in design include:

1. Fixed Speed – operator inputs the pump speed to a percentage output of the maximum pump speed.
2. Fixed Percentage – (control valves) operator inputs the control valve opening as a percentage of the maximum valve opening position.
3. Fixed Flow – operator inputs chemical flow in L/h. This mode can have the following options:
    - Fixed flow without any feedback – the controller output as pump flow for calibrated pumps.
    - Fixed flow with chemical flowmeter feedback – the controller output as pump speed or valve position for non-calibrated equipment with chemical flowmeter feedback.
4. Flow Paced – operator inputs chemical dose in mg/L. The controller first calculates the set point of chemical flow (L/h) based on the dose rate setpoint and main process/water flowmeter. For some applications, the feed water initial chemical concentration (mg/L) is deducted from operator input dose rate (mg/L) to calculate the chemical flow set point (L/h). This scenario as primarily applicable for secondary disinfection and supply system dosing system is not repeated for each case control mode mentioned in Table 7.

This set point chemical flow (L/h) is then used to set the pump flow/speed or valve position with the following options:

- Flow paced without any feedback.
- Flow paced with chemical flowmeter feedback (with or without trim limits).
- Flow paced with analyser trim feedback.
- Flow paced with chemical flowmeter and analyser trim feedback.
- Flow paced with chemical flowmeter trim and analyser trim feedback.

5. Ratio Control – operator inputs the mass ratio of the chemical to be dosed to another chemical already dosed (typically Cl_2 to NH_3-N ratio in chloramination). The controller receives the dose rate (mg/L) of the reference chemical and first calculates the setpoint for the chemical to be dosed in mg/L. It then calculates a flow rate in (L/h) using the main process/water flowmeter. This chemical flow is then used to set the pump speed or valve position as per above Flow Paced control modes.
6. Pressure Set Point – This mode applies to a ring main system and operator inputs a pressure set point to maintain the ring main pressure. The pump speed will continually adjust up or down to ensure the pressure setpoint is maintained within an acceptable margin. A pressure deviation alarm may be available (e.g. if pump at max speed and pressure not achieved).

The tables in the following sections summarise the different Dosing Control Modes for positive displacement dosing systems, ring main dosing systems, chemical transfer systems, and for isolation valves. Automatic Dosing Control Modes as summarised in the tables will only be available when all equipment is in Remote Automatic Equipment Control Mode. In Local/ Remote Manual Modes, the pump speed / valve position is set manually / locally.

Equipment and devices shall be programmed to include Disable and Maintenance Functions as described in *I-SPE-STD-013*. All instruments shall be programmed to include Instrument Calibration Functions as described in *I-SPE-STD-013*.

9.1.1. Positive Displacement Pump Dosing

Table 7 summarises the Equipment and Group Control Modes suitable for positive displacement pump dosing systems. The design shall select the control modes suitable for the system.

Table 7 Typical Positive Displacement Operating and Control Modes

Equipment Control Mode	Dosing Control Mode	Description
Local	N/A	Operator enters pump speed in the field. Pump operates at the designated Fixed Speed
Remote Manual	N/A	Operator enters pump speed remotely from SCADA. Pump operates at the designated Fixed Speed.
Remote Automatic	Fixed Speed	Operator inputs the pump speed to a percentage output of the maximum pump speed. When this mode is selected, it is recommended a timer is incorporated to trigger an operator alert upon timeout to manage the risk of indefinite operation in this mode.

Equipment Control Mode	Dosing Control Mode	Description
	Fixed Flow	Operator inputs chemical flow in L/h. The controller output as pump flow or pump speed is set as described above.
	Flow Paced without any feedback	Operator inputs Chemical Dose Rate (mg/L). The controller calculates the set point of chemical flow (L/h) from the input dose rate and main process/water flow meter. It then calculates the pump speed from the calibrated pump curve. The pump curve needs to be updated for any changes in stroke length (where applicable). Seqwater favours *Flow Paced with Chemical Flow Trim Feedback* (see below) over this mode where analyser trim is not required.
	Flow Paced with Chemical Flowmeter Feedback	Operator inputs Chemical Dose Rate (mg/L). The controller calculates the set point of chemical flow (L/h) from the input dose rate and main process/water flow meter. It then uses the flowrate measured by the chemical line flowmeter to achieve the pump speed for the set point flowrate and adjust the pump speed as required. This is Seqwater's preferred dosing control mode where linear calibrated pump curve is not available or cannot be achieved and analyser trim is not required The chemical flow meter on the dosing line can also be used to raise flow deviation alarms from the set point if the expected flow is not achieved in a pre-set period.
	Flow Paced with Chemical Flowmeter Trim Feedback	Operator inputs Chemical Dose Rate (mg/L). The controller calculates the set point of chemical flow (L/h) from the input dose rate and main process/water flow meter. It then uses the calibrated pump curve and the flowrate measured by the chemical line flowmeter and to achieve the pump speed for the set point flowrate and adjust the pump speed as required. If using this mode, the trimmed flow rate from the flowmeter should be limited to ± 20% of calibrated pump curve. This is limited to overcome major deviations from flowmeter readings. For this mode, the pump curve needs to be updated for any changes in stroke length for diaphragm pumps. Therefore, this mode is not

Equipment Control Mode	Dosing Control Mode	Description
		recommended where pumps are not fitted with servo motors or manual stroke adjustments are needed. This is Seqwater's preferred dosing control mode where linear pump curve is available, analyser trim is not required, and manual pump stroke length adjustment is not needed.
	Flow Paced with Analyser Trim Feedback	Operator inputs Chemical Dose Rate in mg/L. Operator also inputs downstream target Chemical Analyser Setpoint in mg/L or pH. The controller operates a control loop targeting the analyser setpoint. The output of this control loop is limited (or trimmed) to a percentage of the operator chemical dose rate. The controller then calculates the set point of chemical flow (L/h) based on the dose setpoint, the analyser control loop output and main process/water flowmeter. This chemical flow is then used to set the pump flow/speed from calibrated pump curves. If using this mode, the trimmed dose rate from the analyser feedback should be limited to ±10% to 20% of operator chemical dose rate. This is limited since the long-time reliability of an online analyser is low in a continuous system. For this mode, the pump curve needs to be updated for any changes in stroke length for diaphragm pumps (where not fitted with servo motors). Seqwater prefers the use of *Flow Paced with Chemical Flow Feedback and Analyser Trim* (see below) dosing control mode over this control mode.
	Flow Paced with Chemical Flowmeter and Analyser Trim Feedback	This mode combines the requirements of the following control modes: • Flow Paced with Chemical Flowmeter Feedback (with or without trim) • Flow Paced with Analyser Trim Feedback Operator inputs Chemical Dose Rate in mg/L. Operator also inputs downstream target Chemical Analyser Setpoint in mg/L or pH. The controller operates a control loop targeting the analyser setpoint. The output of this control loop is limited (or trimmed) to a percentage of the operator chemical dose. The controller then calculates the set point of chemical flow (L/h) based on the dose setpoint, the analyser control loop output and main process/water flowmeter. This chemical flow is then used to set the pump flow/speed with the chemical flow meter feedback when no trimming from flow meter is included.

Equipment Control Mode	Dosing Control Mode	Description
		Otherwise, it uses the calibrated pump curve and the flowrate measured by the chemical line flowmeter limited to ± 20% of trimming of the calibrated pump curve to set the pump speed. If using this mode, the trimmed dose rate from the analyser feedback should be limited to ±10% to 20% of operator chemical dose rate. This is limited since the long-time reliability of an online analyser is low in a continuous system. This is Seqwater's preferred dosing control mode where analyser trim is used.
	Ratio Control	Refer above for the description of Ratio Control mode. This mode may be combined with chemical flow meter and analyser trim feedback as described above.

9.1.2. Pressurised Ring Main Dosing

In ring main dosing systems, the ring main pumps and dosing line flow control valves operate in separate control loops. Table 8 describes the dosing control modes for the flow control valve, while Table 9 describes the control modes for the ring main pumps.

Table 8 Typical Ring Main Dosing Line Control Modes

Equipment Control Mode	Dosing Control Mode	Description
Local	N/A	Valve open position as percentage of maximum opening is set (%). System operates at set control valve position.
Remote Manual	N/A	Valve open position as percentage of maximum opening is set (%) via SCADA. System operates at set control valve position.
Remote Automatic	Fixed Flow	Operator inputs chemical flow in L/h. The controller determines the valve opening position with the chemical flowmeter feedback. Starting from a fixed position, the controller will output a starting control valve position. The controller will then output control valve positions in step-wise increments until the measured flow achieves the setpoint flow.

Equipment Control Mode	Dosing Control Mode	Description
	Flow Paced with Chemical Flowmeter Feedback	Dose Rate is input (mg/L). The controller calculates the set point of chemical flow (L/h) from the input dose rate and main process/water flow meter. The flowrate measured by the chemical line flowmeter are used to adjust the control valve position as required and maintain the chemical flow rate. This is Seqwater's preferred dosing control mode where analyser trim is not required. The chemical flow meter on the dosing line can also be used to raise flow deviation alarms from the set point if the expected flow is not achieved in a pre-set time period. Consider limiting control valve 'flow-seeking' to no more than ±10% by ratio of the calculated chemical flow rate, alarming if the dosing flow meter does not achieve this within a pre-set duration.
	Flow Paced with Chemical Flowmeter Feedback with Analyser Trim	Operator inputs Chemical Dose Rate in mg/L. Operator also inputs downstream target Chemical Analyser Setpoint in mg/L or pH. The controller operates a control loop targeting the analyser setpoint. The output of this control loop is limited (or trimmed) to a percentage of the operator chemical dose. The controller then calculates the set point of chemical flow (L/h) based on the dose setpoint, the analyser control loop output and main process/water flowmeter. This chemical flow is then used to adjust the control valve position with the chemical flow meter feedback. If using this mode, the trimmed dose rate from the analyser feedback should be limited to ±10% to 20% of operator chemical dose rate. This is limited since the long-time reliability of an online analyser is low in a continuous system. This is Seqwater's preferred dosing control mode where analyser trim is used. The chemical flow meter on the dosing line may be used to raise flow deviation alarms from the set point if the expected flow is not achieved in a pre-set time period.

Table 9 Ring Main Pump Control Modes

Equipment Control Mode	Dosing Control Mode	Description
Local	N/A	Where variable speed pumps are used, pump speed is manually set local to the pump. The pump operates at the designated speed. For fixed speed pumps, the pump is simply switched to 'on'.
Remote Manual	N/A	Where variable speed pumps are used, pump speed is manually entered into SCADA. The pump operates at the designated speed. For fixed speed pumps, the pump is simply switched to 'on'.
Remote Automatic	Fixed Speed	Where variable speed pumps are used, pump speed is entered into SCADA. The pump operates at the designated speed.
	Pressure Setpoint	Where variable speed pumps are used, the pressure setpoint (kPag) is entered into SCADA. The controller receives a pressure measurement from the ring main pressure sensing device and outputs a pump speed. The pump speed will continually adjust up or down to ensure the pressure setpoint is maintained within an acceptable margin. A pressure deviation alarm may be available (e.g. if pump at max speed and pressure not achieved) within a set time period. This is the preferred pump control strategy for the ring main system.

9.1.3. Chemical Transfer

Chemical transfers may be via a pumped transfer system, or a gravity drain system where elevation allows.

9.1.3.1. Chemical Transfer by Gravity

A gravity transfer system will be controlled using actuated isolation valves. Table 10 summarises the Equipment and Group modes suitable to gravity transfer systems.

Table 10 Typical Gravity Chemical Transfer System Operating and Control Modes

Equipment Control Mode	Description
Local	The operator actuates the isolation valve(s) locally to allow and control chemical transfer.
Remote Manual	The operator actuates the isolation valve(s) remotely to allow and control chemical transfer.
Remote Automatic	The actuated valves will actuate automatically when a chemical transfer is called by the control system. This call will be triggered by an operator-set low level being attained in the destination tank. When a programmed tank high-level is reached, the actuated isolation valve(s) will close, stopping the transfer.

9.1.3.2. Chemical Transfer Using Pumps

Table 11 summarises the Equipment and Group modes suitable to pumped transfer systems.

Table 11 Typical Chemical Transfer Pump Operating and Control Modes

Equipment Control Mode	Description
Local	The operator may actuate the isolation valves at the valve locations. The operator starts / stops the pump as required at the pump location.
Remote Manual	The operator may start / stop the pump as required. The operator may actuate the isolation valves remotely.
Remote Automatic	Transfer pumps will generally operate at a fixed flow rate (fixed speed pumps). When a tank reaches a programmed operational low level set point, a transfer will be initiated. The control system will actuate (open) isolation valves in the transfer line. And then initiate the transfer pump(s). The pumps will operate at a fixed speed, stopping when the tank operational high-level setpoint is triggered. Once the transfer is complete, the actuated valves will close, isolating the line. This is the preferred control strategy for pumped transfer systems.

9.1.4. Actuated Isolation Valves

Table 12 summarises the Equipment Control Mode suitable to actuated isolation valves.

Table 12 Typical Actuated Isolation Valve Operating and Control Modes

Equipment Control Mode	Description
Remote Manual	The operator will be able to modulate the actuated isolation valve between open and close to isolate systems or tanks.
Remote Automatic	Isolation valves will open and close based on system demands, faults/alarms, and interlocks.

9.2. Process Control Narratives

9.2.1. Chemical Delivery / Unloading

The following describes a typical process control philosophy for the chemical unloading and delivery system. This should be read in conjunction with Section 5 and Section 6 of this document. The order of operator actions is indicative only and should be reviewed on a site-by-site basis.

Normal Operation

Prior to completing an unloading operation, an operator shall need to enable the relevant chemical specific LCP and select a specific tank in SCADA if this function has been incorporated. A timer shall be included with this SCADA selection considering the approximate time that may need to complete a tank unloading.

Once a delivery tanker is in position, the operator will open the appropriate manual valve from the unloading area sump (in a valve pit) to the appropriate CSHT and close the storm water valve. It the CSHT diversion and stormwater valves are actuated, they should be operated from a local valve operation panel next to the valve pit.

The control system will need to register the CSHT diversion valve in an ‘open’ position and storm water valve in ‘close’ position to allow energisation of the SPO. The delivery personnel shall select ‘ON’ button on the applicable unloading LCP to enable the panel.

The delivery personnel connect the tanker hose to one of the bulk storage tank fill line connections and then open the manual isolation valve on the relevant tank’s fill line. The delivery personnel shall then connect the truck power cable to the relevant SPO at the Unloading LCP. The SPO for the respective tank will then become energised by the control system provided the following permissives are met:

- Correct unloading area CSHT inlet valve open (limit switch).
- Only one delivery area CSHT diversion valve open (limit switch), where applicable.
- Unloading area storm water drain valve close (limit switch).
- Correct fill line manual isolation valve in open position (limit switch).
- More than one fill line isolation valves are not open (limit switch), if included.
- Not higher than allowable gas reading from the gas detector (only for aqueous ammonia).
- No high-high bulk storage tank level.
- No high-high bulk storage bund sump level.
- No high-high level in CSHT.
- Storage bund valve not open (limit switch, where available).

The delivery personnel should then be able to start unloading pushing 'START' button on the truck panel, continue with the filling procedure and monitor the tank level in LCP and tank local level indicating device.

Once the chemical filling operation is completed, the delivery personnel must push 'STOP' at the Unloading LCP. The delivery personnel shall purge the fill line with air using the truck purge line system, then close the fill line manual isolation valve and turn off the panel. Once the tanker has safely rolled off the unloading area, the CSHT diversion valve shall be closed, and storm water valve shall be opened.

Only one Bulk Storage Tank in a single unloading bund and fill point shall be fillable at a time.

Abnormal Operation

The relevant tank SPO shall become de-energised and appropriate alarms triggered if any of the following conditions are met:

- Unloading area CSHT diversion valve limit switch does not register 'open'.
- Unloading area storm water drain valve limit switch does not register 'close'.
- Bulk storage bund sump spill reaches a high-high level (where installed).
- Bulk storage tank high-high level detected.
- CSHT detects a high-high level.
- More than one manual fill line isolation valve opened.
- Higher than allowable gas reading from the gas detector for a defined period, if included (for aqueous ammonia).
- More than one CSHT diversion valves from the unloading area are open (where applicable).
- Storage bund valve open (where applicable).
- Safety shower or eye wash facility flow switch has been trigged.

If a high level is reached on any tank's level transmitter, a visual and audible alarm shall be raised at the Unloading LCP. If a tank reaches a high-high level from the level transmitter or secondary level device, its respective SPO shall be de-energised and interlocked, however the system shall still allow filling of other tanks.

The bulk chemical storage area bund high-high level device, where incorporated, shall de-energise and interlock all unloading LCP SPOs into that bund. In addition, a local and SCADA alarms shall be raised if the storage bund sump level reaches high where the storage bund is indoor or under a shelter and ingress of rainwater into the bund prevented.

Where storage bunds are installed with drain valves, and if a drain valve remains in the open position during unloading, the unloading area LCP SPOs shall be interlocked – refer to Section 6.2.2 for further detail on arrangements.

If the CSHT diversion valve is kept open and storm water valve left closed more than a specified time, an alarm shall be raised in SCADA.

A local and SCADA alarm should be provided to indicate if a tank level rises while the relevant tank LPC SPO is not active.

Alarm and control systems shall be fail-safe and fail to high-high alarm upon loss of echo or instrumentation failure.

9.2.2. Chemical Dosing – Positive Displacement Pumps

The following describes a typical process control philosophy for the chemical dosing system with positive displacement pumps. This should be read in conjunction with Section 7 of this document.

Normal Operation

When initiating a dosing system using positive displacement pumps, the tank selection suction line actuated isolation valve (if closed) and any dosing line actuated isolation valve (where included) will open. The dosing pump will start only when receives open signal from valve position switches.

When called to start, the controller will first calculate a flowrate (in L/h) required to meet the dosing rate setpoint (entered in mg/L), based on flow-pacing to the main process / water flowmeter. The controller output will then be determined by the particular dosing control mode selected (see Table 7 for details on dosing control modes), with the controller continuing to update the required pump speed in order to achieve the calculated set point of chemical flow rate (in L/h).

When using diaphragm pumps, an additional parameter of stroke length may need to be accommodated in the calibrated flow curve and pump speed calculation (where applicable).

The dosing skid (or dosing line) flowmeter will typically provide a flow feedback value (in L/h) to the controller to adjust the pump speed with or without trimming limit, as used. When analyser trim is used, the analyser control loop will be used to trim the chemical dose rate setpoint (mg/L) as described in Table 7.

Abnormal Operation

If a tank reaches a low-low level, its respective actuated outlet valve shall be isolated and dosing pump will be stopped, however the system shall still allow dosing using other tanks automatically if functionality included in the design. The flow meter in the dosing line will identify flow deviations, initiating an alarm in the SCADA if a deviation condition is met.

In the event of a trip, the pump will stop operating and the dosing line actuated isolation valve (where included) will close to prevent any additional chemical dosing because of siphoning. The pump suction side actuated isolation valve may be required to close depending on the trip condition.

If the relevant water quality parameter (chemical concentration or pH) reaches high or high-high or low or low-low, alarms will be raised or interlocked with the dosing pump and actuated isolations valves (as designed) as a protection against overdosing or underdosing scenarios. In the event of a trip from water quality parameters, the system shall not allow automatic dosing using other pumps or dosing lines (where available) unless the system has been re-initiated from SCADA.

The dosing pump shall also trip if it does not register open signal either from relevant suction line actuated valve or pump discharge dosing line actuated valve.

9.2.3. Chemical Dosing – Ring Main System

Normal Operation

Where centrifugal pumps are used, the ring main pumps and flow control valve will operate with different control loops.

The speed of the ring main pumps will typically modulate to achieve a pre-set ring main pressure necessary for dosing. The ring main pressure will be measured and fed back to the pump controller which will output a speed to the pumps. This will modulate the pump's speed to achieve the desired pressure.

A portion of flow from the ring main will typically be bled back into the bulk storage tank through an orifice. This will prevent the system stagnating, keeping the ring main chemical fresh and circulating when there is a low dosing demand.

Upon initiating a ring main dosing system, the pump suction isolation valve will open, any dosing line isolation valve (where installed) will open, and the ring main pump will commence operation to build ring main pressure. The chemical flow control valve will start in the closed position.

Once the ring main pressure setpoint is achieved the chemical flow control valve will begin to modulate open in increments based on the control parameters.

If a ring main system uses fixed-speed pumps instead of pressure setpoint (non-preferred), a delay time between the pumps starting and the control valve opening will be provided.

Each dosing line will have a dedicated flowmeter which will feed back to the flow controller. The flow controller will calculate a flowrate based on the dose rate setpoint (mg/L), and if the measured flowrate does not match the calculated flow rate, the controller will output a flow control valve position change. The flow controller will continue to recalculate and update the flow control valve position to maintain the desired flow rate.

Where required, the ring main pressure set point may need adjustment based on the number of dosing lines in operation in order to provide more efficient operation e.g. particular dosing lines may require additional head, and pressure setpoint adjustment within a defined limit may allow more efficient pump operation.

Abnormal Operation

If a tank reaches a low-low level, its respective outlet valve shall be isolated and ring main pump will be stopped, however the system shall still allow dosing using other tanks.

The flow meter in the dosing line will be used to trigger a flow deviation alarm from setpoint alarm if the flow deviates from the setpoint. If the flow fails to achieve ±10% of the required flow within a defined period upon triggering a valve position change, an alarm will be triggered.

If a system is trying to achieve a setpoint and the analyser trimmed setpoint exceeds ±20% (where used) an alarm shall be triggered. If the relevant water quality analyser (if used) reaches values outside the limits, alarms will be raised or interlocked with the dosing pump and actuated isolations valves (as designed) as a protection against overdosing or underdosing scenarios.

In the event of a trip, the pump will stop operating and the dosing line actuated isolation valve (where included) will close to prevent any additional chemical dosing as a result of siphoning. The pump suction side isolation valve may be required to close depending on the trip condition.

In the event of a trip from water quality parameters, the system shall not allow automatic dosing using other dosing lines (where available) unless the system has been re-initiated from SCADA.

9.2.4. Chemical Transfer

Normal Operation

A low level detected in one of the target tanks will trigger a chemical transfer event. A target tank may be a dosing tank or other tank to which chemical will be transferred.

Where one target tank is in operation, the system shall open its automated inlet valve on transfer initiation.

Where more than one target tank is in operation, the system shall select the target tank with the lowest level and open its automated inlet valve, closing all other target tank inlet valves for that chemical. This is in order to consume older chemical first to manage chemical quality – specifically important for sodium hypochlorite.

If individual bulk storage tanks are used for chemical transfer, rather than where tanks are interconnected, the system shall select the bulk storage tank with the lowest level and open its outlet valve (all other bulk storage tank outlet valves shall be closed unless transfer from a common manifold is required by design).

If bulk storage tanks are inter-connected, the system shall open the isolation valve in the suction line of the transfer skid.

Gravity System

Where a system operates via gravity, the chemical should automatically flow. Chemical will continue to flow until the selected target tank reaches its normal fill level, or the bulk storage tank(s) reaches its low level.

If a low level in the selected bulk storage tank(s) is reached, or a normal fill level in the selected dosing tank is reached, the transfer operation will stop. Once one of these events is triggered, the target tank's inlet valve will close. The bulk storage tank outlet valve may also close.

Pumped System

The system will select the duty chemical transfer pump(s) which will operate and continue to operate at a fixed speed until the selected target tank reaches its normal fill level, or the bulk storage tank(s) reaches its low level.

If a low level in the selected bulk storage tank(s) is reached, or a normal fill level in the selected dosing tank is reached, the transfer operation will stop. Once one of these events is triggered, the duty chemical transfer pump(s) is shutdown, the selected target tank's inlet valve and the selected bulk storage tank's outlet valves are closed.

Where more than one target tanks are in operation and require filling, the process will begin again until all dosing storage tanks have been filled.

Abnormal Operation

If the transfer system flow meter registers a flow rate but there is no change in level detected in the Target Tank within a pre-set time period, a flow deviation alarm will be raised and the system shutdown.

If the system is triggered but no flow is detected within a pre-set time period, a flow deviation alarm will be raised and the system shutdown.

Additional alarms and trips shall be included on a system basis particularly from secondary high-high and low-low level devices similar to the system of chemical delivery from tankers.

9.3. Seed Setpoints

In dosing systems intended to achieve a dynamic where analyser trim may be used (e.g., free chlorine concentration downstream of dose point, which may vary as a result of water quality), dosing systems should use a seed setpoint to calculate dose flow rate on startup. This seed setpoint will be adopted on startup until the control system can calculate a new setpoint. This will help reduce lag time in achieving acceptable water quality parameters being achieved following startup or reinstatement following a trip. Systems should not be designed to use the last known setpoint and should rather adopt this seed setpoint value.

9.4. Dose Rate Calculations

This section provides the sample calculation for control systems to calculate the necessary dynamic chemical flow rate (in L/h) setpoint based on a typical operator or plant setpoint / dose rate in milligrams of chemical per litre of process water (mg/L), main process flow and chemical properties.

Where a chemical is supplied in bulk as a %chemical w/w, the following calculation should be used

$$Chemical\ Flow\ Rate\ (L/h) = water\ flow\ rate\ \left(\frac{L}{s}\right) \times \frac{3600}{1}\left(\frac{s}{h}\right) \times dose\ rate\ \left(\frac{mg}{L}\right) X \frac{1}{[Chem]\left(\%\frac{w}{w}\right)} \times \frac{1}{SG}\left(\frac{mL}{g}\right) \times \frac{1}{1000}\left(\frac{g}{mg}\right) \times \frac{1}{1000}\left(\frac{L}{mL}\right) \qquad (1)$$

Where a chemical is supplied in bulk as a %chemical w/v, the following calculation should be used:

$$Chemical\ Flow\ Rate\ \left(\frac{L}{h}\right) = water\ flow\ rate\ \left(\frac{L}{s}\right) \times \frac{3600}{1}\left(\frac{s}{h}\right) \times dose\ rate\ \left(\frac{mg}{L}\right) \times \frac{1}{[Chem]\left(\%\frac{w}{v}\right)} \times \frac{1}{1000}\left(\frac{g}{mg}\right) \times \frac{1}{1000}\left(\frac{L}{mL}\right) \qquad (2)$$

Where the incoming water chemical concentration (mg/L) needs to be considered to calculate the set point of chemical flow (L/h) (as applicable for secondary disinfection and supply system dosing), the following calculation should be used modifying the above two equations:

$$Chemical\ Flow\ Rate\ (L/h) = water\ flow\ rate\ \left(\frac{L}{s}\right) \times \frac{3600}{1}\left(\frac{s}{h}\right) \times (target\ dose\ rate - incoming\ water\ chemcial\ conc.)\left(\frac{mg}{L}\right) X \frac{1}{[Chem]\left(\%\frac{w}{w}\right)} \times \frac{1}{SG}\left(\frac{mL}{g}\right) \times \frac{1}{1000}\left(\frac{g}{mg}\right) \times \frac{1}{1000}\left(\frac{L}{mL}\right) \qquad (3)$$

$$
\begin{aligned}
&Chemical\ Flow\ Rate\ \left(\frac{L}{h}\right) \\
&\qquad = water\ flow\ rate\ \left(\frac{L}{s}\right) \times \frac{3600}{1}\left(\frac{s}{h}\right) \\
&\qquad \times (target\ dose\ rate\ - incoming\ water\ chemcial\ conc.)\left(\frac{mg}{L}\right) \times \frac{1}{[Chem]\left(\%\frac{w}{v}\right)} \\
&\qquad \times \frac{1}{1000}\left(\frac{g}{mg}\right) \times \frac{1}{1000}\left(\frac{L}{mL}\right) \qquad (4)
\end{aligned}
$$

Where [Chem] = Chemical concentration in either %w/w or %w/v

SG = Specific gravity of chemical

Example of dosing calculations are included in Appendix A –Liquid Chemical Dosing Sample Calculations for various chemicals.

9.5. Alarms

Refer to Seqwater Standard Specifications *I-SPE-STD-013 Control System Design & Construction* and *I-SPE-STD-006 Monitoring and Control System Alarm Strategy* which outlines the philosophy that should be applied to the management of alarms and assessment of alarm priority.

An assessment and validation-based approach shall be applied in determining plant alarms. The requirements for Critical Control Points (CCPs) are described in SPE-00320 WTP and Supply System Process Validation and the above referenced documents.

9.6. Interlocks and Trips

All interlocks shall be defined in the Functional Description, and appropriate CCP protection measures defined in the HACCP Plan.

Refer to *I-SPE-STD-013 Control System Design and Construction* for additional information on the application and structure of interlocks.

The plant (or parts of the plant) shall only be available in Automatic where all plant dosing systems critical to safety/environmental and maintenance of correct treated water quality are also available.

Conditions and failures in each chemical system (or interfacing systems) shall trigger appropriate responses in all affected systems including control systems of other plant areas, overarching control systems, and external control systems.

Additional interlocks should be determined based on chemical, plant and process function and criticality, in accordance with *I-SPE-STD-013* requirements.

Plant trips shall also be determined on a case-by-case basis factoring chemical, plant and process functions and criticality. Before a system is tripped as an action, the following should be considered:

- Can the plant operate without the chemical for a period.
- Are there alternate control parameters that can be applied.
- Can the last known operating parameter be held safely
- Can the plant shut down to a safe state immediately or is a ramp down necessary.
- Are there other safety mechanisms in place that may be preferable to trigger in lieu of a plant trip.

- Could an alternate design prevent the need for a trip in the first place.

Appendix C –Typical Trips and Interlocks for Liquid Chemical Unloading, Storage and Dosing Systems summarises typical trip and hardware/hardwired interlocks to be considered for liquid chemical unloading, storage, and dosing systems and for the preparation of Cause-and-Effect Matrix. Trips and interlocks as defined in *I-SPE-STD-013 Control Systems Design and Construction* have been specified in Appendix C. These must be modified in accordance with project design requirements, and additional interlocks may be necessary depending on the specific application, chemical and design. These should be outlined in key control system documents as mentioned above.

10. Testing and Commissioning

All systems shall be tested and commissioned in accordance with the requirements of

i. *B-SPE-STD-003 Commissioning Requirements*

ii. *E-SPE-STD-001 Electrical Design and Construction*

iii. *M-SPE-STD-001 General Mechanical Specification.*

iv. *I-SPE-STD-011 Control System Testing*

Testing shall, as a minimum, include:

i. Tanks shall be:

   a. Hydrostatically tested using water, to an appropriate hydrostatic test method, by the supplier prior to delivery to site (except where tanks are fabricated and installed on-site). A test report shall be made available to Seqwater.

   b. Where fabricated or constructed on-site, leak tested prior to any painting, coating, or similar treatments being applied using an appropriate hydrostatic test methodology. A test report shall be made available to Seqwater.

   c. Leak tested using water to full volume, on-site, following installation and prior to commissioning any ancillary systems. This test should be held and successfully demonstrated over a minimum of 24 hours.

ii. Tank Liners:

   a. Shall be tested using an approved non-destructive method.

iii. Storage tank bund:

   a. Shall be leak tested for a minimum of 48 hours with potable water. The test should be done before and after installation of all equipment in the bund.

iv. Pipework:

   a. Shall be tested in accordance with the relevant material standards and codes.

   b. Shall be hydrostatically leak tested as per *M-SPE-STD-013 Chemical Dosing Piping.*

v. Dosing systems:

   a. All dosing systems shall be tested and proved first with water prior to the introduction of chemicals:

      - Across the design dosing range.
      - Applying all equipment and dosing control modes.
      - All interlocks and trips function as intended.

   b. Pressure relief valves shall be tested at set pressure in laboratories/workshops or by third parties or as recommended by the supplier.

   c. Water used for the dosing systems testing must be drinking water quality. If the dosing system is designed to dose downstream of filter inlet valves, the system must be cleaned and disinfected before testing with drinking water in a live system.

vi. Proof of Performance Testing (POPT):

   a. POPT shall be conducted for each system as part of the commissioning following the requirements included in *B-SPE-STD-003 Commissioning Requirements*.

A risk assessment must be conducted involving each of the adopted testing and commissioning activities to avoid any inadvertent consequence.

Mixing of sulfuric acid or hydrochloric acid or sodium hydroxide with water can result in heat evolution due to exothermic reactions. Appropriate steps shall be taken to prevent rapid heat evaluation and to ensure safety of personnel, and the integrity of material and equipment. It is strongly recommended to ensure a completely dry system before introducing sulfuric acid into the system.

11. Standard Designs

The Standard Designs or P&ID Standard Drawings, as shown in Table 13, shall be used as the starting design concepts for liquid chemical unloading, storage, transfer and dosing systems for all Seqwater works. The standard designs shall not be used for construction.

A project must develop new P&IDs based on the standard designs after incorporating the project specific requirements, and the outcomes from design reviews and appropriate technical hazard studies.

Table 13 Standard Seqwater P&IDs for liquid chemical storage, transfer and dosing systems.

System	Standard P&ID Drawing	Description
Chemical Unloading, Storage, Transfer and Dosing System	B-DWG-STD-00011	P&ID Liquid Chemical Unloading and Storage (Except Aq. Ammonia)
	B-DWG-STD-00012	P&ID Liquid Chemical Dosing Systems
	B-DWG-STD-00013	P&ID Aqueous Ammonia Unloading and Storage
	B-DWG-STD-00015	P&ID Liquid Chemical Transfer Systems
	B-DWG-STD-00016	P&ID Liquid Chemical Ring Main Dosing System

The standard P&ID drawings as referenced in Table 13 have been developed following Seqwater *Process Flow Diagram and P&ID Requirements Standard Specification B-SPE-STD-007*, P&ID Legend Sheet Drawings *B-DWG-STD-00001 to B-DWG-STD-00007 for Symbols, Instrumentation Valve and Motor Details* and *P&ID Drafting Procedure B-PRO-STD-003*.

12. Definitions and Abbreviations

Table 14 – Definitions

Term	Definitions
Ambient Conditions	Refers to the weather-related conditions of the Site, including minimum, maximum and average values and durations of the following: temperature, UV exposure, humidity, rainfall.
Contractor	An entity engaged by Seqwater to undertake work in accordance with an agreed contract and defined scope of work.
Coefficient of Variation (CoV)	The CoV describes the deviation of local concentration from the mean within a cross section of a radial mixing device such as a pipe or channel. The lower the value of CoV, the better the mixing quality. A CoV of between 0.01 to 0.05 is a reasonable target for most mixing applications.
Critical Control Point	A step in the process where control can be applied to prevent or eliminate a significant hazard that could cause harm to customers, the environment, quality or the business.
Designer	An entity engaged by Seqwater to produce or modify a design for a project (including the design of temporary works); or who provides instructions to another party to complete works in a described manner. May also be the Contractor.
Design Life	The design life of equipment is the period of time during which the item is expected by its designers to provide the required functionality and availability, for the specific operating conditions.
Dosing skid	Dosing Skid refers a modular system to support pumps, piping, instruments, and valves for applications that require metered chemicals. The Dosing Skid is defined by the extremities of the skid frame and the inlet and outlet connection points.
Engineering Standard	Includes Seqwater Engineering Standard Procedures and Standard Specifications and associated supporting documents such as Standard Drawings, Guidelines, Lists, Manuals, Registers, and Templates.
Fibreglass / FRP	Fibreglass reinforced plastic, shall also mean glass reinforced plastic (GRP).
Froude number	It is a dimensionless number that compares the ratio of the inertia forces of a unit of fluid to the weight of the unit of fluid – the inertial force divided by gravitational force.
Glass Reinforced Plastic / GRP	Glass reinforced plastic, shall also mean fibreglass reinforced plastic (FRP).
HACCP	A systematic preventive approach to product safety from physical hazards in production processes that can cause the finished product to be unsafe, and designs measures to reduce these risks to a safe level.

Term	Definitions
HAZOP	A method of study for identifying hazards and operability considerations within chemicals and fuels processing through to electrical and machinery systems.
Liquid Chemical	Chemicals that are delivered to Seqwater sites as liquids, used for the drinking water treatment and maintaining drinking water quality, and included in the list of Section 3.
Manufacturer / Supplier / Vendor / Original Equipment Manufacturer (OEM)	The entity that manufacturers or supplies equipment to meet the specifications of the Contractor.
Normal Fill Level	The maximum level to which a tank will be intentionally filled on a routine basis, using the normal process control system. The capacity at this level from the bottom of the tank is also referred as tank normal capacity.
Owner / Principal / Seqwater	The entity that engages the Contractor to undertake the work and takes custody of the outcome. The Owner may delegate responsibilities to other entities to act on its behalf (e.g. a consultant).
Process Conditions	Refers to the conditions that assets may be subject to as a result of operating plant and equipment.
Response Time	Response time here refers to the time duration between two events of level alarms/interlocks for chemical storage tanks. This time intends to allow an operator or control system to correct itself before an escalation in control system management is triggered.
REX	Seqwater’s Electronic Document and Records Management System.
Safe Fill Level	Refer to tank rated capacity. This refers to the level up to which the tank is allowed to receive the liquid delivery after the normal fill level is attained.
SCADA	The system which acquires data from remote devices such as valves, pumps, instruments, transmitters etc. and provides overall control remotely from a host software platform. The host platform also provides functions for graphical displays, alarming, trending and historical storage of data.
Seqwater Engineering Approval / Acceptance	Written sign-off gained via the deviation process, as detailed in X-PRO-STD-008 Asset Standards Management and Application.
Shall/must	Indicates a mandatory requirement.
Should	Indicates a recommendation.
Site	Refers to the location at which the treatment works exists or is to exist.
Tank Design Capacity	Capacity calculated from the bottom of the tank to the point of tank overflow invert level. This also refers to tank maximum capacity.
Tank Rated Capacity	Capacity calculated from the bottom of the tank to a level below the overflow invert level. This level will allow time for any action necessary to prevent tank overflow. AS 3780 also refers this as Safe Fill Level.
Tank Working Capacity	Volume of available liquid in between tank normal fill level and low liquid level. This refers to the product available under normal operating conditions.

Term	Definitions
Worker(s)	Includes all permanent, temporary, and casual employees of Seqwater, and: • vocational and work experience placements • volunteers • contractors and consultants employed by another entity but temporarily assigned to do work for or on behalf of Seqwater.

Table 15 – Abbreviations

Abbreviation	Description
ADG	Australian Dangerous Goods (Code / Regulations)
ADWG	Australian Drinking Water Guidelines
AM	Asset Management
AS	Australian Standards
CCP	Critical Control Point
CoV	Coefficient of Variance
CPVC	Chlorinated Polyvinyl Chloride
CSHT	Chemical Spill Holding Tank
DOL	Direct Online
DN	Nominal Diameter
FRP	Fibreglass Reinforced Plastic
GPO	General Purpose Outlet
GRP	Glass Reinforced Plastic
HACCP	Hazard analysis and critical control points
HAZOP	Hazard and Operability Study
HMI	Human-Machine Interface
HDPE	High Density Polyethylene
IBC	Intermediate Bulk Container
kPag	Kilo pascal (gauge pressure)
LCP	Local Control Panel
LEL	Lower Explosive Limit
LDPE	Low Density Polyethylene

Abbreviation	Description
LLDPE	Linear Low Density Polyethylene
MCS	Master Control System
LMDPE	Linear Medium Density Polyethylene
NB	Nominal Bore
OFL	Overflow Level
OHL	Operational High Level
OLL	Operational Low Level
PE	Polyethylene
P&ID	Piping and Instrumentation Diagram
PVC	Polyvinyl Chloride
SCADA	Supervisory Control and Data Acquisition
SFL	Safe Fill Level
SME	Subject Matter Expert
SPO	Special Purpose Outlet
SS	Stainless Steel
uPVC	Unplasticised Polyvinyl Chloride
VSD	Variable Speed Drive
WSAA	Water Services Association of Australia
WTP	Water Treatment Plant
WQMF	Water Quality Management Facility

13. References and Related Materials

The documents listed in Table 16, Table 17 and Table 18 below, and the requirements therein, are relevant to this Standard Specification In their latest editions, these documents form a part of this document. Note that this is not an exhaustive list of documents relevant to the works.

Seqwater undertakes regular updates of its Engineering Standards. Before utilising this document, the complete list of Seqwater Engineering Standards should be reviewed to ensure currency and applicability for the proposed works.

Table 16 Reference Seqwater Documentation

Description	Location
SPE-00346 B-SPE-STD-003 Commissioning Requirements	REX & Waternet
SPE-00349 B-SPE-STD-005 Functional Description Documentation	REX & Waternet
SPE-00496 B-SPE-STD-012 Lime Storage, Mixing and Dosing System	REX & Waternet
SPE-00395 D-SPE-STD-001 Water Supply Network Planning, Design and Construction (Seqwater Supplementary Manual to WSAA, Water Supply Code of Australia WSA03-2011)	REX & Waternet
SPE-00352 E-SPE-STD-001 Electrical Design and Construction	REX & Waternet
SPE-00353 I-SPE-STD-015 Instrumentation	REX & Waternet
SPE-00356 I-SPE-STD-005 High Priority Alarms and Interlocks Management	REX & Waternet
SPE-00357 I-SPE-STD-006 Alarm and Event Management	REX & Waternet
SPE-00359 I-SPE-STD-010 Control Systems Tag Naming	REX & Waternet
SPE-00360 I-SPE-STD-011 Control Systems Testing	REX & Waternet
SPE-00361 I-SPE-STD-013 Control Systems Design and Construction	REX & Waternet
TEM-00221 I-TMP-STD-001 Functional Description Part A Template	REX & Waternet
TEM-00222 I-TMP-STD-005 Functional Description Part B Template	REX & Waternet
SPE-00367 M-SPE-STD-001 General Mechanical	REX & Waternet
SPE-00366 M-SPE-STD-002 Fixed Platforms, Walkways, Stairways and Ladders	REX & Waternet
SPE-00323 M-SPE-STD-003 Valves for Water Applications	REX & Waternet
SPE-00348 M-SPE-STD-004 Protective Coatings	REX & Waternet
SPE-00434 M-SPE-STD-009 Flow Meters	REX & Waternet
SPE-00435 M-SPE-STD-010 Chemical Dosing Skids	REX & Waternet
SPE-00430 M-SPE-STD-012 Chemical Dosing Pumps	REX & Waternet
SPE-00355 M-SPE-STD-013 Chemical Dosing Piping	REX & Waternet
PRO-02190 X-PRO-STD-006 Equipment Numbering and Naming Convention Procedure	REX & Waternet
PRO-02205 X-PRO-STD-008 Asset Standards Management and Application Procedure	REX & Waternet

Description	Location
PRO-01617 X-PRO-STD-009 Engineering Design, Construction, Operation and Maintenance Procedure	REX & Waternet
PRO-02140 X-PRO-STD-013 Engineering Technical Hazard Study Procedure	REX & Waternet
TEM-00224 X-TMP-STD-022 Asset Standards Deviation Request Template	REX & Waternet
GDE-00369 E-GDE-STD-001 Energy Metering and Monitoring Guideline	REX & Waternet
MAN-00391 E-MAN-STD-001 Energy Efficiency Manual	REX & Waternet
PRO-02564 Drinking Water Treatment Chemicals – Specifications, Monitoring and Assessment Procedure	REX & Waternet
FRA-00014 Enterprise Risk Management Framework	REX & Waternet
PRO-00008 Hazardous Chemicals Procedure	REX & Waternet
SPE-00320 WTP and Supply System Process Validation Standard	REX & Waternet
REG-00250 Drinking Water Treatment Chemical Supplier Matrix	REX & Waternet
PLN-00452 Corporate Energy Strategy	REX & Waternet
SPE-00502 Control Systems Cyber Security Standard	REX & Waternet
D15/111427 Asset Lifecycle Planning – Liquid Chemical Storage and Asset Class Plan	REX

Table 17 – Reference External Standards, Specifications and Codes

Standard/Specification	Document Title
API 620	Design and Construction of Large, Welded, Low-Pressure Storage Tanks
API 650	Welded Tanks for Oil Storage
ADG 7 Information Guide	Australian Dangerous Goods Code Information Guide – 7th Edition
AS 1000	International System of Units (S.I.) and its Applications
AS 1210	Pressure Vessels
AS 1216	Class Labels for Dangerous Goods
AS 1319	Safety Signs for the Occupational Environment
AS 1345	Identification of the Contents of Pipes, Conduits and Ducts
AS/NZS 1477	PVC pipes and fittings for pressure applications
AS 1530.4	Methods for Fire Tests on Building Materials, Components and Construction
AS 1580	Paints and related materials
AS 1628	Water supply - Metallic gate, globe and non-return valves
AS 1657	Fixed platforms, walkways, stairways and ladders - Design, construction and installation
AS 1668.2	The use of ventilation and airconditioning in buildings, Part 2 – Mechanical ventilation in buildings
AS 1668.4	The use of ventilation and airconditioning in buildings, Part 4 – Natural ventilation of buildings

Standard/Specification	Document Title
AS 1678	Emergency Procedure Guide – Transport
AS 1680.1	Interior and workplace lighting, Part 1: General principles and recommendations
AS 1680.2.4	Interior and workplace lighting, Part 2.4: Industrial tasks and processes
AS 1692	Steel Tanks for Flammable and Combustible Liquids
AS 1940	The Storage and Handling of Flammable and Combustible Liquids
AS 2032	Installation of PVC Pipe Systems
AS 2033	Installation of PE Pipe Systems
AS 2129	Flanges for Pipes, Valve and Fittings
AS 2359	Powered Industrial Trucks
AS 2492	Cross-linked Polyethylene (PE-X) pipes for pressure applications
AS 2537	Mechanical Jointing Fittings for use with Crosslinked Polyethylene (PE-X) for Pressure Applications
AS 2566.1	Buried Flexible Pipelines Part 1: Structural Design
AS 2566.2	Buried Flexible Pipelines Part 2: Installation
AS 2809	Road Tank Vehicles for Dangerous Goods (series)
AS/NZS 3000	Wiring Rules 2007, Electrical Installations
AS/NZS 3500 Set	Plumbing and Drainage Set
AS 3571	Plastic Piping Systems – Glass-reinforced Thermoplastics (GRP) systems based on unsaturated polyester (UP) resin
AS 3735	Concrete structures retaining liquids
AS 3780	The Storage and Handling of Corrosive Substances
AS/NZS 3833	The Storage and Handling of Mixed Classes of Dangerous Goods in packages and IBCs
AS 3879	Solvent Cements and Priming Fluids for PVC (PVC-U and PVC-M) and ABS and ASA Pipes and Fittings
AS 3996	Access Covers and Grates
AS/NZS 4020	Testing of products for use in contact with drinking water
AS/NZS 4024 - Series	Safety of Machinery
AS 4041	Pressure Piping
AS 4326	The Storage and Handling of Oxidizing Agents
AS 4452	The Storage and Handling of Toxic Substances
AS/NZS 4681	The Storage and Handling of Class 9 (miscellaneous) Dangerous Goods and Articles
AS/NZS 4766	Rotationally Moulded Buried, Partially Buried and Non-buried Storage Tanks for Water and Chemicals
AS 4775	Emergency Eyewash and Shower Equipment

Standard/Specification	Document Title
AS 4794	Non-return valves for waterworks purposes – Swing check and tilting disc
AS/NZS 60079 (all parts)	Explosive Atmospheres
ADG Code	Australian Code for the Transport of Dangerous Goods by Road & Rail
ASTM D1785	Standard Specification for PVC Plastic Pipe – Schedule 40, 80 and 120
ASTM D2467	Standard Specification for PVC Plastic Pipe Fittings, Schedule 80
ASTM F493	Standard Specification for Solvent Cements for Chlorinated Poly Vinyl Chlorite (CPVC) Plastic Pipe and Fittings
BS EN 12573 series	Welded Static Non-pressurised Thermoplastic Tanks System
BS EN 13121-3	GRP Tanks and Vessels for use above ground. Design and workmanship. (2008 + A1:2010)
DVS 2205 series	Calculation of Thermoplastic Tanks and Apparatus
EN 1408	European Standard for Chemicals Used for Treatment of Water Intended for Human Consumption – Poly (diallyldimethylammonium chloride)
E.P. Act	Environmental Protection Act (Qld) 1994
HB 76:2010	Dangerous Goods – Initial Emergency Response Guide
NACE SP0294-2016-SG	Design, Fabrication, and Inspection of Tanks for the Storage of Concentrated Sulfuric Acid and Oleum at Ambient Temperatures
NACE SP0391-2016-SG	Materials for the Handling and Storage of Commercial Concentrated (90 to 100%) Sulfuric Acid at Ambient Temperatures
NSF/ANSI/CAN 60	Drinking Water Treatment Chemicals – Health Effects
UN Model Regulation	Recommendations on the Transport of Dangerous Goods
WHS Act 2011	Work Health and Safety Act 2011
WSA 01 - 2004	Polyethylene Pipeline Code V 3.1
WSA 03 - 2011	Water Supply Code of Australia V 3.2
WSA 201-2017	Manual for Selection and Application of Protective Coatings
WSAA Guidance Manual	Water Services Association of Australia *Manual for the application of Health-Based Target's for Drinking Water Safety, September 2015.*
Water Corporation - DS 73-01	Bulk Sodium Hypochlorite Storage and Dosing System – Basis of Design
Water Corporation – DS 79	Design of Chemical Systems – Legislative Requirements and General Principles

Table 18 Seqwater Standard Drawings

Drawing	Description
B-DWG-STD-00001	Standard P&ID Legend - Sheet 1 of 5, Symbols
B-DWG-STD-00002	P&ID Legend - Sheet 2 of 5, Codes and Abbreviations
B-DWG-STD-00003	P&ID Typical Details - Sheet 1 of 2, Instrumentation Valve
B-DWG-STD-00004	P&ID Typical Details - Sheet 2 of 2, Motor Control

Drawing	Description
B-DWG-STD-00005	P&ID Legend - Sheet 3 of 5, Material Codes
B-DWG-STD-00006	P&ID Legend - Sheet 4 of 5, Symbols
B-DWG-STD-00007	P&ID Legend - Sheet 5 of 5, Symbols
B-DWG-STD-00011	Standard P&ID Liquid Chemical Unloading and Storage (Except Aq. Ammonia)
B-DWG-STD-00012	Standard P&ID Liquid Chemical Dosing
B-DWG-STD-00013	Standard P&ID Aqueous Ammonia Unloading and Storage
B-DWG-STD-00015	Standard P&ID Liquid Chemical Transfer Systems
B-DWG-STD-00016	Standard P&ID Liquid Chemical Ring Main Dosing System
B-DWG-STD-00041	Standard P&ID WTP Treated Water Quality Monitoring Analyser Panel
B-DWG-STD-00042	Standard P&ID Supply System Water Quality Monitoring Analyser Panel – Chloramine System
B-DWG-STD-00043	Standard P&ID Raw Water Quality Monitoring Analyser Panel
B-DWG-STD-00044	Standard P&ID Water Quality Analyser Panel Notes
B-DWG-STD-00045	Standard P&ID Supply System Water Quality Monitoring Analyser Panel – Free Chlorine System

14. Changes from previous version

This Standard Specification will be regularly reviewed in accordance with the requirements of the Seqwater Controlled Document Management Procedure. Reviews will include consideration of suggestions for alteration or improvement made in accordance with Seqwater Procedure *X-PRO-STD-004 Development and Review of Asset Standards*.

Changes made from the previous version are summarised in Table 19 below.

Table 19 Changes from previous version

Section Number	Change
Section 3.4 and 3.5	Additional information about Liquid Ammonium Sulfate (LAS) and its comparison to aq. Ammonia
Section 4.12.1.6	Maintenance accessibility for magnetic coupled level switches
Section 5.3	Additional information about drain lines for chemical fill lines
Section 5.3.1	Section title changed to fill points and lines and added more clarity
Section 5.4	Slight modification of chemical unloading local control panel requirements
Section 6.1.7	Magnetic level switches requirement changed
Section 6.1.7	A provision included to delay pump trip from the low-low level switch
Section 6.1.7.1	A typo is corrected for LSLL
Section 6.11.1.1	Additional information added for aqueous ammonia storage tanks
Section 6.2.1	Storage tank bund capacity clarified following AS 3780 requirements
Section 7.2.8	Pressure sustaining valve set pressure information modified
Section 7.2.10	Reference added for chemical return line piping
Section 7.2.12.1	Additional points added about dosing quills
Section 7.2.15	Additional general information provided about chemical mixing
Appendix A-4, A-6	Sulfuric acid dosing formula minor correction, and change in LAS pH range

Appendix A –Liquid Chemical Dosing Sample Calculations

This appendix contains dosing sample calculations for several liquid chemicals with some key data used at Seqwater Sites.

A.1 Liquid Aluminium Sulfate (Alum)

Chemical Formula: $Al_2(SO_4)_3.14H_2O$ / $Al_2(SO_4)_3.18H_2O$

Molecular Weight: 594.4 / 666.4 g/mol

Chemical Concentration: Typically, 46.1% to 48.4% w/w as $Al_2(SO_4)_3.14H_2O$ (i.e. 7.9% to 8.3% w/w as Al_2O_3)

Specific Gravity: Approximately 1.34

pH: 2.3-2.8

Classification: Not classified as dangerous goods in ADG but considered a hazardous substance.

Sample Calculation

Alum flow rate calculation (with a simple example):

Alum Chemical Formula: $Al_2(SO_4)_3.14H_2O$,

Concentration = 47.2% (w/w), SG 1.34, (Al_2O_3 8.1%)

Alum dose rate = 7 mg/L (as Al_2O_3) (input by the operator, assumed)

Raw water flow rate = 1100 L/s (assumption)

$$Alum\ flow\ rate = water\ flow\ rate\ \left(\frac{L}{s}\right) \times \frac{3600}{1}\left(\frac{s}{h}\right) \times dose\ rate\ \left(\frac{mg}{L}\right) X \frac{1}{Al_2O_3\%\frac{w}{w}} \times \frac{1}{SG}\left(\frac{mL}{g}\right) \times \frac{1}{1000}\left(\frac{g}{mg}\right) \times \frac{1}{1000}\left(\frac{L}{mL}\right)$$

$$Alum\ flow\ rate = 1100\ \left(\frac{L}{s}\right) \times \frac{3600}{1}\left(\frac{s}{h}\right) \times 7\ \left(\frac{mg}{L}\right) X \frac{1}{\frac{8.1}{100}} \times \frac{1}{1.34}\left(\frac{mL}{g}\right) \times \frac{1}{1000}\left(\frac{g}{mg}\right) \times \frac{1}{1000}\left(\frac{L}{mL}\right)$$

$$Alum\ flow\ rate = 255.4\ \frac{L}{h}$$

A.2 Sodium Hypochlorite (Hypo)

Chemical Formula: NaOCl

Molecular Weight: 74.44 g/mol

Chemical Concentration: Typically, 10-11% w/v as free Cl_2

Specific Gravity: Approximately 1.14

pH: 11-13

Classification: Dangerous Goods Class 8 (Corrosive), Packing Group III

UN Number: 1791

Sodium Hypochlorite flow rate example calculation (Primary Disinfection):

Chemical Formula: NaOCl

Concentration =10.5% (w/v as Cl_2) (approx.10.5g of NaOCl/100 mL of solution)

Hypo dose rate = 2.5 mg/L (as Cl_2) (input by the operator, assumed)

Filtered water flow rate = 1100 L/s (assumption)

$$Hypo\ flow\ rate = \ water\ flow\ rate\ \left(\frac{L}{s}\right) \times \frac{3600}{1}\left(\frac{s}{h}\right) \times dose\ rate\ \left(\frac{mg}{L}\right) \times \frac{1}{NaOCl\ (\%\frac{w}{v})} \times \frac{1}{1000}\left(\frac{g}{mg}\right) \times \frac{1}{1000}\left(\frac{L}{mL}\right)$$

$$Hypo\ flow\ rate = 1100\ \left(\frac{L}{s}\right) \times \frac{3600}{1}\left(\frac{s}{h}\right) \times 2.5\ \left(\frac{mg}{L}\right) \times \frac{1}{\frac{10.5}{100}} \times \frac{1}{1000}\left(\frac{g}{mg}\right) \times \frac{1}{1000}\left(\frac{L}{mL}\right)$$

$$Hypo\ flow\ rate = 94.2\frac{L}{h}$$

Sodium Hypochlorite flow rate example calculation (WQMF – Boosting Chlorine Residual):

Chemical Formula: NaOCl

Concentration =10.5% (w/v as Cl_2) (approx.10.5 g of NaOCl/100 mL of solution)

Target free chlorine dose rate = 2.5 mg/L (as Cl_2) (input by the operator, assumed)

Incoming water free chlorine concentration = 1 mg/L (as Cl_2)

Filtered water flow rate = 1100 L/s (assumption)

$$Hypo\ flow\ rate = \ water\ flow\ rate\ \left(\frac{L}{s}\right) \times \frac{3600}{1}\left(\frac{s}{h}\right) \times (target\ dose\ rate - incoming\ water\ chemcial\ conc.)\ \left(\frac{mg}{L}\right) \times \frac{1}{NaOCl\ (\%\frac{w}{v})} \times \frac{1}{1000}\left(\frac{g}{mg}\right) \times \frac{1}{1000}\left(\frac{L}{mL}\right)$$

$$Hypo\ flow\ rate = 1100\ \left(\frac{L}{s}\right) \times \frac{3600}{1}\left(\frac{s}{h}\right) \times (2.5 - 1)\ \left(\frac{mg}{L}\right) \times \frac{1}{\frac{10.5}{100}} \times \frac{1}{1000}\left(\frac{g}{mg}\right) \times \frac{1}{1000}\left(\frac{L}{mL}\right)$$

$$Hypo\ flow\ rate = 56.6\frac{L}{h}$$

Sodium Hypochlorite flow rate example calculation (Breakpoint Chlorination):

Chemical Formula: NaOCl,

Concentration =10.5 % (w/v as Cl_2) (approx.10.5 g of NaOCl/100 mL of solution)

Breakpoint (BP) chlorination mass ratio Cl_2:NH_3-N = 9:1 (assumed, input by the operator)

MW of Cl_2 70.9 mg/L, MW of NH_3 17 g/mol, MW of NH_3-N 14 g/mol

Incoming mono-chloramine (NH_2Cl) = 2 mg/L (as Cl_2) (assumed)

Incoming total chlorine = 2.2 mg/L (as Cl_2) (assumed)

Incoming free ammonia = 0.2 mg/L (NH_3-N) (assumed)

Target free chlorine after breakpoint chlorination = 2.5 mg/L (as Cl_2) (assumed)

Water flow rate = 1100 L/s (assumed)

$$Chlorine\ required\ dose\ rate\ (as\ Cl_2)$$
$$= \left[\left\{(Incoming\ NH_2Cl\ (as\ Cl_2)\ \left(\frac{mg}{L}\right)\ X \frac{MW\ of\ \ NH_3 - N}{MW\ of\ Cl_2}\ \left(\frac{g\ of\ NH_3 - N}{g\ of\ Cl_2}\right)\right.\right.$$
$$\left.\left. + Incoming\ free\ NH_3 - N\left(\frac{mg}{L}\right)\right\} \times BP\ Cl_2{:}\ NH_3 - N\ \left(\frac{g\ of\ Cl_2}{g\ of\ NH_3 - N}\right)\right]$$
$$- Incoming\ total\ chlorine\ (as\ Cl_2)\ \left(\frac{mg}{L}\right) + \ Target\ free\ chlorine\ \ (as\ Cl_2)\ \left(\frac{mg}{L}\right)$$

$$= \left[\left\{(2.0\ \times \frac{14}{70.9}) +\ 0.2\right\} \times\ 9\right]\ (\frac{mg}{L}) - 2.2\ \left(\frac{mg}{L}\right) + 2.5(\frac{mg}{L})$$

$$=\ 5.7\ \ (\frac{mg}{L})$$

$$Hypo\ flow\ rate =\ \ water\ flow\ rate\ \left(\frac{L}{s}\right) \times \frac{3600}{1} \left(\frac{s}{h}\right) \times required\ BP\ chlrine\ dose\ rate\ \left(\frac{mg}{L}\right) \times \frac{1}{NaOCl\ (\%\frac{w}{v})} \times \frac{1}{1000}(\frac{g}{mg}) \times \frac{1}{1000}\left(\frac{L}{mL}\right)$$

$$Hypo\ flow\ rate = 1100\ \left(\frac{L}{s}\right) \times \frac{3600}{1} \left(\frac{s}{h}\right) \times 5.7\ \left(\frac{mg}{L}\right) \times \frac{1}{\frac{10.5}{100}} \times \frac{1}{1000}(\frac{g}{mg}) \times \frac{1}{1000}\left(\frac{L}{mL}\right)$$

$$Hypo\ flow\ rate = 214.9\ \frac{L}{h}$$

If monochloramine and free ammonia concentrations are not known, then the required BP chlorine concentration can be calculated with the following equation which is based on only incoming total chlorine level:

$$Chlorine\ required\ dose\ rate\ (as\ Cl_2)$$
$$= \left[\left\{Incoming\ total\ chlorine\ (as\ Cl_2)\ \left(\frac{mg}{L}\right)\ X \frac{MW\ of\ \ NH_3 - N}{MW\ of\ Cl_2}\ \left(\frac{g\ of\ NH_3 - N}{g\ of\ Cl_2}\right)\right\}\right.$$
$$\left. \times BP\ Cl_2{:}\ NH_3 - N\ \left(\frac{g\ of\ Cl_2}{g\ of\ NH_3 - N}\right)\right] - Incoming\ total\ chlorine\ (as\ Cl_2)\ \left(\frac{mg}{L}\right)$$
$$+\ Target\ free\ chlorine\ \ (as\ Cl_2)\ \left(\frac{mg}{L}\right)$$

$$= \left[\ 2.2\ \times \frac{14}{70.9}\ \times\ 9\right]\ (\frac{mg}{L}) - 2.2\ \left(\frac{mg}{L}\right) + 2.5(\frac{mg}{L})$$

$$= 4.2\ \ (\frac{mg}{L})$$

$$Hypo\ flow\ rate =\ \ water\ flow\ rate\ \left(\frac{L}{s}\right) \times \frac{3600}{1} \left(\frac{s}{h}\right) \times required\ BP\ chlorine\ dose\ rate\ \left(\frac{mg}{L}\right) \times \frac{1}{NaOCl\ (\%\frac{w}{v})} \times \frac{1}{1000}(\frac{g}{mg}) \times \frac{1}{1000}\left(\frac{L}{mL}\right)$$

$$Hypo\ flow\ rate = 1100\ \left(\frac{L}{s}\right) \times \frac{3600}{1} \left(\frac{s}{h}\right) \times 4.2\ \left(\frac{mg}{L}\right) \times \frac{1}{\frac{10.5}{100}} \times \frac{1}{1000}(\frac{g}{mg}) \times \frac{1}{1000}\left(\frac{L}{mL}\right)$$

$$Hypo\ flow\ rate = 158.4\ \frac{L}{h}$$

A.3 Sodium Hydroxide (Caustic Soda)

Chemical Formula: NaOH

Molecular Weight: 40 g/mol

Chemical Concentration: 25%, 32% or 50% w/w as NaOH

Specific Gravity: approximately 1.3 – 1.5

pH: 14

Classification: Dangerous Goods Class 8 (Corrosive), Packing Group II

UN Number: 1824

Sodium Hydroxide flow rate example calculation:

Chemical Formula: NaOH

Concentration =32% (w/w) (32 g of NaOH/100 g of solution), SG: 1.3

Sodium Hydroxide dose rate = 5 mg/L (as NaOH) (input by the operator, assumed)

Water flow rate = 1100 L/s (assumed)

$$Sodium\ Hydroxide\ flow\ rate = \ water\ flow\ rate\ \left(\frac{L}{s}\right) \times \frac{3600}{1}\left(\frac{s}{h}\right) \times dose\ rate\ \left(\frac{mg}{L}\right) X\ \frac{1}{NaOH\ (\%\frac{w}{w})} \times \frac{1}{SG}\left(\frac{mL}{g}\right) \times \frac{1}{1000}\left(\frac{g}{mg}\right) \times \frac{1}{1000}\left(\frac{L}{mL}\right)$$

$$Sodium\ Hydroxide\ flow\ rate = 1100\ \left(\frac{L}{s}\right) \times \frac{3600}{1}\left(\frac{s}{h}\right) \times 5\ \left(\frac{mg}{L}\right) X\ \frac{1}{\frac{32}{100}} \times \frac{1}{1.3}\left(\frac{mL}{g}\right) \times \frac{1}{1000}\left(\frac{g}{mg}\right) \times \frac{1}{1000}\left(\frac{L}{mL}\right)$$

$$Sodium\ Hydroxide\ flow\ rate = 47.6\frac{L}{h}$$

A.4 Sulfuric Acid

Chemical Formula: H_2SO_4

Molecular Weight: 98.08 g/mol

Chemical Concentration: 70% w/w or 98% w/w as H_2SO_4

Specific Gravity: 1.6 at 70%, 1.8 at 98%

pH: <1

Classification: Dangerous Goods Class 8 (Corrosive), Packing Group II

UN Number: 1830

Sulfuric acid flow rate example calculation:

Chemical Formula: H_2SO_4

Concentration =70% (w/w) (70g of H_2SO_4/100 g of solution), SG: 1.6

Acid dose rate = 8 mg/L (as H_2SO_4) (input by the operator, assumed)

Water flow rate = 1100 L/s (assumed)

$$Acid\ flow\ rate = water\ flow\ rate\ \left(\frac{L}{s}\right) \times \frac{3600}{1}\left(\frac{s}{h}\right) \times dose\ rate\ \left(\frac{mg}{L}\right) X\ \frac{1}{\mathrm{H2SO4}\ (\%\frac{w}{w})} \times \frac{1}{SG}\left(\frac{mL}{g}\right) \times \frac{1}{1000}\left(\frac{g}{mg}\right) \times \frac{1}{1000}\left(\frac{L}{mL}\right)$$

$$Acid\ flow\ rate = 1100\ \left(\frac{L}{s}\right) \times \frac{3600}{1}\left(\frac{s}{h}\right) \times 8\ \left(\frac{mg}{L}\right) X\ \frac{1}{\frac{70}{100}} \times \frac{1}{1.6}\left(\frac{mL}{g}\right) \times \frac{1}{1000}\left(\frac{g}{mg}\right) \times \frac{1}{1000}\left(\frac{L}{mL}\right)$$

$$Acid\ flow\ rate = 28.3\frac{L}{h}$$

A.5 Aqueous Ammonia

Chemical Formula: *$NH_{3(aq)}$ / NH_4OH*

Molecular Weight: *35.04*

Chemical Concentration: *25% as NH_3*

Boiling Point: *37.7°C.*

Vapour Pressure: *25% w/w solution, 19 – 29°C: 37 – 84 kPa*

Specific Gravity: *at 10% – 35%, 0.88 – 0.96 (at approximately 20°C)*

pH: *11.7 (1% aqueous solution)*

Explosive Limits: *LEL – 15%, UEL – 28%*

Classification: Dangerous Goods Class 8 (Corrosive), Packing Group III

UN Number: *2672*

Aqueous Ammonia and sodium hypochlorite flow rate example calculation (secondary disinfection):

Sodium Hypochlorite, NaOCl, Concentration =10.5 % (w/v) (10.5 g of NaOCl/100 mL of solution), SG = 1.2

Aqueous Ammonia: $NH_{3\ (aq)}$, Concentration = 25 % (w/w) (25 g of NH_3 / 100 g of solution), SG = 0.9

Incoming residual free chlorine = 1.5 mg/L (as Cl_2) (assumed)

Input Cl_2:NH_3-N mass ratio = 4.8:1 (assumed, input by the operator), MW of NH_3 17 g/mol, MW of NH_3-N 14 g/mol

Target monochloramine (NH_2Cl) (or total chlorine) set point = 3.5 mg/L (as Cl_2) (assumed)

Treated water flow rate = 1100 L/s (assumed)

Make-up chlorine needed = 3.5 mg/L – 1.5 mg/L = 2 mg/L (as Cl_2)

$$Hypo\ flow\ rate = water\ flow\ rate\ \left(\frac{L}{s}\right) \times \frac{3600}{1}\left(\frac{s}{h}\right) \times make\ up\ chlorine\ \left(\frac{mg}{L}\right) X\ \frac{1}{NaOCl\ (\%\frac{w}{v})} \times \frac{1}{1000}\left(\frac{g}{mg}\right) \times \frac{1}{1000}\left(\frac{L}{mL}\right)$$

$$Hypo\ flow\ rate = 1100\ \left(\frac{L}{s}\right) \times \frac{3600}{1}\left(\frac{s}{h}\right) \times 2\ \left(\frac{mg}{L}\right) X\ \frac{1}{\frac{10.5}{100}} \times \frac{1}{1000}\left(\frac{g}{mg}\right) \times \frac{1}{1000}\left(\frac{L}{mL}\right)$$

$$Hypo\ flow\ rate = 75.4\ \frac{L}{h}$$

$$Aqueous\ Ammonia\ flow\ rate =$$

$$water\ flow\ rate\ \left(\frac{L}{s}\right) \times monochloramine\ or\ total\ chlorine\ residual\ set\ point\ \left(\frac{mg}{L}\right) \times \frac{1}{Cl_2{:}\,NH_3 - N}\left(\frac{g\ of\ NH_3 - N}{g\ of\ Cl_2}\right) X\ \frac{MW\ of\ NH_3}{MW\ of\ NH_3 - N}\left(\frac{g\ of\ NH_3}{g\ of\ NH_3 - N}\right) \times \frac{3600}{1}\left(\frac{s}{h}\right) \times \frac{1}{NH_3\ \left(\%\frac{w}{w}\right)}\left(\frac{g\ of\ sol}{g\ of\ NH_3}\right) \times \frac{1}{SG}\left(\frac{ml\ of\ sol}{g\ of\ sol}\right) \times \frac{1}{1000}\left(\frac{g}{mg}\right) \times \frac{1}{1000}\left(\frac{L}{mL}\right)$$

$$Aqueous\ Ammonia\ flow\ rate = 1100\ \left(\frac{L}{s}\right) \times \frac{3600}{1}\left(\frac{s}{h}\right) \times 3.5\ \left(\frac{mg\ of\ Cl_2}{L}\right) X\ \frac{1}{4.8}\left(\frac{g\ of\ NH_3 - N}{g\ of\ Cl_2}\right) \times \frac{17}{14}\left(\frac{g\ of\ NH_3}{g\ of\ NH_3 - N}\right) \times \frac{1}{\frac{25}{100}}\left(\frac{g\ of\ sol}{g\ of\ NH_3}\right) \times \frac{1}{0.9}\left(\frac{ml\ of\ sol}{g\ of\ sol}\right) \times \frac{1}{1000}\left(\frac{g}{mg}\right) \times \frac{1}{1000}\left(\frac{L}{mL}\right)$$

$$Aqueous\ Ammonia\ flow\ rate = 15.6\frac{L}{h}$$

Note: If the incoming measured chlorine is mono-chloramine chlorine instead of free chlorine as for WQMF boosting facility, substitute the value of the mono-chloramine (or total chlorine residual) setpoint (mg/L) with the make-up chlorine value (mg/L) to the above equation to calculate the aqueous ammonia flow rate.

A.6 Liquid Ammonium Sulfate (LAS)

Chemical Formula: *$(NH_4)_2SO_4$*

Molecular Weight: *132.14*

Chemical Concentration: *10.3 ± 0.3 % (w/w) as NH_3*

Specific Gravity: *1.24 (at approximately 15.5°C)*

pH: 3.5 to 7.5

Liquid ammonia sulfate (LAS) and sodium hypochlorite flow rate example calculation (WQMF chloramine boosting):

Sodium Hypochlorite, NaOCl, Concentration =10.5 % (w/v) (10.5 g of NaOCl/100 mL of solution), SG = 1.2

LAS, *$(NH_4)_2SO_4$* Concentration = 10.3 % as NH_3 (w/w) (10.3 g of NH_3 / 100 g of solution), SG = 1.24

Incoming residual total chlorine = 1.5 mg/L (as Cl_2) (assumed)

Input Cl_2:NH_3-N mass ratio = 4.8:1 (assumed, input by the operator)), MW of NH_3 17 g/mol, MW of NH_3-N 14 g/mol

Target monochloramine (NH_2Cl) (or total chlorine) set point = 3.5 mg/L (as Cl_2) (assumed)

Treated water flow rate = 1100 L/s (assumed)

Make-up chlorine needed = 3.5 mg/L – 1.5 mg/L = 2 mg/L (as Cl_2)

$$Hypo\ flow\ rate = \ water\ flow\ rate\ \left(\frac{L}{s}\right) \times \frac{3600}{1}\left(\frac{s}{h}\right) \times make\ up\ chlorine\ \left(\frac{mg}{L}\right) X\ \frac{1}{NaOCl\ (\%\frac{w}{w})}\ \left(\frac{ml}{mg}\right) \times \frac{1}{1000}\left(\frac{g}{mg}\right) \times \frac{1}{1000}\left(\frac{L}{mL}\right)$$

$$Hypo\ flow\ rate = 1100\ \left(\frac{L}{s}\right) \times \frac{3600}{1}\left(\frac{s}{h}\right) \times 2\ \left(\frac{mg}{L}\right) X\ \frac{1}{\frac{10}{100}}\ \left(\frac{mL}{mg}\right) \times \frac{1}{1000}\left(\frac{g}{mg}\right) \times \frac{1}{1000}\left(\frac{L}{mL}\right)$$

$$Hypo\ flow\ rate = 75.4\ \frac{L}{h}$$

$$LAS\ flow\ rate = water\ flow\ rate\ \left(\frac{L}{s}\right) \times make\ up\ chlorine\ \left(\frac{mg}{L}\right) \times \frac{1}{Cl_2 : NH_3 - N}\left(\frac{g\ of\ NH_3 - N}{g\ of\ Cl_2}\right) X \frac{MW\ of\ NH_3}{MW\ of\ NH_3 - N}\left(\frac{g\ of\ NH_3}{g\ of\ NH_3 - N}\right) \times \frac{1}{NH_3\ \left(\%\frac{w}{w}\right)}\left(\frac{g\ of\ sol}{g\ of\ NH_3}\right) \times \frac{1}{SG}\left(\frac{ml\ of\ sol}{g\ of\ sol}\right) \times \frac{1}{1000}\left(\frac{g}{mg}\right) \times \frac{1}{1000}\left(\frac{L}{mL}\right)$$

$$LAS\ flow\ rate = 1100\ \left(\frac{L}{s}\right) \times \frac{3600}{1}\left(\frac{s}{h}\right) \times 2\ \left(\frac{mg\ of\ Cl_2}{L}\right) X \frac{1}{4.8}\left(\frac{g\ of\ NH_3 - N}{g\ of\ Cl_2}\right) \times \frac{17}{14}\left(\frac{g\ of\ NH_3}{g\ of\ NH_3 - N}\right) \times \frac{1}{\frac{10.3}{100}}\left(\frac{g\ of\ sol}{g\ of\ NH_3}\right) \times \frac{1}{1.24}\left(\frac{ml\ of\ sol}{g\ of\ sol}\right) \times \frac{1}{1000}\left(\frac{g}{mg}\right) \times \frac{1}{1000}\left(\frac{L}{mL}\right)$$

$$LAS\ flow\ rate = \ 15.7\frac{L}{h}$$

Note: If the incoming measured chlorine is free chlorine for secondary disinfection, substitute the value of the required make-up chlorine (mg/L) with the target mono-chloramine or total chlorine concentration setpoint (mg/L) to the above equation to calculate the LAS flow rate.

Appendix B –Materials Selection for Liquid Chemical Storage Tanks

This Appendix provides a guideline to the selection of materials for the construction of liquid chemical storage or dosing tanks. Guidance shall be sought from other Seqwater documents (where available) and Asset Class Plans, relevant Australian and industry standards and specifications for the material(s) selected. Expected design life, life cycle cost, tank size and Seqwater current practice and experience shall also be considered to the selection of tank materials.

Tank materials selection shall be confirmed with suppliers. Refer to Section 6.1.1 and Section 6.1.5 for applicable tank standards applied to specific materials and other relevant information.

For associated chemical fill lines, dosing, and transfer pipework, refer to *M-SPE-STD-013 Chemical Dosing Piping* for guidelines to the selection of materials.

B.1. Aluminium Sulfate (Alum)

Asset	Tank Materials
Storage Tanks	<u>Rotationally Moulded:</u> Usually, Linear Low-Density Polyethylene (LLDPE) or Linear Density (Polyethylene) or Linear Medium Density Polyethylene (LMDPE) tanks. Fittings are cast PE welded manually to the tank. Vertical tanks only.
	<u>Polymer Welded Fabricated Tanks:</u> Welded sheets of polymer. Usually, High-Density Polyethylene (HDPE). HDPE is known to provide higher strength and stiffness with higher chemical resistance compared to LLDPDE or LDPE tanks.
	<u>Fibreglass Lined :</u> Resin and fiberglass applied in layers in a mould either manually or by machine. Fibreglass fittings are attached manually with layers of resin and fibreglass. Use a PTFE or other suitable liner for maximum life.
	<u>Lined Carbon Steel Tank</u>: Stress relieve all welds to extend the life of the tank. Horizontal or vertical tanks are acceptable. Use a PTFE liner for maximum life.
	<u>Stainless Steel (304 SS or 316 SS) Tank:</u> Provide superior corrosion resistance, should be assessed the benefits in against of other materials on a case by case with the consideration of design life and cost. A similar assessment requires to select suitable SS grade for tank material. Ensure all welds are passivated correctly. Horizontal or vertical tanks are acceptable.

B.2. Sodium Hypochlorite (Hypo)

Asset	Materials
Storage Tanks	Rotationally Moulded: Usually, LLDPE or LDPE or LMDPE tanks. Fittings are cast PE welded manually to the tank. Vertical tanks only. Recommended for frequent inspection of storage tanks.
	Polymer Welded Fabricated Tanks: Welded sheets of polymer (usually High-Density Polyethylene (HDPE). HDPE is known to provide higher strength and stiffness with higher chemical resistance compared to LLDPDE or LDPE tanks.
	Fibreglass Lined : Resin and fiberglass applied in layers in a mould either manually or by machine. Fibreglass fittings are attached manually with layers of resin and fibreglass. Internal coating must be compatible with %w/w sodium hypochlorite.
	Lined metal tanks are not advised due to the specialist requirements for attaching liners, the relatively short lifetime of liners, maintenance requirements, risk of damage and potential corrosion from pin hole.

B.3. Sodium Hydroxide (25%, 32% or 50% w/w)

Asset	Materials
Storage Tanks	Rotationally Moulded Usually, LLDPE or LDPE or LMDPE tanks. Fittings are cast PE welded manually to the tank. Vertical tanks only. It is recommended that these tanks are made with a Specific Gravity (SG) rating of 1.9.
	Polymer Welded Fabricated Tanks: Welded sheets of polymer (usually High-Density Polyethylene (HDPE). It is recommended that these tanks are made with a Specific Gravity (SG) rating of 1.9.
	Fibreglass Lined : Resin and fiberglass applied in layers in a mould either manually or by machine. Fibreglass fittings are attached manually with layers of resin and fibreglass. Use a PTFE liner for maximum life.
	Unlined Carbon Steel: Stress relieve all welds to extend the life of the tank. Horizontal or vertical tanks are acceptable. Normally, externally coated along with internally coated to prevent atmospheric corrosion when empty.

Asset	Materials
	Tanks can be lined with PTFE or natural rubber to provide an extra measure against corrosion and recommended when iron pickup by the chemical solution is a concern.
	Stainless Steel (304 SS or 316 SS) Tank: Provide superior corrosion resistance, should be assessed the benefits in against of other materials on a case by case with the consideration of design life and cost. A similar assessment is required to select suitable SS grade for tank material. Ensure all welds are passivated correctly. Horizontal or vertical tanks are acceptable.

B.4. Sulfuric Acid (70% and 98%)

Asset	Materials
Storage Tanks	Rotationally Moulded: Usually, LLDPE or LDPE or LMDPE tanks. Fittings are cast PE welded manually to the tank. Vertical tanks only. It is recommended that these tanks are made with a Specific Gravity (SG) rating of 1.9 or higher. Recommended for frequent inspection of storage tanks.
	Polymer Welded Fabricated Tanks: Welded sheets of polymer (usually High-Density Polyethylene (HDPE). HDPE is known to provide higher strength and stiffness with higher chemical resistance compared to LLDPDE or LDPE tanks. It is recommended that these tanks are made with a Specific Gravity (SG) rating of 1.9 or higher.
	Fibreglass Lined (recommended only for 70%): Resin and fiberglass applied in layers in a mould either manually or by machine. Fibreglass fittings are attached manually with layers of resin and fiberglass. Use a PTFE or other suitable liner for maximum life.
	Unlined Carbon Steel: Stress relieve all welds to extend the life of the tank. Horizontal or vertical tanks are acceptable. Normally externally coated along with internally coated to prevent atmospheric corrosion when empty.

B.5. Aqueous Ammonia

Asset	Materials
Storage Tanks	Lined Metal Tank: Stress relieve all welds to extend the life of the tank. Horizontal or vertical tanks are acceptable. Use an inside PTFE liner for maximum life along with inside and outside coating.
	Stainless Steel 304 SS or 316 SS: Ensure all welds are passivated correctly. Horizontal or vertical tanks are acceptable. Exact choice of SS grade based on economics and availability analysis.

B.6. Liquid Ammonium Sulfate

Asset	Materials
Storage Tanks	Rotationally Moulded Usually, LLDPE or LDPE or LMDPE tanks. Fittings are cast PE welded manually to the tank. Vertical tanks only.
	Polymer Welded Fabricated Tanks: Welded sheets of polymer. Usually, High-Density Polyethylene (HDPE).
	Fibreglass Unlined: Resin and fiberglass applied in layers in a mould either manually or by machine. Fibreglass fittings are attached manually with layers of resin and fibreglass.
	Lined Metal Tank: Stress relieve all welds to extend the life of the tank. Horizontal or vertical tanks are acceptable. Use a PTFE liner for maximum life.

Appendix C –Typical Trips and Interlocks for Liquid Chemical Unloading, Storage and Dosing Systems

Device / Instrument	Cause	Action	Trip interlock	Hardware / Hardwired interlock
Fill Line Manual Isolation Valve – Limit Switch	Fault	Fill Point SPOs are isolated / interlocked.	Y	
	Power Loss			
	Limit Switch - Not Opened			
	More than one limit switch open or partially open.			
Chemical Unloading Area Sump CSHT Diversion Valve – Limit Switch	Fault	Fill Point SPOs are isolated / interlocked.	Y	
	Power Loss			
	Limit Switch – Not Opened			
Chemical Unloading Area Sump Stormwater Valve – Limit Switch	Fault	Fill Point SPOs are isolated / interlocked.	Y	
	Power Loss			
	Limit Switch – Not Closed			
Bulk Storage Tank Bund Sump – High-High Level (where included)	Fault	Fill point SPOs are isolated/interlocked.	Y	
	Power Loss			
	High-High Level Detected			
Bulk Storage Tank Bund Drain Valve Open during unloading (where included)	Limit Switch – Not Closed	Fill point SPOs are isolated/interlocked.	Y	
Bulk Storage Tank Level Transmitter	Fault	Pumps tripped and interlocked.	Y	
	Power Loss			
	High-High Level	Fill point SPO interlocked.		
	Low-Low Level	Storage tank isolated, pumps interlocked. Changeover to alternate tank.		

Device / Instrument	Cause	Action	Trip interlock	Hardware / Hardwired interlock
	Level decrease but pumps inactive, or level change exceeds pump operating rate.	Storage tank isolated, pumps interlocked.		
Bulk Storage Tank High-High Level Switch	Fault	Relevant Fill Point SPO isolated/interlocked		Y
	Power Loss			
	High-High Level Detected			
Fixed gas detector (for aqueous ammonia)	Fault	SPOs isolated/interlocked	Y	
	Power Loss			
	Concentration higher than allowable limit for a defined period			
Safety shower or eye wash flow switch	Activated during chemical unloading	SPOs isolated/interlocked	Y	
Bulk Storage Tank Low-Low Level Switch	Fault	Relevant Pump tripped / interlocked. Relevant Storage tank isolated.	Y	
	Power Loss			
	Low-Low level Detected			
Bulk Storage Tank Outlet Valve	Fault	Relevant dosing pump interlocked	Y	
	Power Loss			
	Fails to open / close in time limit			
Dosing Tank Level Transmitter	Fault	Pumps tripped and interlocked.	Y	
	Power Loss			
	High-High Level	Fill / transfer pumps tripped / interlocked.		
	Low-Low Level	Dosing pumps tripped / interlocked.		
	Level decrease but pumps inactive, or level change exceeds pump operating rate.	Storage tank isolated, pumps interlocked.		
Dosing Tank High-High Level Switch	Fault	Fill / transfer pumps tripped and interlocked.		Y
	Power Loss			
	High-High level detected			

Device / Instrument	Cause	Action	Trip interlock	Hardware / Hardwired interlock
Dosing Tank Low-Low Level Switch	Fault	Dosing pumps tripped / interlocked. Tank isolated.	Y	
	Power Loss			
	Low-Low level Detected			
Dosing Flowmeter	Fault	Interlock dosing pumps.	Y	
	Power Loss			
	Flow below setpoint for pre-set period.	Changeover to standby pumps.		
Dosing Line Actuated Valve	Fault	Pumps interlocked.	Y	
	Power Loss			
	Fails to open / close in time limit			