Standard Specification

Engineering Standard B-SPE-STD-011 Polymer, PAC, Pot Perm and Soda Ash Systems

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(Refer Controlled Document in REX for Author, SME, Owner and Approver details)

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, economic over the life of the asset, and meets Seqwater's Work Health and Safety obligations.

This Standard Specification provides the minimum requirements and recommendations for all Seqwater works relating to the design and construction of Polymer, Powder Activated Carbon (PAC), Potassium Permanganate (Pot Perm) and Sodium Carbonate (Soda Ash) powder chemical delivery, storage, batching and dosing systems used in drinking water treatment.

This document outlines Seqwater's preferences and best practices, derived from years of experience. It applies to the delivery of Polymer, PAC, Pot Perm, and Soda Ash in solid or powder form. For detailed information on the specific chemicals covered by this standard and their applications, refer to Section 3.

The standard specifically does not apply to chemicals delivered to Seqwater sites as liquids or gases, nor does it cover other powdered chemicals not listed in this document. Additionally, the standard does not specify the requirements for trucks or tankers used to deliver powder chemicals to storage silos or hoppers.

This document must be used in conjunction with the documents it references to assist in ensuring fit for purpose infrastructure. This Standard Specification 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.

2. Scope

This Standard Specification applies to all Seqwater employees, contractors, suppliers 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 system are to be replaced, refurbished or modified, this standard should not automatically be applied to the entire system retrospectively, however consideration should be given, in consultation with relevant stakeholders, to the extent of the application of the standard outside of the components requiring replacement, refurbishment or modification, to ensure safe, economic, and fit for purpose infrastructure.

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 Water Services Association of Australia). 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 Specification requires written agreement from Seqwater as per the deviation process detailed in Procedure PRO-02205 X-PRO-STD-008 Asset Standards Management and Application Procedure. That process includes completion of an TEM-00224 X-TMP-STD-022 Asset Standards Deviation Request Template and submission by the Seqwater Project Representative to the Seqwater Engineering Mailbox. Where noted in this Standard Specification that Seqwater approval, agreement, or acceptance shall/must be sought, such approval, agreement 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 infrastructure. This includes modifications to the functional design of the infrastructure including technical changes made which would extend an asset outside of its design operating envelope and/or approved operation and maintenance practices.

Any ambiguities or conflicts identified between specific requirements within this Standard and project documents, another Seqwater Engineering Standard or Australian Legislation, Standards, Codes or Guidelines, these must be brought to the attention of the Seqwater Document Owner, via the Engineering Mailbox, for clarification. Where it is proposed to proceed without meeting the requirements of this standard, agreement must be obtained via the Deviation Process, as outlined above.

Seqwater undertakes regular updates of its Engineering Standards. Before utilising this Engineering Standard, the complete list of Seqwater Engineering Standards should be reviewed to ensure currency and applicability of standards to be applied to the works. These can be accessed on the Waternet Seqwater Engineering Standards & Framework page or from your Seqwater project manager or engaging officer.

3. Applicable Powder Chemicals

This section provides a brief overview on the four powder chemicals covered by this standard and details why and how they are used in Seqwater drinking water treatment plants. The four powder chemicals as stated below are dosed into the process system as a chemical slurry or chemical solution. The four powder chemicals this standard specification applies to are:

- Polymer
- Powder Activated Carbon (PAC)
- Potassium Permanganate (Pot Perm)
- Sodium Carbonate (Soda Ash)

Additional powder chemicals may be considered or required for the application of this standard specification. Approval shall be sought from the Seqwater Principal Engineering Standards and Assurance for the validity and application of this standard in such circumstances.

For key risks associated with specific chemicals, generic requirements and considerations, Seqwater PRO-00008 Hazardous Chemicals Procedure and the chemical specific Safety Data Sheet (SDS) shall be referred to.

Some additional details for each chemical may be found in Appendix A, including:

- Chemical Formula
- UN Number (ADG Code Number)
- Dangerous Goods Classification
- Physical/Chemical Properties

3.1. Polymer

At Seqwater, the term “polymer” usually refers to various types of polyacrylamides. Polyacrylamide is used across Seqwater sites as a flocculation aid, filter aid or for conditioning of water sludges prior to thickening and dewatering. When employed as a flocculation aid it acts as a bridging agent, binding flocs together and promoting the formation of larger flocs, which facilities easier settlement.

Polyacrylamide is a synthetic polymer that exists in non-ionic, anionic and cationic forms with varying degrees of ionic charge. Depending on the specific application requirements, types of polyacrylamides are selected. Refer to REG-00250 Drinking Water Treatment Chemical Supplier Matrix for the complete and current list of polyacrylamides used in Seqwater.

The polyacrylamide dose in Water Treatment Plants (WTPs) is managed to limit the monomer-acrylamide level in treated water below the ADWG health limit of 0.2 µg/L.

Polyacrylamides are supplied as free flowing white powder. Depending on the site-specific demand, they are delivered to Seqwater sites in small package bag (15-25kgs), large package bag (700-750 kgs), or bulk delivery by trucks.

PolyDADMAC or Polydiallyldimethylammonium Chloride is another polymer used at Seqwater sites primarily as a coagulant aid. PolyDADMAC is delivered at Seqwater sites as a liquid in an Intermediate Bulk Container (IBC).Therefore , the requirements outlined in standard specification SPE-00445 B-SPE-STD-009 Liquid Chemical Storage and Dosing Systems shall be applied to the handling and dosing of this chemical.

3.2. Powered Activated Carbon (PAC)

Powdered activated carbon is used in water treatment for the removal of dissolved organic chemicals and/or taste and odour compounds. PAC works by the non-specific adsorption of contaminants to the surface of the carbon. Pore structure, surface area, bulk density, particle size, activation process and materials source are among the important characteristics that influence the adsorption capacity.

At Seqwater sites, PAC is dosed into the front end of the treatment process and then removed via clarification or sedimentation.

PAC is a black crystalline powder. Depending on the site-specific demand, PAC is delivered to Seqwater sites using either small package bags (15-25 kg) or large package bags (400-500 kg).

For more information on the chemical hazards associated with PAC that designers must consider and mitigate, refer to Section 4.1.1.1.

3.3. Potassium Permanganate (Pot Perm)

Potassium permanganate or Pot Perm ($KMnO_4$) is a strong oxidizing agent and used at Seqwater sites for the removal of iron and manganese from raw water sources. Additionally, the capacity to dose into centrate return exists at one Seqwater site, although it is not frequently in use, if ever.

Raw water sources may contain high levels of dissolved iron and manganese in their lowest oxidation states of ferrous (Fe(II)) and manganous (Mn(II)). Potassium Permanganate oxidises dissolved iron and manganese ions and converts them to ferric Fe(III) and Mn(IV) ions which allows physical removal of these metals as precipitates of ferric hydroxide ($Fe(OH)_3$) and manganese dioxide (MnO_2) during clarification or sedimentation and filtration.

Potassium permanganate ($KMnO_4$) dissolves readily in water, and its solubility increases with rising temperature, as shown in Table 1. Upon dissolution, it dissociates into potassium ions (K^+) and permanganate ions (MnO_4^-), forming a characteristic pink to purple-coloured solution.

Although potassium permanganate is not combustible, it acts as a strong oxidizer and can accelerate combustion reactions. It may even induce spontaneous ignition when in contact with combustible material. Therefore, it must be stored separately from flammable materials, reducing agents, and powdered metals to prevent hazardous reactions.

In addition, $KMnO_4$ should be stored in a well-sealed container and in a location without access to drainage or sewer systems, in order to minimize the risk of accidental contamination and environmental harm.

Table 1 Pot Perm Solubility at different temperatures

Temperature (ºC)	Solubility (%wt)
0	2.8
20	6.3
30	9.0
40	12.6
60	22.1

In theory, dissolving Pot Perm ($KMnO_4$) in water should result in a solution that is neutral to slightly basic, with a pH of 6-8. However, the manufacturing process of Pot Perm typically involves either acidic or alkaline conditions, depending on the method used. As a result, residual substances from these processes may remain in the final product. These impurities can influence the pH of dilute $KMnO_4$ solutions and should not be overlooked, as they may lead to variations in the measured pH.

Pot Perm is a dark purple coloured crystalline solid. This chemical is usually delivered to Seqwater sites with small package bags/pails with the weight of 15-25 kg .

Australian Dangerous Goods (ADG) code has classified Pot Perm under Division 5.1 with the packaging group II. Therefore, Australian Standard *AS 4326 The storage and handling of oxidizing agents* shall apply for the safe storage and handling of Pot Perm.

Due to its ADG code classification, Pot Perm is also captured under schedule 15 of the Work Health and Safety Act 2011 (WHS Act 2011). This means that Work Health and Safety QLD must be notified if pot perm is present in quantities above 10% of the Schedule 15 threshold value.

Additionally, when quantities above 10% of the Schedule 15 value are present, or likely to be present, Planning Guideline State Code 21 for hazardous Chemical facilities is applicable for any new facility or any work that would trigger a material change of use (MCU).

3.4. Sodium Carbonate (Soda Ash)

Sodium carbonate or soda ash is used in water treatment for pH correction, water softening, and corrosion control.

Soda ash is typically a greyish-white powder and is usually used at small Seqwater sites for pH correction. The chemical is normally delivered in small 25kg bags and dosed as a solution.

Soda ash is soluble in water, with the solubility increasing with temperature. It tends to absorb water and carbon dioxide to form sodium sesquicarbonate ($Na_2CO_3 \cdot NaHCO_3 \cdot 2H_2O$), thus need to be stored in dry, ventilated place. Table 2 shows soda ash's typical solubility in water at different temperatures.

Table 2 Soda Ash Solubility at different temperatures

Temperature (ºC)	Solubility (%wt)
0	7
10	12.5
20	21.4
30	39.7

Soda ash solution is alkaline (pH>7), with Table 3 show the indicative pH of soda ash solution at different strengths.

Table 3 pH of soda ash solution at different concentrations

Solution (%wt)	pH (at 25ºC)
1	11.37
5	11.58
10	11.7

Soda ash is not classified as dangerous goods in accordance with the Australian Code for the Transport of Dangerous Goods by Road and Rail (ADG). However, it is classified as a hazardous chemical in accordance with the criteria of Safe Work Australia - Globally Harmonized System (GHS). Please refer to PRO-00008 Hazardous Chemicals Procedure for requirements regarding storage and handling of soda ash.

3.5. Powder Chemical Quality

Seqwater only uses powder 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 powder chemicals.

In addition to complying with the Seqwater chemical quality specifications, the design shall ensure that the quality of chemical meets the requirements of the Australian Drinking Water Guidelines (ADWG), the American Water Works Association (AWWA) Standards, and the NSF/ANSI/CAN 60 – Drinking Water Treatment Chemicals – Health Effects and NSF/ANSI/CAN 61 - Drinking Water System Components - Health Effects (+ Errata), which are recognized by NSF International, the American National Standards Institute, and the Standards Council of Canada. Existing supply contracts should be used as a reference for chemical specific considerations, in accordance with REG-00250 Drinking Water Treatment Chemical Supplier Matrix.

Designs shall account for reasonable and foreseeable variations in the quality or purity of supplied chemicals to ensure the facility can operate safely and respond effectively or be readily adapted to alternative chemical supplies.

4. General Requirements

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

4.1. Safety in Design

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

1. PRO-01617 X-PRO-STD-009 Engineering Design, Construction, Operation and Maintenance Procedure
2. PRO-02140 X-PRO-STD-013 Engineering Technical Hazard Study Procedure

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 is undertaken. 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, generic requirements and considerations, refer to PRO-00008 Hazardous Chemicals Procedure, relevant Safety Data Sheets (SDS) for specific chemicals and 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 60079.10.2 Explosive atmospheres – Classification of areas – Explosive dust atmospheres and AS/NZS 60079.10.1 Explosive atmospheres – Classification of areas – Explosive gas atmospheres*.

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

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

Hazardous area zoning and classification shall be undertaken by a qualified person certified in hazardous area compliance. 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 being undertaken.

4.1.1.1. PAC

The installation and storage of PAC system must be assessed to determine whether the area is classified as a hazardous area. If the area is classified as a hazardous area, all electrical equipment must be certified for the hazardous area classification with the requirements as specified in SPE-00352 E-SPE-STD-001 Electrical Design and Construction and SPE-00367 M-SPE-STD-001 General Mechanical.

PAC is combustible and may be ignited by heat, sparks, or flame, hence the design shall mitigate all potential explosion risks. When burnt, it smoulders and releases Carbon Monoxide (CO) and Carbon Dioxide (CO_2) gases. CO gas, at its explosive concentration range (12.5% – 74.2%) in the headspace may react explosively with oxygen. PAC dust clouds produced typically from unloading may be explosive in addition to the risk of CO formation.

PAC and its combustion products may form an oxygen deficient environment and creates an asphyxiation hazard. The design shall consider all asphyxiation hazards and mitigate these. Both CO and CO_2 are highly toxic and asphyxiant gases and when released into the atmosphere, they displace the oxygen and reduce the amount of oxygen available. In addition, CO gas and wet activated carbon removes oxygen from the air, and as result slurry tanks or other enclosed spaces containing carbon may have significantly lower oxygen levels.

PAC is an electrical conductor and should not be allowed to accumulate as dust near or on open electrical circuits. Electrical equipment in the PAC building should be designed with IP66 rating.

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

4.2. Engineering Units

Where not specified in this document, equipment and instrument units shall be in accordance with the requirements of *AS 1000 International System of Units (S.I.) and its Applications and* SPE-00361 I-SPE-STD-013 Control Systems Design and Construction.

4.3. Design Life

Seqwater PLN-00402 Powder Chemical Storage and Batching Asset Class Plan shall be referred for the design life of silos, hoppers, batching tanks and storage tanks. Table 4 provides reference sources that define the required Seqwater asset design lives. Where there is no document relevant to the asset, the required design life has been provided.

Table 4 Summary of references for asset design life

Asset Class	Design Life
Batching Tanks	Refer PLN-00402 Powder Chemical Storage and Batching Tanks Asset Class Plan.
Chemical Dosing Skid Components: • Pumps • Valves • Pipework • Motors • Instrumentation • Electronics • Protective Coatings • Non-specified items	Refer SPE-00367 M-SPE-STD-010 General Mechanical, PLN-00397 Chemical Dosing Asset Class Plan and other Asset Class Plans as relevant.

Asset Class	Design Life
Chemical Pipework	Refer SPE-00367 M-SPE-STD-010 General Mechanical.
Concrete Structures (excl. pipes)	80 years.
Electrical Installations / Assets	Refer SPE-00352 E-SPE-STD-001 Electrical Design and Construction.
Field Devices (Instrumentation)	10 years.
Flow Meters	Refer SPE-00367 M-SPE-STD-010 General Mechanical
General Mechanical Equipment	Refer SPE-00367 M-SPE-STD-010 General Mechanical.
Metalwork and Structural Steel	Refer SPE-00367 M-SPE-STD-010 General Mechanical.
Pipework (general & non-chemical)	Refer SPE-00367 M-SPE-STD-010 General Mechanical.
Platforms, Walkways, Stairways Ladders	Refer SPE-00367 M-SPE-STD-010 General Mechanical.
Protective Coatings	Refer SPE-00348 M-SPE-STD-004 Protective Coatings and WSA 201 Manual for Selection and Application of Protective Coatings.
Silos and Hoppers	Refer PLN-00402 Powder Chemical Storage and Batching Tanks Asset Class Plan.
Dosing Tanks: Steel, Plastic, FRP / GRP (with UV protection)	Refer SPE-00367 M-SPE-STD-010 General Mechanical and PLN-00402 Powder Chemical Storage and Batching Tanks Asset Class Plan.
Tank Liners	10 years.
Valves	Refer SPE-00323 M-SPE-STD-003 Valves for Water Applications.

4.4. Site Conditions

The term 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:

1. SPE-00367 M-SPE-STD-001 General Mechanical
2. SPE-00352 E-SPE-STD-001 Electrical Design and Construction

3. SPE-00361 I-SPE-STD-013 Control System Design and Construction

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, site 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 for silos, hoppers, batching and storage tanks, piping and equipment shall be appropriate to the applications and compatible to powder chemicals and site conditions for which they are intended. Requirements shall be sought from the following sources as a minimum:

1. Relevant Australian and industry standards and specifications for the material(s) selected.
2. Vendor and supplier recommendations and experience
3. Safety Data Sheet (SDS) of relevant chemicals
4. SPE-00367 M-SPE-STD-001 General Mechanical
5. SPE-00366 M-SPE-STD-002 Fixed Platforms, Walkways, Stairways and Ladders
6. SPE-00348 M-SPE-STD-004 Protective Coatings
7. SPE-00435 M-SPE-STD-010 Chemical Dosing Skids
8. SPE-00355 M-SPE-STD-013 Chemical Dosing Piping
9. SPE-00395 D-SPE-STD-001 Water Supply Networks Planning, Design and Construction
10. PLN-00402 Powder Chemical Storage and Batching Asset Class Plan – Assessment

Note that where powder chemicals, chemical slurries and solutions are corrosive to a particular material, a protective lining may be applied to storage and batching tanks to prevent corrosion.

4.6. Equipment Selection

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

1. REG-01074 X-LST-STD-001 Seqwater Preferred Equipment Register
2. SPE-00430 M-SPE-STD-012 Chemical Dosing Pumps
3. SPE-00434 M-SPE-STD-009 Flow Meters
4. SPE-00367 M-SPE-STD-001 General Mechanical
5. SPE-00342 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:

6. PLN-00452 Corporate Energy Strategy
7. GDE-00369 E-GDE-STD-001 Energy Metering and Monitoring Guideline

8. MAN-00391 E-MAN-STD-001 Energy Efficiency Manual

4.7. Colour and Protective Coatings

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

1. SPE-00367 M-SPE-STD-001 General Mechanical
2. SPE-00348 M-SPE-STD-004 Protective Coatings
3. WSA 201-2017 Manual for Selection and Application of Protective Coatings
4. AS 2312.1 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings - Paint coatings
5. AS 2312.2 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings – Hot dip galvanizing
6. Other relevant legislation and Australian Standards, especially those referenced in the above documents.

4.8. Pipework, Fittings, Valves, and Isolation

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

1. SPE-00367 M-SPE-STD-001 General Mechanical
2. SPE-00323 M-SPE-STD-003 Valves for Water Applications
3. SPE-00435 M-SPE-STD-010 Chemical Dosing Skids
4. SPE-00355 M-SPE-STD-013 Chemical Dosing Piping

Valves and actuators shall comply with the requirements of SPE-00323 M-SPE-STD-003 Valves for Water Applications.

In chemical piping systems exceeding 50mm, consideration should be given to the use of butterfly and diaphragm valves over ball valves.

Mechanical isolation of piping and dosing systems shall be in accordance with SPE-00367 M-SPE-STD-001 General Mechanical.

4.8.1. Pipework sizing and Line velocity

Suitable pipeline velocities must be maintained in all pipework to manage stagnation, settlement and degradation of chemical as well as maintain the integrity of assets. Piping velocities should generally comply with

Table 5 and Table 6, unless deemed inappropriate by the designer for a particular application.

Table 5 Recommended line velocities for chemical solutions

Purpose	Pipe Material	Maximum (No Fast Opening/Closing Valves)	Maximum (Fast Opening/Closing Valves)	Minimum line velocity
General	Plastic, GRP	2 m/s	1.5m/s	0.5 m/s
	Metallic	3 m/s	2.5 m/s	0.5 m/s
Pump suction	All	1 – 1.5 m/s		0.5 m/s

Table 6 Recommended Line Velocities for slurries and suspensions

Purpose	Pipe Material	Maximum (No Fast Opening/Closing Valves)	Maximum (Fast Opening/Closing Valves)	Minimum line velocity
General	Plastic, GRP	2.5 m/s	2m/s	1.5 m/s
	Metallic	3 m/s	2.5 m/s	1.5 m/s
Pump suction	All	1.5 m/s		1 m/s

The pipework layout for chemical slurries such as PAC shall be designed to minimise solid deposition. Wherever practicable, vertical pipe drops should be avoided, as these can lead to solids settling and potential blockages if the system is not used continuously or adequately flushed

To prevent pipe clogging, a minimum velocity of 1.5 m/s should be maintained in all pipework carrying chemical slurries or suspensions, especially after the pump discharge where flow is pressurized and continuous. To help maintain adequate line velocity, the design should incorporate the injection of carrier water either downstream of the chemical dosing pump or at the outlet of the chemical dosing skid.

Additionally, all such pipework should be designed for post use flushing with an appropriate water source (e.g., raw water, site service water, or potable water, depending on the application).

For pneumatic conveying system, the designer shall determine and apply optimum air velocities to both prevent settlement and minimise wear or erosion of the conveying pipework and associated materials.

4.9. Civil Works

Civil works shall comply with the requirements of *WSA 03-2011 Water Supply Code of Australia as amended by* SPE-00395 D-SPE-STD-001 Water Supply Networks Planning, Design and Construction, 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 SPE-00348 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 Standard Specifications, Australian and industry codes, specifications and legislative requirements.

Refer to SPE-00367 M-SPE-STD-001 General Mechanical for further guidance.

4.11. Electrical Works

All electrical works, motors and variable speed drives (VSDs) shall comply with the requirements of SPE-00352 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 *SPE-00352* E-SPE-STD-001 Electrical Design and Construction for further details.

Emergency stops shall be incorporated into the design in accordance with AS/NZS 4024. Where emergency stops are omitted, a supporting risk assessment must be provided.

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

Instrumentation shall comply with the requirements of SPE-00352 E-SPE-STD-001 Electrical Design and Construction, SPE-00353 I-SPE-STD-015 Instrumentation, and relevant Australian and industry standards, specifications and codes.

All Instrumentation:

1. Shall be selected to prevent or minimise the potential of contact with any chemical as part of routine maintenance.
2. Transmitters and control circuits shall comply with the voltage requirements of SPE-00352 E-SPE-STD-001 Electrical Design and Construction.
3. Indicators shall comply with the requirements of the Instrumentation Indicators section of SPE-00352 E-SPE-STD-001 Electrical Design and Construction.
4. Displays shall be digital and suitably weatherproof to the Site Conditions and shielded to prevent glare.
5. 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 SPE-00361 I-SPE-STD-013 Control Systems Design and Construction.
6. Flow meters shall comply with the requirements of SPE-00434 M-SPE-STD-009 Flow Meters and REG-01074 X-LST-STD-001 Seqwater Preferred Equipment Register for the selection and installation. Flow switches may be used as a secondary means of flow identification

4.12.1. Level Sensors and Switches

In addition to Section 4.12, All level instrumentation:

1. Where available and suitable for the site installation, non-contact continuous level sensors and non-contact level switches should be considered to minimise personnel exposure to chemicals during maintenance and commissioning activities.
2. Where a redundant level sensor is selected instead of switches, it should be of a dissimilar technology to the primary level sensor.

3. Radar-type level transmitters and vibrating level switches should be considered for use in powder and slurry or solution environments. To maintain the performance of level instruments in high-dust conditions, appropriate protective measures—such as a PVC sleeve extending into the liquid surface—should also be considered.
4. 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.
5. 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.
6. 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.
7. Where contact level switches are selected, they should generally be of conductive or vibration fork types. Ball float switches shall not be used for 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.
8. 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.
9. 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.
10. Level instrument materials shall be compatible and resistant to corrosion from the chemicals and vapours with which they may be in contact.
11. Refer to SPE-00353 I-SPE-STD-015 Instrumentation for further details for the requirement of level instruments.
12. 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 (%).
13. Level instrument materials shall be compatible and resistant to corrosion from the powder chemicals, slurries or solutions with which they may be in contact.

4.13. Telemetry and Control

Control systems shall comply with the requirements of the standards listed below, the requirements of this standard, and relevant Australian and industry standards, specifications and codes:

Table 7 Approved standard for Telemetry and Control

Document Number	Document Title
SPE-00356	I-SPE-STD_005 High Priority Alarms and Interlocks Management
SPE-00358	I-SPE-STD-009 Control Systems Architecture
SPE-00361	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.

4.14. Cyber Security

For all storage, batching and dosing units, 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 Standard.

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

4.15. Safety Shower and Eyewashes

Safety showers, eye wash facilities and hose reels shall be provided at all levels within the powder 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.

Safety showers and eyewashes shall comply with the requirements of *AS 4775 Emergency Eyewash and Shower Equipment*. In addition to the requirements of *AS 4775 Emergency Eyewash and Shower Equipment,* potable water pipework and materials installed for use in supplying water to emergency showers and eyewashes:

1. Shall be installed out of direct sunlight, or
2. Where it is not practicable to install pipework out of direct sunlight, the following measures shall be implemented:
    a. Insulation of pipework
        i. All associated pipework shall be insulated with a suitable lagging material to prevent water temperatures from exceeding 38°C, thereby ensuring the safety of personnel.
    b. Thermostatic Relief Valve for High Ambient Temperature Locations
        i. In environments where high ambient temperatures may prevent insulation alone from maintaining water below 38°C, a thermostatic relief valve shall be installed.
        ii. The valve shall be set to open at 37°C and close at 35°C.
        iii. The relief valve shall be positioned such that discharged hot water is directed away from chemical solution pipework and concrete surfaces to minimise the risk of algal growth and potential slip hazards.

iv. The installation must be designed to avoid triggering flow alarms from the safety shower or eyewash flow switches during normal hot water relief events.

3. All safety showers and eyewash stations shall be equipped with flow switches that generate a flow alarm to the SCADA system upon activation. This alarm serves to alert personnel monitoring SCADA that an individual may have used the equipment in response to an incident and may require assistance.
4. To aid in locating safety showers and eyewash stations, a green light shall be installed above the facilities at a suitable height. The colour green is used to signify a medical or emergency facility, and it remains the most distinguishable colour when eyesight is compromised, helping affected individuals locate life-saving equipment. This light shall be hardwired to the site's electrical system and backed up by a battery to ensure continued operation during power outages.
5. The safety shower shall be installed on the same level as the associated hazard, and the design of any surrounding bunds must ensure a clear and unobstructed path to the equipment, free from trip hazards. The safety shower and eyewash must be accessible within 10 seconds from any point of potential exposure.
6. Safety showers and eyewash stations must be adequately illuminated and clearly signed in accordance with *AS 1319 – Safety Signs for the Occupational Environment.* Additionally, *AS 4326 – The storage and handling of oxidizing agents* should be consulted for specific requirements related to safety showers when handling oxidizing agents such as potassium permanganate.

4.16. Signage, Tagging, Marking and Labelling

All equipment, instrumentation, and pipework should be numbered and labelled, and include nameplates in accordance with:

1. SPE-00367 M-SPE-STD-001 General Mechanical
2. SPE-00352 E-SPE-STD-001 Electrical Design and Construction
3. SPE-00353 I-SPE-STD-015 Instrumentation
4. SPE-00359 I-SPE-STD-010 Control System Tag Naming
5. PRO-02190 X-PRO-STD-006 Equipment Numbering and Naming Convention Procedure
6. PRO-00008 Hazardous Chemicals Procedure

4.17. Design Philosophy

This standard outlines the design and construction requirements for four types of powder chemical storage and dosing systems.

The design of any powder chemical handling system must prioritise reliability, low maintenance requirements, and whole-of-life cost efficiency. These considerations are especially important due to the inherent challenges in handling dry powders, chemical solutions, and slurries, including issues related to flowability, clogging, and wear.

For slurry-based systems, the typical configuration includes a single storage silo or hopper, duty/standby screw feeders, and duty/standby mixing or batching tanks. This arrangement ensures operational continuity and provides flexibility for maintenance without interrupting chemical delivery and dosing. The mixing or batching tanks in these systems are necessary to prepare a consistent slurry concentration before dosing.

For chemical solution systems, a different configuration is proposed. This consists of a single storage silo or hopper, a screw feeder, and separate batching and dosing tanks. The separation of batching and dosing functions allows for adequate solution maturation time and enables more precise control over both solution concentration and dosing rates, particularly beneficial in applications where chemical demand is variable.

For polymer and pot perm systems, it is generally recommended to maintain a fixed batching concentration with variable dosing flow rates. This allows for consistent product preparation while adapting to changing process demands. These systems typically require dedicated batching and dosing tanks to decouple the two functions and maintain process stability.

For PAC slurries and soda ash solutions, both fixed concentration with variable dosing flow rate and variable concentration with fixed dosing flow rate system types may be suitable. The selection depends on site-specific requirements, including control strategy, dosing accuracy, and operational preferences. The design must evaluate these factors to determine the most appropriate configuration.

In slurry systems that operate with variable concentration and fixed dosing flow rates, Seqwater has observed significant operational challenges when minimum recommended line velocities are not maintained or when flushing sequences are not implemented at defined intervals or after dosing stoppages. Common issues include pipeline and nozzle blockages caused by high solids content, as well as increased lag times when adjusting batching concentrations. These problems can negatively impact dosing accuracy and reduce overall system availability.

To mitigate these risks, it is recommended to incorporate service water injection at the pump discharge to maintain line velocity, along with a regular flushing sequence.

4.18. Asset Redundancy

This Standard Specification does not specify redundancy requirements for all essential equipment and dosing lines associated with powder chemical unloading, storage and dosing systems.

The project shall determine redundancy requirements and the final number for equipment, trains 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. Powder Chemical Delivery and Unloading System

The powder chemical delivery and unloading system mainly includes the following:

1. Modes of powder chemical delivery
2. Unloading bay, filling point and control panel for bulk delivery
3. Powder transfer from large and small package bags

This section should be read in conjunction with standard P&IDs as referenced in Table 11, Section 9.

5.1. Modes of Powder Chemical Delivery

Seqwater receives powder chemicals through several acceptable delivery modes including:

1. **Bulk powder chemical delivery**: delivered by trucks and pneumatically transferred into a storage silo.
2. **Large package bag delivery**: delivered with 400 – 750 kg bags on a pallet and temporarily stored in a storage area.
3. **Small package bag/pail delivery**: delivered with 15-25 kg bags or pails on a pallet and temporarily stored in a storage area.

The delivery mode will be determined by site and process specific requirements, stored chemical properties, site staffing, frequency of use, economy of scale, cost, protection against shortage, transportation difficulty (e.g. in fair and poor weather), and by average consumption rates. The mode of delivery selected should reduce the frequency of unloading due to health and safety concerns.

When the average consumption rate is considered in determining the powder chemical delivery form, the following guidelines should be used while noting that chemical specific supply arrangement constraints may result in different supply methods:

4. Sites actively using >1000 kg/week or more than two large bags per week of dry chemical powder should receive as bulk delivery from truck.
5. Sites actively using >100 kg/week but <1000 kg week of dry powder chemical should receive as large package bags.
6. Sites actively using ≤ 100 kg/week of dry powder chemical should receive as small package bags or pails.

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

5.2. Bulk Delivery

Bulk delivery using delivery trucks shall use a pneumatic transfer system to load powder chemicals directly into storage silos.

Out of the four powder chemicals covered in this standard, only polymer is currently delivered in bulk by road tankers at a number of Seqwater sites. It is anticipated that this will not change in the immediate future. In addition to polymer, the bulk delivery requirements of this section shall apply to PAC and soda ash. Pneumatic conveyance of PAC is not preferred; the powder chemical supplier must be consulted for appropriate transfer options.

Bulk delivery of Pot Perm is not anticipated at Seqwater sites in the immediate future. Pot Perm is a crystalline solid and a strong oxidizing agent. Additional requirements may need to be followed for pneumatic transfer of Pot Perm from delivery trucks. Considering its chemical properties, and in the absence of established relevant literature and practices, Pot Perm bulk delivery is not recommended and not covered in this section.

The bulk delivery system should include:

1. Unloading Bay
2. Transfer/Fill Point
3. Transfer Fill Line
4. Local Control Panel (LCP)

The road tankers for bulk delivery have their own power supply for pneumatic transfer. Therefore, the requirement of site power supply for bulk delivery is not considered in this standard specification.

5.2.1. Unloading Bay

A chemical unloading bay shall be designed and constructed to transfer powder directly to storage silos from trucks. The unloading bay is needed to provide safe arrival, parking, unloading, vehicle turning and departure for delivery trucks.

The design shall consider specific chemical suppliers' requirements which may be obtained directly from chemical suppliers.

The bulk chemical unloading area shall include the following:

1. A design that avoids the reversing of delivery vehicles. If reversing cannot be avoided, the design should allow the driver to reverse the vehicle into the unloading area and leave the site in a forward direction.
2. Delivery apron not to be located on the main plant access unless sufficient road access space for other vehicles to safely pass during chemical unloading is provided.
3. Appropriate markings and signs to identify the entry and exit of the unloading bay.
4. Unloading platform with a suitable level hardstand area for chemical delivery truck.
5. Be isolated from liquid chemical systems and areas likely to be subject to liquid spills from chemical or water.
6. Refer to Section 5.2.1.1 for the information whether trafficable lips or delivery bunds should be used in the delivery area.

5.2.1.1. Powder Chemical Spillage Capture

All powder chemical spillage must be contained and controlled to prevent any discharge into sewers, stormwater drains, basements, confined spaces or the environment.

For a small-scale spill, and where appropriate, powder chemical is to be swept or collected with appropriate absorbent and stored in a chemical waste bin. For a largescale spill, powder chemical is preferably to be removed from site by an approved industrial vacuum system either installed permanently in the unloading area or provided by a waste removal specialist company. In all cases it is preferrable to clean powder chemical spills dry.

A risk assessment should be used to determine whether trafficable lips or delivery bunds should be used in the delivery area for spillage control. The risk assessment should also assess the need of a sump, drainage and underground spillage tank in the unloading area. This is to manage the washdown water when used to prevent the potential spread of airborne dust from a spillage or to manage spillage during a rain event.

The risk assessment should consider the following:

- Likelihood of spillage.
- Powder chemical properties.
- Operational issues to manage the sump, drainage and underground tank in presence of potential chemical slurry or viscous chemical solution.
- Additional control requirements to isolate the stormwater system during a delivery.
- Availability of suitable spill kits to contain powder chemical during a rain event.
- Stormwater management.
- Regulatory requirements, including development approval and environmental authority conditions.
- Site emergency plan.
- Industry best practice.

5.2.2. Transfer/Fill Point

The transfer/fill point is the connection point at which the delivery truck connects the delivery hose to transfer powder chemicals into the storage silos using the transfer line.

Fill points shall be located adjacent to the unloading area such that a tanker hose should not generally exceed 6m, but this length should be confirmed with chemical suppliers. Hose lengths shall be sized such that they can be connected in a straight line with no bends or kinks.

Each storage silo shall be filled individually, having its own fill line and fill connection point. Fill points for the same chemicals shall be separated by a minimum of 400 mm and for different chemicals by a minimum of 5 m.

Fill points shall:

1. Be clearly labelled, including a nameplate/identification plate above each filling point defining its name and grade, and the silo into which it feeds.
2. Include a mechanical coupling for connection to a tanker delivery hose and:
    a. The connection type shall be confirmed based on consultation with specific chemical suppliers and Seqwater. Where this cannot be confirmed, a 100mm male camlock mechanical coupling type can be considered.
    b. Be fitted with a dust cap capable of being locked (via padlock) if necessary.
    c. The material should preferably be galvanised carbon steel or stainless steel.
    d. Be preferably connected to a fill line with a flanged connection to allow for easy replacement if damaged.
3. Be 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 – 1200mm above ground level at the point of connection to a tanker hose.
4. Be installed between 45° and 90° to the vertical (in a horizontal to downward orientation).

5. Include a safety shower and an eye wash facility located between 2 m and 7 m from the transfer point and compliant with Section 4.15 of this standard.

5.2.3. Transfer/Fill Line

The powder chemical transfer line(s) shall:

1. Be minimum of 100mm diameter and constructed of appropriate pipe material as specified in SPE-00355 M-SPE-STD-013 Chemical Dosing Piping.
2. Use straight lengths as much as possible, minimise the use of sharp and right-angle bends and be kept as short as is practicable. Where using bends, use only sweeping, long radius bends. Bends should generally be a minimum of 10-12D radius. If consecutive bends are required, provide a minimum of 30 pipe diameters distance between bends.
3. Enter the storage silo from the top and centre of the vessel to maximise silo storage volume.
4. Include an actuated valve which should:
   a. Be opened automatically during filling operation and closed by the operator at the end of filling procedures.
   b. Be fitted with limit switches to obtain open and close position feedback.
   c. Preferably be a fail-safe butterfly or pinch valve with pneumatic actuation.
   d. Be accessible from the ground level and should be located within 400 mm from the filling point.
5. Be considered to include a thermostatically controlled heat trace to reduce moisture in the transfer line and actuated valve to prevent clogging.
6. Be assessed for the need to include disassembly points for safe cleaning.

5.2.4. Local Control Panel

A Local Control Panel (LCP) shall be provided for powder chemical bulk delivery location. Where multiple silos and fill points for a single chemical exist, a single LCP shall be provided for that chemical and be clearly labelled and identified for which silo they apply to.

The LCP arrangement shall, as a minimum:

1. Be clearly labelled with the panel ID, chemical, all dials, buttons and displays as per Seqwater's labelling requirements.
2. Include:
   a. An Off/On Filling switch to initiate the panel. The status shall be viewable remotely via SCADA.
   b. A ready indicator (e.g. Green Light) – indicating all pre-requisites to fill the silo are met.
   c. A not ready indicator (e.g. Amber Light) – indicating it is not safe to fill.
   d. Filling line actuated valve position indication.
   e. A running indicator.
   f. An alarm test button which activates both the visual and audible alarms to verify their operation.

3. Include a local warning device providing visual and audio alert if the chemical delivery exceeds the high weight in the storage silo or if the silo pressure exceeds the safe setpoint:
    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 assessment. Beacon light colour shall be as per SPE-00352 E-SPE-STD-001 Electrical Design and Construction *and AS/NZS 4024*.
4. Be designed such that only one storage silo may be filled at a time.
5. Be fitted with a test pushbutton to allow operators to check alarm operation.
6. Include a digital readout of silo weight (kg). Additional parameters may be provided and selectable as fill weight percentage, available weight for fill (kg) and full weight (kg). 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 designed with an appropriate IP rating in accordance with the requirements provided in SPE-00352 E-SPE-STD-001 Electrical Design and Construction.
    d. Be visible and readable from at least 5m.

LCP operation may include operator initiation of silo filling procedure via SCADA in addition to selection of “filling” 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 is assumed that all chemical deliveries will be undertaken with supervision and attendance of a site operator as an additional layer of protection.

5.3. Large Bag Delivery

The large bag delivery shall include facilities and unloading equipment required to transfer bags from the delivery truck into the storage area and/or filling point and transfer powder into storage silos/hoppers. The large bag delivery shall include:

1. Large Bag Unloading
2. Discharge Hopper System
3. Conveyance System
4. Local Control Panel

5.3.1. Large Bag Unloading

The design shall include the following requirements to transfer large powder chemical bags from the truck into the storage area and filling point:

1. The ability to drive the delivery vehicle as close as practicable to the storage area and filling point.
2. Delivery vehicle as a lifting appliance to minimise manual handling including mobile trollies and forklifts.
3. Forklift trucks shall comply with the relevant requirements of AS 2359 Powered Industrial Trucks and AS 4326 for Pot Perm.

If package storage area is not within the same level as the delivery truck, an inclined conveyor, dock leveller, hoist, or an elevator shall be considered.

5.3.2. Discharge Hopper System

Powder chemical from large bags is transferred into storage silos by a large (bulk) bag discharging system. The system shall be designed to empty the large bags, minimise manual labour requirements, ensure reliable material flow, and provide a dust free transfer process.

The discharge hopper system shall include the following:

1. A supported safety platform frame to securely position the powder chemical large bag over the top of the discharge hopper.
2. A gantry crane and electric hoist, controlled by an operator via a remote controller connected via a cable to manoeuvre the package bag into and out of the transfer hopper discharge point. The hoist must be suitable for the design lifting capacity and comply with *AS 1418, Cranes, hoist and winches set.*
3. A safety gate to access hoist operation and be fitted with a safety guard switch and local reset push button to de-energise/re-energise the hoist motor operation. Safety gate must be closed and the reset button activated prior to the start of the unloading sequence.
4. A safety door to access the discharge hopper and be fitted with a safety guard switch and local reset push button to de-energise/re-energise the conveyance system, dust extraction fan, and dust extraction valve operation (if actuated). Safety door must be closed and the reset button activated prior to the start of the unloading sequence.
5. A pneumatically operated mechanical paddle as a bag massager or a vibrating pan or other types of bag flow activators to overcome bridging and ratholing and thus assist powder flow from the package bag to the unloading/discharge hopper.
6. A suitable fixed support frame for the bag to prevent the need to work under a load while connecting and untying the bag.
7. A mechanism to seal the package bag discharge spout and prevent dust escape during connection and emptying. An extendable flexible tube fitted with a clamp ring may be used for the application.
8. A suitable mechanism to collapse the bag during bag removal and minimise dust emission to the working environment.
9. Pneumatically or manually operated knife gate valve at the bottom of the discharge hopper is to provide positive isolation during maintenance. Designer should include the provision to close the valve from LCP after completion of powder transfer to avoid the risk of moisture entering into the storage silo.
10. Dust extraction pipe connection from the discharge hopper to the storage silo or to the central dust collection system. The dust extraction line should have a solenoid valve to open/close automatically during unloading operation.
11. Vibrator or other type mechanism is to assist in powder flow from the discharge hopper to the conveyance system.
12. A low-level switch in the discharge hopper shall trigger an alarm on the LCP and stop the unloading sequence with time delay.

5.3.3. Conveyance System to Storage Silo

The designer shall select the preferable conveyance system between mechanical and pneumatic systems to transfer powder from the discharge hopper to the storage silo considering the material properties, reliability and safety.

5.3.3.1. Mechanical Conveyance

Typically, across Seqwater sites, helical screw conveyors are used for mechanical conveyance. Where selected, screw conveyance system shall consider the following requirements:

1. A single or multiple helical flight mounted on a central shaft aligned vertically/horizontally or combination, depending on the requirement.
2. Include an enclosed fabricated casing comprising standard lengths bolted together as required. Riveted sections should not be used for maintenance access.
3. Provide interlocking of the screw conveyor motor to the high-high weight of the storage silo.
4. Discharge into the centre top part of the storage silo to allow for an equal distribution of powder chemical.
5. A mechanism that prevents the operation of screw conveyor when the conveyor housing is left open to avoid an unsafe condition.

Alternative mechanical conveyance systems, such as bucket conveyors, can be considered if they can operate successfully with the chemical powder and can be sealed to contain dust.

5.3.3.2. Pneumatic Conveyance

Pneumatic conveyance system utilises motive air to carry and transfer the powder from the unloading hopper to the storage silo. The powder is transferred through an enclosed pipeline in air suspension (i.e. Positive Pressure System) or pulled by vacuum (i.e. Negative Pressure System).

The pneumatic conveyance design criteria includes:

- Minimum and optimum air flow rate
- Optimum pipeline diameter
- Powder to air ratio
- Pressure gradient along the pipeline

Pneumatic conveyance must not be used to convey reactive materials if there is a risk of dust explosion. Where selected, the system shall use dilute phase conveyance either with positive or negative pressure (i.e. vacuum) system.

Positive Pressure System

The positive pressure system operates at above the atmospheric pressure conveying material from the unloading bag discharge to the storage silo. The powder chemical enters the transfer line at a higher pressure via a special feeding device, typically a rotary airlock valve. The suspended powder-air stream is separated by a dust collection and vent filter system fitted in the storage silo.

The positive pressure system comprises of the following:

- Air blower
- Transfer line
- Rotary valve
- Dust collection and vent filter (discussed in Storage Silo Section 6.1.9)

The air blower shall have the following requirements:

1. Use either centrifugal or positive displacement type blower.
2. Use a fixed speed blower driven by an electrical motor and should be sized:
    a. To prevent powder settlement in the conveying system.
    b. To prevent erosion of conveying pipework/materials.
3. Provide a minimum air to solid loading ratio of 2:1 (by weight).
4. Be designed to operate at positive pressure between 35 kPa – 80 kPa.
5. Be fitted with a filter on the suction side with a pore size of maximum 10µm. Filter shall be easily removed and replaced for maintenance.
6. Appropriate protection device for blower protection against excessive discharge pressure and inlet pressure loss (e.g. due to inlet filter blockage) including mechanical relief valve, temperature switch, and pressure switch should be considered.
7. Base and supporting frame design must be rigid and mounted on a flat surface to minimise the possibility of piping deflection.
8. Be designed to mitigate any possible ignition or detonation points.
9. The design shall comply with the requirements of SPE-00367 M-SPE-STD-001 General Mechanical.

The transfer line shall include the following requirements:

10. Be designed as short and direct as possible. Bends to be minimised and only long section bends > 10D are to be used to minimise the potential for powder material settling.
11. Fitted with a heat tracer on the early pipe section to reduce moisture content in the powder and assist in flow.
12. The piping material shall be chemically compatible with the material being handled and resistant to abrasive wear from materials such as PAC.
13. The line shall be designed to withstand the pressure generated in the system and should include a safety factor of 2x of the pressure rating of the blower.

When used, the rotary valve in the powder feeding should include the following requirements:

14. Be an airlock rotary valve properly designed to minimise the air leakage. Suitable vent ports on the housing of the rotary valve or vent box shall be provided to discharge the leaked air into atmosphere before entering into the unloading hopper. Air leakage rate should be accounted into the blower sizing calculation.
15. Include a fixed speed drive and be capable to discharge powder chemical at a rate as determined from the process requirement.
16. Be constructed of material compatible with the chemical.

17. Include a durable and dust tight seal on the rotating shaft and external fittings to prevent chemical powder emission to the atmosphere.
18. Be designed to provide easy and safe cleaning of both the external and internal surfaces, including a provision of simple extraction of rotor/end cover assembly.

Vacuum System

Vacuum transfer system may be used as an alternative to positive pressure system. The system operates by using vacuum pump to create vacuum in the transfer line allowing chemical powder to be drawn into the transfer line and vacuum filter receiver prior to discharge into the storage silo via an airlock rotary valve. The vacuum filter receiver is fitted with the dust collection and vent filter system to extract and collect the powder dust generated. Vacuum system is generally used when the required conveying rate is less than 10 tonnes/hr.

The vacuum system comprises of the following main components:

- Vacuum generator
- Transfer line (see above for positive pressure system)
- Vacuum filter receiver
- Airlock rotary valve (for feeder and vacuum receiver)

The maximum vacuum generated, the overall capacity and general operating characteristics of the systems, are determined by the type of vacuum generator used.

The vacuum generator should generally have the following:

19. A fixed speed, positive displacement vacuum pump.
20. Be sized for appropriate conveying velocity to prevent powder settling and avoid erosion of pipework.
21. Be designed to mitigate any possible ignition or detonation points.

The vacuum filter receiver should have the following:

22. Generally, be installed on the top of the storage silo.
23. Be designed to separate the powder chemical from the air stream using filter media and gravity.
24. Be fitted with reverse-pulse jet filter cleaning system to dislodged accumulated powder into the storage silo.
25. The dust and vent filter design requirement shall follow requirements provided in Section 6.1.9.

An airlock rotary valve separates the storage silo from the vacuum receiver. When used, it must comply with the requirements provided in the above section.

5.3.4. Local Control Panel

A Local Control/Operator Panel shall be provided to operate the bag discharge and conveyance systems locally.

The LCP arrangement shall, as a minimum:

1. Be clearly labelled with the panel ID, chemical, all dials, buttons and displays as per Seqwater’s labelling requirements.
2. Include:
    a. An On/Off switch to initiate the panel. The status shall be viewable remotely via SCADA.

b. A Start/Stop Pushbutton to initiate the bag discharge and conveyance system. The status shall be viewable remotely via SCADA.

c. A ready indicator – indicating that pre-requisites for bag unloading and conveyance are met.

d. A running indicator.

e. An amber beacon type lamp to alert the operators to alarm conditions.

f. An alarm test button which activates both the visual and audible alarms to verify their operation.

g. A lamp test button.

h. Include an audible alarm to alert the operators if the storage silo reached high or high-high weight/level; or the discharge hopper becomes empty.

3. Include Open/Close/Remote selector switches for each of the valves used in the bag discharge and conveyance system.

4. Include one latched, twist to release Emergency Stop Pushbutton and an illuminated Emergency Stop Reset Pushbutton located in front of the panel. 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 designed with the appropriate category of emergency stop circuit as decided by the designer. Emergency Stop category and design must comply with the requirements of SPE-00352 E-SPE-STD-001 Electrical Design and Construction and related Australian Standards including AS/NZS 4024 Safety of Machinery relevant series.

   d. Be detailed with the functionality by the project specific design team. But, as a minimum, this shall isolate power to all drives in the unloading and conveyance system upon activation.

As a minimum, the design shall include the following signals related with the operation of bag discharge and conveyance system viewable remotely via SCADA:

5. Unloading sequence status.

6. Safety door and gate limit switch indicator.

7. Motor running status, motor temperature, and fault status. This may include vibrator, hoist/gantry crane, screw conveyor/blower, and dust extraction fan operation.

8. Any valve position status includes but not limited to bag massager solenoid valve, knife gate valve, dust extraction line valve, airlock rotary valve and filling line actuated valve (only for pneumatic conveyance system).

9. Discharge hopper low-level switch indicator.

10. Emergency stop status.

5.4. Small Bag/Pail Transfer

The preferred method of transferring powder chemical from small package bags/pails to storage silos/hoppers shall be by vacuum conveyor systems. This is to ensure a dust free working environment and minimises direct contact with the chemical.

This section should be read in conjunction with standard P&IDs referenced in Section 9.

The design shall include a similar system to transfer small powder bags from the truck into the storage area as provided in Section 5.3.1.

Vacuum conveyance transfer arrangements shall include:

1. An unloading point: The unloading/fill point of the transfer system should be a hand-held pick-up wand that the operator may freely move and insert into a container of powder chemical to facilitate the transfer. This will prevent unnecessary manual handling of chemicals and pouring of bags of chemical into silos/hoppers which can result in airborne dust.
2. A vacuum generator: A number of devices including low pressure blowers, compressed air driven venturi units, positive displacement vacuum pumps can be used as vacuum generators. The air flow generated by the vacuum generator moves the chemical through the conveying piping to the receiving storage silo/hopper.
3. A hand-held vacuum suction wand: When inserted into a bag/pail, the powder withdrawn, and the air shall be drawn upwards by a vacuum motor through the filter to remove any powder particles and the withdrawn powder shall enter into the collection unit. A large volume inside the unit will cause the air velocity to drop and thus allow the powder to drop to the bottom of the unit.
4. A flexible or rigid type vacuum transfer line to the silo/hopper with minimum pipe bends. The transfer line pipework is required to be resistant to abrasion and corrosion from powder chemical materials. The transfer pipe shall have a minimum ID of 50 mm, and the pipe length should be kept as short as possible.
5. A collection unit with a solenoid dump valve which shall open to dump powder to the silo/hopper when the vacuum motor stops.
6. A filter, and the filter shall:
    a. be generally a cartridge type and housed in a container within the collection unit with an access lid for filter replacement unit located on top of the silo/hopper. The filter lid shall be sealed to prevent the escape of powder chemical dust.
    b. be capable to remove at least 99.9% of the smallest powder particle size as defined on the chemical Safety Data Sheet (SDS) or 1 µm, whichever is lower.
    c. be designed to be cleaned with a compressed air reverse pulse for a couple of seconds while the dump valve remains open. The filter self-cleaning system must prevent dust escaping to the environment. Refer Section 6.1.9.3 for reverse pulse filter cleaning system requirement.
7. Have a dust extraction line from the filter via the vacuum motor into a suitable location to collect any residual dust.
8. A vacuum motor/fan which is side mounted or positioned in a way that allows for filter maintenance/replacement without the need for it to be removed.
9. The vacuum transfer system should be designed to transfer 25kg of powder generally in less than 5 minutes.
10. A local control panel shall be provided to transfer the chemical from small bags to the storage silo/hopper. The LCP arrangement shall:
    a. Be clearly labelled with the panel tag number, chemical name, all dials, buttons and displays as per Seqwater's labelling requirements.

b. LCP should Include:
   i. A "ON/OFF" pushbutton to initiate the panel.
   ii. A ready indicator.
   iii. A "START/STOP" pushbutton to initiate the powder transfer.
   iv. A running indicator.
   v. Alarm and lamp test buttons as appropriate.

c. Include one latched, twist to release Emergency Stop Pushbutton and an illuminated Emergency Stop Reset Pushbutton located in front of the panel. The emergency stop shall:
   i. Be clearly labelled.
   ii. Be designed with the appropriate category of emergency stop circuit as decided by the designer. Emergency Stop category and design must comply with the requirements of SPE-00352 E-SPE-STD-001 Electrical Design and Construction and related Australian Standards including AS/NZS 4024 Safety of Machinery relevant series.
   iii. Be detailed with the functionality by the project specific design team. But, as a minimum, this shall isolate power to all drives in the vacuum transfer system upon activation.

The design shall include the following signals related with the operation of vacuum transfer system viewable remotely via SCADA:

- Vacuum motor status.
- Storage hopper low-level switch indicator.
- Emergency stop status.
- Compressed air solenoid valve signal (if applicable).

5.4.1. PAC Small Bags

Experience using vacuum transfer systems for PAC indicates that the vacuum filter blocks rapidly and is not suitably cleaned by air pulsing. Due to this, the designer shall identify another safe and ideally dust free method of emptying small bags.

6. Powder Chemical Storage

This section describes the requirement for the design and construction of powder chemical storage systems.

The main components of powder chemical storage systems include:

1. Storage Silo/Hopper
2. Storage of large and small bags
3. Chemical Enclosure, Building and Access

This section should be read in conjunction with standard P&IDs referenced in Table 11, Section 9 of this document.

6.1. Storage Silos and Hoppers

Storage silo(s) shall be used for the storage of powder chemicals prior to chemical batching. In the case of small and large bag systems, a storage hopper may be used instead of a silo. Hoppers should meet the same requirements as silos outlined in the following sections unless specifically noted otherwise.

Storage silos shall be above-ground, fixed, well-supported, permanently positioned silos that are filled and discharged in situ and preferably be located inside a building.

The storage silo shall be designed to provide a flow pattern that ensures flow of all materials whenever any solid is withdrawn to avoid ratholing, short circuiting or retention, aging of pockets of chemical powder, powder sidewall hang-ups and cohesive arching under all condition.

The storage silo shall have a supporting structure and foundations. The silo structure is to be designed to ensure the strength and stability to withstand any relevant load including the load exerted by the bulk solid on the silo walls, the impact stress caused by large portion of chemical powder falling from the top of the silo, pressure caused by wind, and asymmetrical loading from the contents.

The design of the silo cap shall be with a slight radial downward slope from the centre to prevent pooling of water.

The design and construction of the storage silo should follow the appropriate standards, those of which are acceptable to Seqwater as listed below in Table 8. Designer can apply additional standards as required.

Table 8 Recommended standards for the design and construction of storage silo

Standard Number	Standard Title
AS1170	Structural Design Actions (set)
AS 3774	Loads on Bulk Solids Containers
AS 1657	Fixed Platforms, Walkways, Stairways and Ladders
AS 3990	Mechanical Equipment – Steelwork
AS 4100	Steel Structures
AS 1554	Structural Steel Welding

All silo equipment and instruments should be fitted such that they may be removed without draining the silo contents, e.g. compressed air fluidisation inlet pipe may be fitted with an isolation valve.

The storage silo, at a minimum, shall include the following main equipment, instruments and fittings:

1. Silo fill line
2. Weight and level monitoring device
3. Silo access (both internal and external)
4. Dust filter and extraction fan
5. Pressure/vacuum relief device
6. Bin vibrator
7. Aeration system
8. Dehumidifier
9. Knife gate isolation valve

6.1.1. Number and Size of Silos

The number and size of storage silos shall be determined by the following requirements:

1. Generally, include one (1) storage silo. The determination of the final number should consider the site's availability and criticality requirements, the stored chemical properties, the site's size and usage, site staffing, site location and access (e.g. in fair and poor weather), reliability, operability and maintainability considerations.
2. Where powder chemical is delivered in bulk, should provide a minimum demand quantity by sizing based on the greater of:
    a. 14 days storage at maximum dose rate, average plant flow; or
    b. 28 days storage at average dose rate, maximum plant flow

    For situations where dose rates fluctuate significantly due to water quality variations, the maximum dose rate shall be determined based on 1-2 weeks of historical average dose data from periods of water quality events, rather than relying on an instantaneous maximum dose rate.

    The silo sizing should also consider the following:

    c. The silo should be sized to accommodate at least one full truckload of powder.
    d. Include a contingency for future expansion, ensuring the silo allows for an additional height in the silo structure.
    e. For packaged powder chemicals (both small and large bags), the silo or hopper should be sized to hold 4-5 days of storage at the maximum dose rate with average plant flow.

The final storage silo's size should be determined considering the stored chemical properties, general availability of the chemical including the chemical supplier's location and reliability of supply during any period of shortage, delivery time delay due to natural or human-caused emergencies, site's availability, criticality requirements and other site constraints

6.1.1.1. Potassium Permanganate

Potassium Permanganate has the tendency to form hard cakes during prolonged storage. Due to the limited shelf life, the maximum allowable number of storage days of the storage silo is 7 days in according to the requirement of *AS 4326 The Storage and Handling Oxidizing Agents*.

6.1.2. Silo Labelling

All silos shall have placard and be labelled in accordance with PRO-00008 Hazardous Chemicals Procedure, *Work Health and Safety Regulation 2011*, Globally Harmonised System of Classification and Labelling of Chemicals (GHS), *AS 60079 Explosive Atmosphere*, Australian Dangerous Goods Code and relevant legislative requirements.

Where multiple silos of the same chemical are installed, each silo shall be labelled with the silo number of each specific chemical (i.e. Silo 1, Silo 2 etc) such that it is clearly visible and readable from the silo fill point. This labelling convention should also be carried over into SCADA.

Each silo shall include a name plate printed on stainless steel and intended to remain in place and clearly legible for the design life of the silo. It shall be positioned to allow visibility from the ground level, if adhered to the silo surface. Each nameplate shall include the following information:

- Manufacturer
- Manufacturer's details (name, address, contact number)
- Design Code or Standard
- Date of manufacture
- Serial Number
- Silo Number (if applicable) / Tag Number
- Materials of construction
- Product/content (including chemical name, formula).
- Design Mass Capacity
- Design Life
- Height and Diameter
- Design Temperature and Pressure
- Powder Chemical Bulk Density
- Maximum Specific Gravity (of powder to be contained)
- Maximum mass in kilograms of stored chemical

6.1.3. Design Pressure and Temperature

Silos shall be designed for Site Conditions, Atmospheric Conditions and Process Conditions as defined in Section 4 of this document.

The pressure or vacuum resulting from filling, emptying, thermal inbreathing and outbreathing, or atmospheric change shall not exceed the maximum design stress of the silo. The silo shall be designed to withstand the pressure generated in the system and shall include a safety factor of 2x of the calculated possible built-up pressure.

Storage silos shall generally be designed and constructed to operate at near atmospheric pressure and slightly negative pressure for silo filling and discharge operations.

6.1.4. Silo Materials

Materials for silo construction shall ensure silos and their fittings and attachments are suitable for use under the Site Conditions. Where materials require additional protection as a result of Site Conditions, adequate protection, appropriate shelter, painting or coating, or other fit for purpose means of ensuring the required design life is achieved shall be provided.

Materials for silo construction shall ensure silos and their fittings and attachments that are likely to come into contact with chemicals are substantially immune from attack by the chemicals under all service conditions.

6.1.4.1. Potassium Permanganate

Material of construction of Pot Perm storage silos/hoppers shall comply with the requirements in *AS 4326*. All materials and fittings that may come into contact shall be constructed from non-combustible materials or protected by the application of a suitable, non-combustible, robust coating.

6.1.5. Fill Line Connection

This section builds on the requirements of Transfer Fill Line discussed in section 5.2.3 for bulk delivery, section 5.3.3 for large bag transfer, and section 5.4 for small bag transfer. The battery limit drawn from the flange connection at the silo nozzle to the silo internal. This shall:

1. Include a separate flanged nozzle/connection on the topside (roof) of each silo with the same diameter as the fill line.
2. Enter the roof of the silo in a vertical orientation and connected through the centre of the storage silo roof to maximise storage volume.
3. Provide a 100mm straight funnel discharge pipe connection from the silo flanged nozzle connection on the internal topside roof to direct the discharge orientation.

6.1.6. Weight Measuring Device

Silo weight shall be the primary monitoring and control parameter for the operation of the storage silo. The silo shall be mounted on load cells to measure the silo weight with the following requirements:

1. There shall be a load cell mounted on each silo leg (i.e. three or four in total). Load cells shall be mounted along with a junction box and a transmitter with the ability to send the weight signal to the site PLC/SCADA.
2. The silo stairs and platforms shall not be structurally connected to the silo otherwise the performance of silo load cells can be affected.
3. The vibration of bin vibrator shall not affect the performance of load cells.
4. The load cells shall have combined accuracy within ±0.5% across all design conditions (i.e. temperature and silo content weight).
5. Electrostatic charges must be discharged to the ground without crossing the load cells. Earthing shall be provided according to the requirements in SPE-00353 I-SPE-STD-015 Instrumentation.
6. The load cell types, and its components shall be suitable for site conditions.
7. Silo weight shall be readily viewable as an electronic digital readout at:
    a. Local to the silo and viewable at ground level.

b. Local to the silo filling Control Panel, and viewable by Operator/Delivery Staff during filling operation.

c. Remotely at SCADA.

6.1.6.1. Alarm and Trip Setpoints

The following provides guidance as to Seqwater's requirements for alarming and trip from the weight measuring device for the operation of storage silos.

The following high-weight setpoints shall be available for storage silo operation:

1. Maximum Operating Weight/Operation High Weight (OHW): This operator settable setpoint provides no alarm. The process will continue to run with no action. Reaching this level will record as an Event[1] only in SCADA.
2. High Weight (WAH) Setpoint: At this point 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.
3. High-High Weight (WAHH) Setpoint: At this point, the alarms and interlocks are based on the delivery mechanism of the followings:
   a. Bulk Delivery: At this point a further alarm will be triggered, and the Delivery Staff/Operator will be notified with a local audible alarm. The silo filling process shall be interrupted by the Delivery Staff.
   b. Large Bag Discharge: At this point, a further alarm will be triggered, and the silo filling must be stopped via interlocking the screw conveyor system, blower or vacuum generator depending on the type of conveyance system.
   c. Small Bag Discharge: At this point, a further alarm will be triggered, and the silo filling must be stopped via interlocking the vacuum loader system.
4. For bulk delivery, the filling line actuated valve must not be interlocked with high-high silo weight as there are risks to the driver/operator and pipework from a sudden closure of the actuated valve before stopping the truck blower.

The following low-weight setpoints shall be available for storage silo operation:

5. Minimum Operating Weight/Operational Low Weight (OLW): This operator settable setpoint provides no alarm. The process will continue to run with no action. Reaching this level will record as an Event[1] only in SCADA. This may be used to fill the silo or automatically switch over to another silo where available.
6. Low Weight (WAL) Setpoint: At this point 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.
7. Low-Low Weight (WALL) Setpoint: At this point a further alarm will be triggered, and the Operator notified. At this point Operator action has been unavailable or unable to correct the low-weight event. The powder feeding system should be interrupted by stopping the screw feeder, bin vibrator operation, silo aeration system, and closing the knife gate valve thereby inhibiting the powder batching sequence to occur.

[1] Events are a fifth priority alarm in the Seqwater alarm system as defined in SPE-00357 I-SPE-STD-006 Alarm and Event Management.

6.1.7. Silo Level Switches

In addition to silo weight measurement device, the storage silo and silo discharge chute shall be fitted with level switches to provide additional control redundancy with the following requirements:

1. Two separate and independent hardwired level switches devices to provide point detection level at High-High and Low-Low Level on the storage silo.
2. Level switch device to provide point detection level at Low Level on the silo discharge chute. Noting that for small bag systems with relatively small storage hoopers/silos (eg. 200 kg), the choke point of the chute may be similar to the Low-Low level on the hopper/silo and a second instrument may not be required.
3. Electronic level switches must be suitable for site conditions and compatible with the chemical in service.
4. The level switches must be positioned where they will provide a best representative level of the silo content.

6.1.7.1. Alarm and Trip Setpoints

The following provides guidance as to Seqwater's requirements for trip setpoints and alarming from level switches for storage silos and silo discharge chute:

Storage Silo

1. High-High Level (LSHH): The High-High Level setpoint and alarm triggered on the High-High Level switch device shall provide the same action as WAHH discussed previously in Section 6.1.6.1.
2. Low-Low Level (LSLL): The Low-Low Level setpoint and alarm triggered on the Low-Low Level switch device shall provide the same action as WALL discussed previously in Section 6.1.6.1.
3. Silo discharge chute Low Level (LSL): The Low Level setpoint and alarm triggered on the silo discharge chute Low Level switch should be considered to close the knife gate valve, stop screw feeder and inhibit the e batching sequence if the sensor still detects no powder upon activation of bin vibrator and silo aeration operation.

6.1.8. Silo Access

6.1.8.1. Access Manhole

Storage silo shall be fitted with an access manhole for an inspection with requirements to include:

1. A minimum of 600mm opening mounted on the top of the storage silo. The silo should be designed in a way that the internal access is not required, or the need is minimised or restricted.
2. Access cover shall be made from the same material as the silo 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 silo to facilitate access.
3. Access cover shall be easily lifted by one person and shall be capable of being restrained in an open position.
4. Access cover shall be fully sealable and airtight to prevent chemical powder escaping to the environment.
5. A hinged access cover shall be considered and shall open sideways as it can be positioned as closed to access walkway or silo side to limit the reach required. The hinged opening shall not impede safe access to the other assets.
6. Include required signage for confined space if required.

6.1.8.2. Stairway Access

Stairway access to the top of the storage silo shall be provided. The stairs and platform structure shall not be connected to the storage silo to allow free movement of the silo and also not to impede the load cells weight measurement.

The stairway and platforms shall comply with the requirements of SPE-00366 M-SPE-STD-002 Fixed Platforms, Walkways, Stairways and Ladders.

6.1.9. Dust Collector and Vent Filter System

Storage silo shall be fitted with a vertically mounted self-cleaning dust collector and vent filter system on the top of silo. The system must be designed to vent clean, dust-free, filtered air to the atmosphere and return chemical powder removed from the filter to the inside of the silo. The main components of the system shall include:

- Dust Filter
- Extraction Fan
- Reverse Pulse Filter Cleaning System

Where the silo is fitted with a vacuum conveyance system for unloading small bags/pails, the vacuum system will provide venting and filtration while filling the hopper/silo to meet the requirements captured in the following sections. In this case a second dust collection and filtration system may not be required.

6.1.9.1. Dust Filter

The dust filter requirement shall include the following:

1. Be either bag or cartridge type of filter with filtration capacity sufficient to accommodate the maximum volume of air to be handled without over pressuring the storage silo, particularly during delivery.
2. Be capable to remove 99% (or greater) of the smallest powder particle size as defined on the chemical Safety Data Sheet (SDS).
3. For bulk delivery, the filter filtration rate shall be capable to withstand the maximum air volumetric flow rate of the truck or conveyance system blower.
4. The airflow capacity of the dust filter shall be sized according to the volume of air displaced during the unloading process. It shall be capable of handling the peak airflow during the filling operation, considering the silo size, the truck's unloading rate, and the dust generation rate.
5. A minimum airflow rate can be calculated based on the silo's volume, the unloading truck's capacity, and the duration of filling.
6. The filter shall be housed in a container with an access lid for filter replacement. The filter lid shall be sealed to prevent the escape of powder chemical dust.
7. The filter container and access lid shall be securely positioned to prevent it being dislodged in high winds.
8. The filter shall be sized appropriately to allow maintenance staff to safely carry replacement filter elements to the top of silo for replacement.
9. Adequate platform shall be provided for safe access and work on the filter for maintenance/replacement.

10. The design should allow for easy maintenance and replacement of filter elements. This includes ensuring proper access for inspection and cleaning, as well as the ability to safely replace filter bags or cartridges without exposing operators to harmful dust.
11. Dust-tight doors or access panels should be included to allow for safe, dust-free maintenance.

6.1.9.2. Extraction Fan

The requirements for extraction fan are as follows:

1. Each dust filter shall be fitted with a dedicated extraction fan which will maintain a slight negative pressure in the storage silo during silo filling.
2. The extraction fan shall be side mounted or positioned in a way that allows for filter maintenance/replacement without the need for it to be removed.
3. The extraction fan shall discharge to atmosphere, outside of any building.
4. The fan vent shall be designed to prevent vermin ingress.

6.1.9.3. Reverse Pulse Filter Cleaning

1. The reverse pulse filter cleaning system shall automatically clean the dust filter with a compressed air pulse preferably at a certain interval. The pulse cleaning system shall also be activated at a pre-set pressure differential across the dust filter. The system should trigger an alarm to the site control system for filter blockage from a high-pressure differential across the filter at a pre-set time.
2. The compressed air supply for the pulse air cleaning shall be clean, dry and comply with the pulse air cleaning system manufacturers specification.
3. Air supply system should be fitted with a pressure regulator if a specific pressure is required for filter cleaning. A high-pressure switch should also be considered in the air supply line to isolate the air supply in the event of a pressure regulator failure.

6.1.9.4. Dust Extraction Line for Discharge Hopper

The above dust collector system can also be fitted with a dust extraction line from the discharge hopper for a large bag unloading system. The dust extraction line connection should enter the top side of the storage silo/hopper or to the central dust collection system as discussed in Section 5.3.2.

The silo nozzle shall be of the same size as the extraction line with a minimum diameter of 50 mm.

The extraction line shall be connected with a flange joint to the storage silo to allow dismantling for maintenance.

6.1.10. Pressure/Vacuum Relief Device

A pressure/vacuum relief valve shall be mounted on the top of the storage silo to protect the silo against excessive pressure and vacuum.

The device shall protect the silo against over pressure from filter blockage during powder chemical filling, it shall also protect the silo from an implosion resulting from excessive air extraction due to erroneous fan extraction operation or a sudden powder chemical discharge.

The pressure/vacuum relief device shall be sized appropriately with consideration given to the following factors:

1. Maximum allowable pressure ratings of the silo and dust filter
2. Maximum air inflow required by the silo during the highest powder drawdown rate and silo filling
3. Venting capacity of the device at specified over-pressure conditions

The set points for both pressure and vacuum relief valves shall comply with the hopper manufacturer's recommendations.

The selected relief device shall allow for connection of an exhaust line that links with the dust extraction fan vent line and extends outside the silo building. This configuration is intended to minimise the formation of dust clouds during relief valve operation.

Where vent lines are directed outdoors, the following requirements shall be met:

4. The vent line shall be directed downward, with the outlet opening facing the ground
5. The outlet shall be positioned at least 500 mm above ground level to minimise the risk of dust exposure to personnel
6. The discharge point shall be fitted with vermin mesh featuring a 2 mm aperture, secured using mechanical fasteners

In addition to a pressure/vacuum relief valve, the design should evaluate the potential benefits of incorporating a pressure switch to protect the silo from overpressure during silo filling. The pressure switch must be suitable for site conditions and compatible with the stored powder.

The design shall consider access requirements to both a pressure/vacuum relief device and switch.

6.1.11. Bin Vibrator

The storage silo shall be fitted with bin vibrators to aid in powder flow discharge. The designer shall select suitable vibration mechanisms to aid smooth powder flow considering:

- Powder density and flow properties,
- Discharge rate and
- Silo diameter.

Electric vibrators are generally preferred over pneumatic vibrators for medium to large silos and hoppers, as any disruption to the compressed air supply may compromise the operation of both the vibrator and the silo aeration system. However, several smaller hoppers installed at Seqwater sites have experienced cracking associated with the use of electric bin vibrators. Where electric vibrators are proposed, the design shall ensure that the risk of cracking is appropriately assessed and adequately mitigated.

When specifying bin vibrators, the following design aspect shall be considered:

1. Number of vibrators required
2. Optimal location for vibrator installation – including structural reinforcement and consideration for future maintenance and removal.
3. Appropriate vibration force based on silo cone geometry, material load, resonate frequency and vibration isolation pads.
4. Vibrator run time, limited to when needed while screw feeder is operating.

5. Impacts on expected life of the silo/hopper.

A bin activator may be used in place of bin vibrators if determined to be suitable by the designer. Where a bin activator is provided, it shall be suspended beneath the silo with a vibrated cone powered by one or two electric motivators. The cone should be designed with a suitable cone angle to avoid arching, bridging and rat-holing for smooth powder flow. The entire bin activator unit moves horizontally in response to vibration forces generated to allow smooth material flow through the bin activator outlet.

The bin activator design shall:

6. Ensure a consistent powder discharge to the screw feeder to enable accurate powder feeding.
7. Include flexible connection between the silo and the bin activator
8. Include sealed connections at both ends of the bin activator to prevent powder chemical escape to the atmosphere.
9. Include an easy to fit, highly chemically resistant, food grade, seamless seal for the flexible connection between the storage silo and the bin activator.
10. Be programmed with the screw feeder to allow vibration to only occur during powder discharge at the required frequency and intervals depending on the type of material handled. The bin activator supplier shall be consulted to determine the appropriate run and off times during powder discharge to avoid any unwanted compaction at the lower cone that may arise from excessive operation.
11. Be constructed of material compatible with chemical being handled.

6.1.12. Silo Aeration

In addition to the bin vibrator, the silo may be fitted with an aeration system to aid in powder flow.

The aeration system provides flow of pressurised air to break agglomerated powder to prevent silo arching/ratholing, and to aid and ensure smooth powder flow during discharge. The specifications shall include the following requirements:

1. Silo aerator shall only operate during the operation of screw feeder. The designer should select the option of continuous or intermittent aeration operation when the screw feeder runs.
2. It shall not create excessive dust at all silo powder levels.
3. The design shall ensure a consistent powder discharge to the screw feeder to provide an accurate powder feeding.
4. The silo aeration shall not create any excessive pressure in the silo. The designer shall determine whether operation of extraction fan is needed during aeration.
5. The aeration system shall be sufficient to break the agglomerated powder and allow powder to detach from the silo wall.
6. The silo aerator compressed air line into the storage silo shall be fitted with a solenoid valve, a pressure regulator, a high-pressure switch and a manual isolation valve.
7. A pressure switch shall be able to isolate the air supply line in the event of high air pressure which may arise from pressure regulator failure.

6.1.13. Dehumidifier

Storage silo(s) may be fitted with a dehumidifier to prevent condensation and moisture inside the storage silo, which may lead to caking and agglomeration of powder.

The dehumidifier shall include the following requirements:

1. A suitable mechanism, such as desiccant dehumidifier, to provide fresh dry air into the filling line or with a separate pipe into the storage silo head space to prevent moisture condensation.
2. The dehumidification unit to be mounted at the silo roof or ground level depending on the accessibility, operation and maintenance requirements.
3. Any excessive pressure build-up in the silo due to the dehumidifier operation be exhausted through the vent filter assembly and considered in sizing of any pressure relief valves.
4. The system shall be sized to deliver at least one air change per hour based on an empty silo. The designer shall determine the suitable relative humidity (RH) required for the inside air considering the material properties.
5. The system shall include a mechanism to stop the dehumidifier operation or isolate the dry air supply duct during silo filling. The operation should start again after 15 minutes of silo filling operation finishing.
6. If an air re-circulation dehumidifier system is recommended, additional air filtration modules must be used to avoid dust drawn into the air return line.

6.1.14. Knife Gate Isolation Valve

The storage silo shall be fitted with a sliding knife gate valve to provide positive isolation for downstream maintenance. The knife gate valve:

1. Shall be located at the bottom cone of the storage silo upstream of the agitator.
2. Should be pneumatically driven unless it is determined and agreed that remote actuation is not required throughout the design process.
3. Consideration should be given to close upon trigger from the silo discharge chute low level switch indicating hopper blockage.
4. Shall include open and close position switches readable from SCADA.
5. Shall have a suitable platform or appropriate steps for easy access.
6. Shall have an enclosure bonnet and a leak-proof stem seal to prevent escape of powder dusts. During commissioning, where needed, the sealing procedure needs to be established to ensure a dust tight seal at the valve open position.

6.2. Storage of Large and Small Bags

This section provides the design and construction requirements for the storage of large and small package bags.

Powder chemical package bags shall be stored inside a building in a cool, dry, and well-ventilated area. The chemical supplier shall be consulted for the requirement of humidity-controlled area. The design and construction requirements of the building is discussed separately in Section 6.3.1.

The sizing of the storage bag area shall generally follow the same basis for the sizing of bulk storage silo as provided in Section 6.1.1.

The storage of package bags should consider:

1. The large package bags may be stored on pallets on the floor depending on the site space availability.
2. Small bags may be stacked or positioned on shelves or racks.
3. The layout of the package storage shall:
    a. Allow the rotation of chemical bags (to manage aging).
    b. Provide clear passage of personnel to locate/remove bags using delivery vehicles (where applicable).
    c. Permit full observation and provide suitable access and manoeuvrability for cleaning spills.
4. Separation and isolation from any incompatible liquid and powdered chemicals or potential spills to avoid adverse chemical reaction.

6.2.1. Potassium Permanganate

In addition to the above requirements, Pot Perm storage area shall include:

1. Materials of construction to be non-combustible and compliant with AS 4326.
2. Storage capacity, separation distance between chemicals, sources of heat to the protected places shall comply with the requirements in AS 4326.
3. Consideration of the storage recommendations in ANSI/AWWA B603-03 in addition to those stipulated in AS 4326.

6.3. Chemical Enclosures, Buildings, and Access

6.3.1. Powder Chemical Storage Building

As a minimum, the design and construction of the chemical powder building should include the following:

1. For each powder chemical system, the storage silo, storage bag area, batching and dosing equipment should preferably be located inside one building. This would minimise moisture ingress that can disrupt the operation of silos and feeding equipment. In addition, process units located inside a building will reduce the impact to the environment from powder dust emission.
2. Incompatible material shall not be located inside the same building.
3. Where required due to size, storage silos should be allowed to protrude through the roof/ceiling of the chemical building. Appropriate sealing of the building shall be provided to ensure weathertightness. Soft-seals (or similar) shall be provided to ensure vibration and movement of the silo or building does not induce vibration or movement in the other.
4. Designer to consider most suitable location of the chemical building depending on the chemical application and site layout (e.g. PAC system might be located near the source to prevent piping long distance and polymer system might be stored centrally to provide access to wastewater system, filter and sedimentation/clarifier).
5. Where needed an intermediate platform shall be provided for easy access to silo equipment and instruments.

6. Internal layout shall allow for:
    a. Sufficient access for maintenance and cleaning (typically minimum 1m between walls, equipment, panels, etc.). Equipment spacing and walkways must comply with the requirements of SPE-00367 M-SPE-STD-001 General Mechanical and SPE-00366 M-SPE-STD-002 Fixed Platforms, Walkways, Stairways and Ladders.
    b. Separation between chemicals.
    c. Vehicle access for removal of equipment.
7. All trafficable areas shall include a non-slip (or slip resistant) finish.
8. All surfaces that may come into contact with powder and wetted chemicals shall be chemically resistant to attack and degradation.
9. The building should include a suitably designed bund (i.e. generally a concrete bund or an HDPE bund for a small powder chemical system) where the batching tank and dosing tanks are located. The bund floor and similar surfaces shall be graded towards a drainage sump. The sump shall be sized suitably to accommodate sump pump and level indication device. Bund arrangement is discussed separately in Section 7.3.3.
10. The room in which bulk chemicals are stored should be suitably humidity controlled and ventilated as recommended by the chemical supplier, refer to Section 6.3.3 for further details on ventilation requirements.
11. Where the building is located in bushfire-prone areas, the requirements of AS 3959 Construction of Buildings in Bushfire-prone Areas shall be addressed.
12. Sufficient internal and external lighting to be provided and include the provision for easy access for lamp maintenance/replacement as according to AS 1680 Interior and Workplace Lighting.
13. Safety showers, eye wash facility and hose reels complying with Section 4.15 of this standard shall be provided at all floors.
14. Water hose reels shall be made available for chemical wash down during spill, where appropriate.
15. Fire services which would include fire hose reels, sprinklers, alarming etc. to be installed in accordance with the Building Code of Australia and AS 2118 Automatic Fire Sprinkler System.
16. Building needs to be protected against lightning in accordance with the requirements of SPE-00352 E-SPE-STD-001 Electrical Design and Construction.

6.3.1.1. Potassium Permanganate

In addition to the above conditions, Pot Perm storage building shall comply with the following *AS 4326* requirements:

1. Buildings, including all materials and fittings that may come into contact with potassium permanganate must be constructed of non-combustible materials.
2. Building floors shall have a fall to an open drainage system so that Pot Perm will not be trapped in the event of a fire. The drainage system shall be directed away from the storage area and buildings with a collection area so that the substance can be easily collected after solidification.
3. Electrical equipment, wiring and lighting in the building shall have a minimum IP65 rating in accordance with AS 62509 and other requirements provided in SPE-00352 E-SPE-STD-001 Electrical Design and Construction.

4. Buildings shall be provided with the fire protection facilities as specified in AS 4326 except for minor storage (quantity <250 kg) facilities.

6.3.2. Access and Layout

The access and layout of the building shall include the following:

1. Access and layout (internal and external) of structures, including buildings and enclosures 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.
2. All access doors shall open outward and be fitted with panic release bars.
3. Access doors shall be designed sufficiently large to enable the installation, replacement and maintenance of equipment. 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.
4. The distance between the top of any tanks and storage silos should be a minimum of 1.2 m from the roof of any structures in all circumstances, except when the top of storage silo protrudes through the building. Notwithstanding the previous statement, there shall be sufficient space provided between the top of any tanks or silo and the ceiling of any structures or buildings to allow ergonomic access for expected maintenance to take place.
5. If an access platform is required, a minimum clearance of 2.4m shall apply between platforms and building ceilings.

6.3.3. Ventilation

Storage and chemical area layout shall be designed using suitable natural or forced ventilation to:

1. Maintain exposure level to any vapour or dust in the workspace below the recommended workplace exposure standard.
2. Prevent the accumulation of chemical powder, fumes, mists or vapours.
3. Prevent condensation build up.
4. Ensure a safe operating atmosphere at a level determined in the hazard identification, assessment and control process.

The exhaust from any mechanical ventilation shall be directed away from any sources of ignition and areas where people are likely to congregate.

Ventilation systems shall be designed in accordance with relevant Australian Building Codes, legislation, Industry Standards, Specifications, and *AS 1668 The Use of Ventilation and Air-conditioning in Buildings set*. Considerations shall also be given for the hazardous area requirements as per *AS 60079* for powder activated carbon.

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

6.3.4. Compressed Air Room

Compressed air is required to operate air-driven instrumentation, powder aeration systems and filter cleaning. The compressed air supply system should include air receivers and dryers. The air compressor/blower shall be fitted with a filter in the suction side to prevent dust to entrain into the system where applicable.

Depending on the site layout and chemical, the system may be housed in a separate room from the chemical storage building or located sufficiently far from the chemical stores to avoid clogging and contamination.

Room design shall ensure a safe working atmosphere for personnel and mitigate the effects of pressure changes and noise level resulting from the compressor/blower operation and shall comply with requirements in SPE-00367 M-SPE-STD-001 General Mechanical.

7. Batching System

This section describes the requirements for the design and construction of powder chemical batching system.

The batching system is used to prepare powder chemical slurry/solution for chemical dosing. Powder chemical is transferred from the storage silo/hopper into the batching tank via wetting system (where applicable) to prepare the chemical slurry/solution prior to transfer into the dosing tank for dosing or dosed directly from the batching tank Refer to Section 8 for information on the two types of dosing systems.

This section should be read in conjunction with standard P&IDs referenced in Table 11, Section 9.

Powder chemical batching system should include the following main components:

1. Powder Feeding and Conveyance System
2. Powder Wetting System (where applicable)
3. Batching Tank System

Redundancy requirements (duty/standby) are not specified for motive and make-up water systems, feeder, wetting system, batching tank, batch transfer system including pumps, solenoid valves and lines. However, these redundancy requirements should be assessed on a project basis to ensure the required availability and reliability criteria can be achieved.

7.1. Powder Feeding and Conveyance System

The powder feeding system is used to transfer powder chemical from the storage silo/hopper into either the wetting system or directly into the batching tank, depending on the site layout, chemical and process requirements.

Seqwater prefers the use of storage silos and batching tanks in vertical orientation. This removes the additional conveyance system from storage silo to the batching tank. Where, due to plant configuration, batching tanks are located away from the silo, either mechanical or pneumatic conveyance systems may be considered.

The main components of powder feeding and conveyance systems as addressed in this standard are:

- Screw feeder system
- Agitator
- Conveyance system

7.1.1. Screw Feeder System

Screw feeders shall be mounted below the silo discharge chute to accurately control the amount of powder chemical feed for batching. Each screw feeder must fill each individual batching tank separately when more than one batching tank is used.

The screw feeder shall include the following requirements:

1. Provide volumetric control (i.e. discharge powder chemical at certain volumetric feed per unit time).
2. Preferable be fitted with a variable speed drive. Note that a fixed speed drive feeder can be used for a fixed concentration with variable dosing rates system, however a variable speed drive will provide more flexibility to accommodate any potential changes in chemical properties, material flow characteristics, wetting rates,

and batching concentration etc. The system should generally be considered to operate at a particular speed using the timer approach as determined and optimized during commissioning.

3. Be fitted with a timer to vary the feeder run time at a particular speed manually or automatically to change the batching concentration when needed.
4. Be suitably sized to accommodate across the span of designed powder delivery rates.
5. Have an accuracy of ±2% by weight or better over the full operating range.
6. Include screw feeder pitch, flight and shaft and be designed to prevent plugging and flooding.
7. Be fully contained within a housing to prevent powder dust escaping and prevent air being drawn inside.
8. Be preferably designed with heat tracing with thermostat to avoid powder clogging.
9. Include access with sufficient space to safely measure powder discharge for calibration and collection of samples. A sliding collection tray under the feeder may be considered.
10. Be made available through SCADA for calibration mode to verify the discharge volume and the corresponding motor speed.
11. The motor drive power to be suitably sized to accommodate the bulk powder weight in the feeder inlet over the full silo operating range.
12. Not be fitted with slide gates underneath the discharge as it may compress the powder material and damaged the screw feeder if closed during operation.
13. Include a powder discharge chute at the end of the screw feeder that connects to either the batching tank or wetting assembly. The discharge chute line should:
    a. Be designed to discharge powder in a controlled manner to prevent unwanted dust clouds and risk of spills.
    b. Include a vibrator to prevent powder chemical build-up in the delivery chute.

7.1.1.1. Agitator

An agitator is required to achieve a uniform powder bulk density with a consistent flowrate to ensure an accurate volumetric feeder operation. An agitator shall be installed at the top of the screw feeder with the following requirements:

14. Be preferably fitted with a variable speed drive with its speed matched to the speed of the screw feeder to prevent inconsistent batching strength and programmed to run during screw feeder operation only.
15. Shall be positioned inside the silo discharge chute and be mounted above the screw feeder.
16. Should be a horizontal type of agitator with the preference of propeller type blades.

7.1.2. Conveyance System

Where batching tanks cannot be installed underneath storage silos/hoppers, either mechanical or pneumatic conveyance system may be used for the transfer of powder chemicals for batching.

Mechanical and pneumatic conveyance systems to transfer powder to batching systems shall follow the requirements provided in Section 5.3.3.

Pneumatic conveyance must be used for the polymer systems where a wetting head is used to pre-wet the powder.

7.2. Powder Wetting System

A powder wetting system is used to pre-condition chemical powder prior to entering the batching tank(s). The chemical powder is wetted to prevent powder agglomeration during mixing and ensure homogeneous mixing, minimise dust emission, and reduce mixing time.

Dry polymer powder specifically, is susceptible to the shear stresses induced by the tank mixer. If not wetted properly, the polymeric chains can become sheared and lose efficacy. Similarly, when PAC is added directly to water, it tends to float or form clumps instead of dispersing evenly. A wetting system ensures each particle is properly hydrated, allowing it to mix uniformly.

Typically. wetting systems are not required for chemicals such as pot perm and soda ash, as these powders dissolve readily without the need for pre-wetting.

7.2.1. Wetting System Selection

The need for and selection of wetting systems, as well as specific system details, will be determined by the designer and project specific requirements. Wetting system can include types such as wetting cones and wetting heads. Where feasible, installing the wetting system directly on top of the batching tank should be prioritised. Some design features of wetting cone and wetting head systems are described below.

7.2.2. Wetting Cone System

This section provides the design and construction requirement for wetting cone systems and should be read in conjunction with standard P&ID drawings, as referenced in Section 9:

Powder chemical from the feeder is mixed with water in a swirling motion inside the wetting cone creating a water powder mixture. A stream of motive water generally passing through the eductor creates a sub-atmospheric pressure which draws the mixture and flows into the batching tank.

When more than one batching tank is used, each batching tank must be supported with an individual wetting cone system and all its required components.

The main components of a wetting cone system generally include:

- Wetting cone – for initial mixing of powder and water.
- Eductor – used to create suction and promote slurry transfer; may be omitted when the wetting cone is installed directly on top of the batching tank, depending on the design.
- Motive water system – supplies high-velocity water to drive the eductor and facilitate mixing.

7.2.2.1. Wetting Cone

The wetting cone should:

1. Be installed straight below the feeder discharge spout and preferably directly on top of the batching tank where the mixing objective can be achieved.
2. Be selected such that adequate wetting is provided across the full turndown range of operating conditions and powder delivery rates.
3. Include a straight funnel outlet port at the bottom of the cone that connects to the eductor through secure, sealed fittings (where eductor used).

4. Have a sealed top cover that prevents dust emission and is removable allowing internal inspection.
5. Be fitted with a water line connection to the wetting ring, which circles the perimeter of the cone and flows down the wall and into the base where it blends with the powder chemicals.
6. Be fitted with an overflow line connected at the top of the wetting cone with a high-level switch for alarm. The designer should provide an interlock from the high level switch to shut off the inlet water supply and powder feeding system.
7. Be supplied from the same water source as the eductor motive water using a tee connection with a separate flow control. The wetting cone water supply line shall include:
    a. A manual flow control valve, preferably a V-notch ball valve with the option of lock-in position.
    b. A flowmeter with the option to generate flow deviation alarm.
    c. A manual isolation valve for upstream of the wetting cone connection for maintenance.

7.2.2.2. Eductor

An eductor may be used to further mix the resulting solution and facilitate the transfer of powder and water mixture from the wetting cone to the batching tank. This is achieved by accelerating the velocity of the motive water through a constriction, resulting in a pressure differential between the bottom of the wetting cone and the motive water line. The eductor should:

1. Be designed to provide suitable conditions to prevent overflowing of the wetting cone, and adequate mixing of powdered chemical to avoid clumping in the batching across the span of designed powder delivery rates.
2. Where required (i.e. for abrasive slurries such as PAC), the eductor materials should be constructed from materials resistant to abrasion.
3. Include replaceable wear parts, if required.
4. Be designed to consider using union or camlock connection in the suction and discharge side for easy removal.
5. Be connected to the wetting cone discharge and include the following:
    a. Be designed as short as possible to reduce the motive water pressure requirement.
    b. Include an injection nozzle, if required, to enhance suction and mixing of the slurry into the motive water stream.
6. Be connected to a line from the discharge side to the batching tank. The discharge line should:
    a. Be sized to accommodate the required slurry feed flowrate and achieve the required minimum velocity to prevent solid settling.
    b. Be connected to the top of the batching tank with a flanged connection and with a manual isolation value for maintenance requirement.

7.2.2.3. Motive Water System

The motive water system is designed to provide a fixed flowrate regardless of the batching concentration to the eductor. The water flowrate must not vary/fluctuate unless adjusted by the plant operators.

The water supply may be sourced from raw water, potable water or suitable site service water sources, depending on the site availability and dosing application. The water source selected must not adversely affect treatment or pose a risk to treated water.

The design shall ensure that simultaneous operation of the make-up, wetting/motive water system shall not impact the required consistent or controlled flow of water (i.e. flow rate and supply pressure).

The motive water line should:

1. Include a Y-strainer with a minimum mesh of 0.5mm.
2. Include a solenoid valve and interlock water supply system upon reaching high-high level in batching tank or high level in the wetting cone.
3. Include a booster pump when the water source does not have sufficient capacity to maintain a constant pressure and flow. The booster pump design shall provide sufficient flow and pressure for the operation with a variable speed drive where needed. Pump operation shall be interlocked with the same requirement of the solenoid valve mentioned above.
4. Be fitted with a non-return valve and preferably be positioned downstream of the booster pump, where applicable.
5. Be fitted with a pressure transmitter with high and low pressure alarms and to be installed at the pump discharge side, where applicable.
6. Have a manual flow control valve, preferably a V-notch ball valve with the option of lock-in position.
7. Have a flowmeter with the option to generate flow deviation alarm.
8. A pressure sustaining valve to ensure the consistent feed pressure.
9. Have a manual isolation valve upstream of the batching tank connection for maintenance.

In addition to the above requirements, where a potable water system is used as a source of motive water, the potable water system shall be protected from the wetting cone/eductor by the use of a reduced pressure zone (RPZ) valve – only proprietary back flow prevention devices shall be used. Double check valves are not considered adequate double layer protection. Arrangement must comply with the *AS/NZS 3500 and Queensland Plumbing and Wastewater Code*.

7.2.3. Wetting Head System

The Wetting head assembly is installed on the top of the batching tank to wet the powder as pre-conditioning requirement, to prevent dust emission, and ensure dissolution of powder chemicals.

Typically, the wetting head systems include a centrally located powder feed discharge encircled by wetting spray nozzles. The pneumatic powder conveyance system, commonly used with the wetting head, must be designed to provide sufficient powder dispersion, allowing individual particles to be thoroughly wetted. This ensures the optimal particle wetting and reliable operation.

The wetting head system should:

1. Be fitted on the top of the batching tank with a support structure (where needed) to hold the wetting head.
2. Have preferably a transparent section to allow for visual inspection.
3. Be designed to provide adequate wetting across the range of design powder feed rates.

4. Include separate inlet connections for powder chemical and water.
5. Be considered for spray nozzles in the water line to provide an adequate powder spraying. The general design requirements for the wetting head water supply system as provided in Section 7.2.2.3 for the motive water system shall apply.

7.3. Batch Tank System

This section describes the requirements for the design and construction of powder chemical batching tank system and shall be used in conjunction with standard P&ID drawings, as referenced in Section 9.

The batching system shall be fully automated. It shall be capable of transferring the required powder and water to produce the required batch strength at an operator set point.

The system includes batching tank, batching transfer system and tank bund arrangement. Batching tank is also used as a dosing tank for the variable concertation and fixed flow system.

7.3.1. Batching Tank

Batching tanks shall be above the ground, fixed, permanently positioned tanks that are filled and discharged in situ. The batching tank should:

1. Generally, be vertically oriented cylindrical or rectangular tanks and preferably located underneath the storage silo/hopper.
2. Be considered in the design for the liquid level to tank diameter (or equivalent diameter for rectangle tanks) ratio of 0.8 to 1 to allow proper axial mixing.
3. Be fitted with connections for powder fill line or wetting assembly, make-up water line (if applicable), mixer, discharge line, overflow line, drain line, return line, vent, level switch and level transmitter.
4. Have a fixed roof and if used as a working platform, it shall be designed to support the weight of personnel.
5. Be considered to have a hinged top manhole cover, where applicable, with a minimum opening of 600 mm. The cover should open sideways and lay flat on the roof of the tank, have restrained option for open position, and be able to be lifted by one person. Signage for confined space and other hazards should also be included when required.
6. Include a suitably sized side mounted flanged and bolted access to allow easy access for maintenance for large batching tanks.
7. Comprise internal baffles for large cylindrical tanks to avoid a swirling motion for mixing.
8. Be considered in the design to avoid the formation of packets of solids in the corners for slurry systems as commonly observed for rectangular tanks.
9. Include an outlet connection at least 200 mm above the tank floor to prevent solid entrainment, and the outlet line to be fitted with a manual isolation valve installed close to the tank.
10. Have a base that slopes to one direction to the drain outlet for complete emptying and solids removal. The tanks should be allowed to drain directly into the bund floor with a short drain line to avoid settled solids clogging the piping.

11. Include an overflow line at least 1.5 times the diameter of the fill line with a minimum size of 80 mm and open to atmosphere with vermin proof mesh. The overflow line must be installed below the level of the inlet line and discharge directly to the bund sump or the tank bund floor.
12. Include a separate vent line with vermin proof mesh if the overflow line is insufficient to prevent excessive positive or negative pressures during filling/emptying and exceeding structural limitations of the tank. The vent needs to be sized considering tank inflow, outflow, thermal inbreathing and outbreathing.
13. Be designed and constructed to operate at atmospheric pressure.
14. Be earthed (where needed) in accordance with SPE-00352 E-SPE-STD-001 Electrical Design and Construction, relevant codes and standards.
15. Be designed following the appropriate codes and standards. A number of standards for the tank design and construction as acceptable to Seqwater are listed below in Table 9:

Table 9 Recommended standards for the design and construction of batching and dosing tanks

Recommended Standard(s)	Comment
AS/NZS 4766 ASTM 1998	For Polyethylene tanks
BS EN 13121-3	For Glass-fibre Reinforced Plastic (GRP) tanks
AS 1692 BS EN 14015 API 650 API 620	AS 4326 specifies (as applicable for Pot Perm) these standards for the design and construction of fixed steel tanks to be operated below <17 kPa. These standards can also be considered for other powder chemicals.

7.3.1.1. Tank Number and Sizing

There should be a minimum of one (1) batching tank to maintain dosing continuity. The final number should be determined considering the plant's size, plant's availability and criticality requirements, chemical properties, reliability and maintainability. Where shutdown or failure of reliability, operability and maintainability cannot be tolerated, two batching tanks should be provided. When sizing the batching tank, the design should consider the followings:

1. The batching tank should be sized based on the highest chemical consumption rate and the batching time required. It shall ensure that batching can be completed and transferred without any interruption to dosing capability.
2. The batching time requirement includes the time it takes to fill, mix, and transfer. It shall also consider the chemical dissolution and maturation time requirement where applicable.
3. The batching frequency should not be excessively high or low.
4. Polymer: The design should also consider viscosity of polymer solutions which varies with polymer types and decide an appropriate batching strength and tank size.

Table 10 provides powder chemical specific recommended mixing time and must be considered to determine the number and size of tank(s):

Table 10 Mixing time requirement for different powder chemicals

Chemical	Mixing Time (Minutes)
Polymer Cationic	45 – 60 (For maturation or aging requirement)
Polymer Anionic	120 (For maturation or aging requirement)
PAC	5 – 10 (For mixing requirement)
Soda Ash and Pot Perm	15 – 20 (For powder dissolution requirement)

The batching tank design shall include the provision for an operator adjustable batching time set point in SCADA.

Where more than one batching tank is provided for a system or multiple systems, they should be capable of operating, batching and transferring simultaneously.

In particularly cold environments, the use of heated service water should be considered for batching Pot Perm.

7.3.1.2. Tank Labelling

Batching tanks shall be labelled and placed in accordance with PRO-00008 Hazardous Chemicals Procedure, *Work Health and Safety Regulation 2011*, Globally Harmonised System of Classification and Labelling of Chemicals (GHS), *AS 60079*, Australian Dangerous Goods Code and relevant legislative requirements. Where multiple batching 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).

1. 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:
    a. Manufacturer's details
    b. Date of manufacture
    c. Tank number
    d. Materials of construction
    e. Product content
    f. Dimensions
    g. Design volume
    h. Design temperature and pressure
    i. Overflow level
    j. Design standard
    k. Specific gravity of chemical solution/slurry etc.
2. Chemical hazard placard shall be printed on stainless steel, adhered to the tank and intended to remain in place and legible for the design life of the tank.

7.3.1.3. Tank Materials

Refer to Section 4.5 for tank material selection. Where materials require additional protection as a result of site conditions and chemical attack, adequate protection, paint or coating, or other fit for purpose means of ensuring the required design life is achieved shall be provided in accordance with SPE-00348 M-SPE-STD-004 Protective Coatings.

7.3.1.4. Level Devices

Each chemical batching tank shall include level control and protection. This shall be achieved by the use of:

1. An electronic level transmitter to measure the tank level/quantity. The electronic level transmitter output shall be used for the following control and alarming:
   a. Alarm – Low Level (LAL) – 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.
   b. Batch Start (or Operational Low Level) – level that starts the batching sequence.
   c. Batch Stop (or Operational High Level) – level that stops the batching sequence.
   d. Alarm – High Level (LAH) – 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.
2. Two separate and independent hardwired level devices (sensor 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 LSHH and LSLL:
   a. At LAHH (or LSHH) measured on the High-High level device, tripping of chemical batching sequence including screw feeder, make-up and motive water shall occur.
   b. At LALL (or LSLL) measured on the Low-Low level device, closure of the batching tank outlet valve and trip the chemical transfer pump, when used, shall occur.
3. Where another sensor (instead of switch) is used for the purpose as stated in (ii), a dissimilar technology to the primary sensor shall be used.
4. A mechanical level indicating device, preferably magnetic coupled type, with appropriate display to provide local level indication can be considered, where needed.

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

7.3.1.5. Tank Mixer

The tank mixer should:

1. Enter from the top and suitably supported and suspended from a tank roof if the tank has been structurally designed to accommodate this. Otherwise supporting frames shall be designed and installed.
2. Be designed to prevent solid settling and provide adequate mixing energy to homogenously mix chemical solution within the range of tank operational level.
3. Be removable from the tank without the need to remove the roof in its entirety.
4. Be accessible for maintenance or removable to allow maintenance.

5. Be considered to install with an offset from the tank centre to avoid wave formation. For an offset mixer, any additional stress on the mixer shaft due to potential unbalanced forces shall be considered in the mixer selection.
6. Be designed such that the mixer blades provide uniform velocity throughout the tank and operate without cavitation. Blades shall be of one-piece construction and 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.
7. Have the option to start and stop remotely and locally. The designer shall decide the need of delivering varied shear force by the adjustable variable speed drive instead of a fixed speed motor.
8. Include alarms and ability to interlock with the batching system when the mixer fails.
9. Be designed to eliminate any chance of leakage of oil from the gearbox with appropriate sealing measures to prevent gearbox oil from entering the process solution and meet the requirements of SPE-00367 M-SPE-STD-001 General Mechanical for the oil used.
10. For polymer, the missing speed to prepare the polymer solution should be determined in consultation with the chemical supplier since high chemical shear may degrade the polymer chains.

7.3.1.6. Powder Fill Line

Batch tank powder or connection from wetting assembly fill lines shall:

1. Include a separate flanged nozzle/connection on the topside (roof) of each batching tank with the same diameter as the fill line diameter or the size of the discharge spout.
2. Enter the top of the batching tank in a vertical orientation and above the overflow height.
3. Provide a minimum 50mm straight funnel discharge pipe connection from the batching tank flanged nozzle connection on the internal topside roof to direct the discharge orientation.

7.3.1.7. Make-up Water Line

Make-up water line may be required to fill the batching tank when the wetting system is not available or the flow is insufficient.

The design requirements of the make-up water supply system should generally follow the requirements as provided in Section 7.2.2.3 for the motive water system with the following exceptions:

1. Source of water may depend on the available pressure and flow of the site service water offtake without requiring a booster pump.
2. Should include a flow switch with a low flow alarm instead of a flow meter to indicate the system failure. Alternatively, the batching tank fill rate from the level transmitter can be used to indicate system failure.
3. Should include local pressure indicator. Requirements for pressure transmitter and manual control valve are not needed.

7.3.2. Batching Transfer System

Where used, the batching transfer system transfers the chemical slurry/solution from the batching tank to dosing tank(s) and shall operate automatically.

Batching transfer may be achieved via gravity or pumping. Where gravity transfer can be achieved by positioning batching tank at a level above the dosing tank, this shall be the preferred method.

The batching transfer system should consider the following:

1. Transfer line to be sized and run with a continuous downward gradient so chemical slurry does not accumulate in the line.
2. Include an actuated isolation valve to start and stop transfer (only applicable for gravity transfer).
3. When transfer pump is needed, the following should be considered:
   a. Peristaltic hose pump should preferably be used for chemical slurry due its capability to handle solids and low maintenance requirements.
   b. Progressive cavity pumps should be considered to handle shear sensitive and viscous fluids such as Polymer. Designers are to consider the maximum pump rpm in handling the chemical solution to avoid molecular shearing.
   c. The system should generally be capable of transferring an entire batch solution under 10 minutes.
   d. The transfer pump should be fitted with a fixed speed motor with the option of a soft starter.
   e. Manual isolation valves should be provided at pump suction and discharge sides for maintenance. Generally, duty/standby pump arrangement is not required unless the transfer pump operation is critical for the plant continuous operation.
   f. The line shall include a pressure relief valve installed immediately at pump discharge. The relief vale shall be sized for a full flow relief and the relief line should preferably be returned on the top of the batching tank.
   g. Appropriate flushing connections should be provided particularly for a slurry system with a normally closed valve, non-return valve and a camlock connection.

7.3.3. Bund Arrangement

Secondary containment shall be provided, in the form of a bund, for all batching and dosing tanks. Each chemical type shall be installed in a separate bund.

Batching tank and/or dosing tank bund:

1. The bund shall preferably be constructed of concrete; however, HDPE bunds are acceptable for small tanks.
2. The bund shall be sized to contain a minimum of 110% of the capacity of the largest dosing or batching tank when multiple tanks are located within the same bund.
3. The bund shall be designed with bund walls and shall generally include a minimum freeboard of 100 mm above the design fill volume.
4. The bund floor shall be designed to prevent pooling of chemicals or water by providing a suitably finished surface with a minimum gradient of 1:75 towards the bund sump. Refer to Section 7.3.3.1 for bund sump requirements.
5. The design shall account for potential liquid jetting or spraying resulting from tank or nozzle failures. Mitigation measures may include increasing the distance between the tank and the bund wall, increasing the bund wall height, or installing splash screens.

6. The design shall include open-channel collection gutters fitted with grating covers and connected to the bund sump for the collection of wash-down water, spills, overflows, and scours.
7. The bund shall incorporate chemically compatible wall and floor coatings in accordance with SPE-00348 M-SPE-STD-004 Protective Coatings.

7.3.3.1. Bund Sump

A low point bund sump shall be provided in each bund to:

1. Provide means for detection of spills or batching/dosing tank overflows.
2. Provide a point of collection or extraction of chemical slurry/solution.

The bund sump shall:

3. Be sufficiently sized to accommodate two portable sump pumps and level instrumentation. A typical sump size of 1200mm (long) x 500mm (wide) x 500 mm (deep) may be considered for concrete bunds.
4. Include a chemical-compatible material grating sufficient to withstand any weight reasonably expected to be applied during construction, maintenance and operations activities.
5. Provide a local and remote high-level alarm (LAH) from the level instrumentation to alert the operator of a high chemical solution or water level. The instrumentation shall include, as a minimum, a high-level switch (LSH) (ball float, conductivity or similar).

The design shall take into consideration, and clearly define, how a filled bund or sump will be drained in the event of a chemical spill, clean up or scouring activities. Depending on the site facilities, consideration should be given to include a drainage pipe to transfer wash down water or spill to the site waste handling facility or sludge treatment area or to a vacuum truck.

Where the vacuum truck option is selected, the drainage pipe would be expected to extend from the base of the sump to above the bund wall with a suitable mechanical coupling allowing connection.

Where drainage to site facility option is selected, the drainage pipework should include an isolation valve with limit switches with the followings:

6. 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. This is to provide operator initiated release of chemical slurry/solution to the designated location.
7. The isolation valve limit switch shall provide an alarm to alert operators if the isolation valve is in the open position for a defined period of time.

7.3.3.2. Safety Showers and Eyewashes

Each chemical storage bund shall include a safety shower and eyewash station which complies with the requirements of Section 4.15 of this standard. Bunds shall be arranged to ensure a clear path, free of hazards, to the safety showers and eyewash station is provided.

8. Dosing System

This section describes the requirement for the design and construction of Powder chemical dosing systems and shall be read in conjunction with standard P&IDs referenced in Table 11, Section 9.

There are two common configurations for powder chemical dosing systems:

1. variable concentration/fixed flow rate and
2. fixed concentration/variable flow rate systems.

The choice between these two systems should be based on the chemical properties, required mixing time, plant flow stability, process flexibility, the level of dosing control needed and plant operating conditions. Refer to Section 4.17 for additional related information.

Key features of these two systems are given below:

Variable Concentration with Fixed Flow Rate

In this configuration, the dosing flow rate remains constant, while the chemical concentration is adjusted as needed.

Key Features:

- Best suited for chemicals with short mixing or hydration times.
- Works effectively where plant production rates and raw water quality remain stable.
- The batching tank also serves as the dosing tank.
- Less effective for processes that require rapid response to changing conditions, as concentration adjustments take longer to take effect.
- Not ideal for chemicals requiring long maturation or activation times (e.g. polymers).

Fixed Concentration with Variable Flow Rate

In this configuration, the chemical concentration in the batching tank is maintained at a constant level, while the dosing rate is varied to meet process demands. The batching concentration can, however, be adjusted when necessary to keep the selected dosing pump operating within its optimal range.

Key Features:

- Recommended for chemicals that require maturation time and thorough mixing, such as polymers.
- Well-suited for treatment plants with variable flow rates or fluctuating raw water quality.
- Enables faster operational response by varying the dosing flow rate while maintaining a known, consistent concentration.
- Requires separate batching and dosing tanks, as well as a batching transfer system.

Regardless of configuration, a typical powder chemical dosing system generally includes the following components:

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

8.1. Dosing Tank

Dosing tank(s) refers to the tank(s) used to store chemical slurry/solution for dosing to the process system as transferred from the batching tank(s). However, the batching tank(s) can also function as dosing tank(s) for the variable-concentration, fixed-flow system noted above.

Dosing tank(s) shall be above the ground, fixed, permanently positioned tanks that are filled and discharged in-situ. All chemical dosing tanks should be designed and constructed to the appropriate codes and standards as mentioned in Table 9 of Section 7.3.1.

Bunding shall be provided as outlined in Section 7.3.3.

The general mechanical requirements for dosing tank(s) shall be as provided in Section 7.3 for batching tank(s), with some exceptions and requirements as mentioned below.

The dosing tank should:

1. Be vertically oriented unless design requirements dictate a horizontal orientation.
2. Include a feed line with the requirements as provided in Section 7.3.1.6.
3. Be considered to include a return line connection from the dosing skid to accommodate chemical return from the pump during commissioning, pump calibration and pressure relief valve discharge.
4. Be fitted with connections for discharge line, overflow line, drain line, return line, vent, level switch and level transmitter with general requirements provided in Section 7.3.1.
5. Include a top manhole cover, where applicable, as per the relevant tank design and construction standard. A hinged manhole is not required. Include confined space signage as required.
6. Not be fitted with internal baffles.
7. Be filled via an automated transfer system and shall include level control and protection as defined in Section 7.3.1.4.
8. Be fitted with mixers for PAC and Soda Ash system to maintain the slurry in suspension and avoid powder settling. Polymer and Pot Perm solution generally do not require mixers in the dosing tank because the powder has been fully dissolved in the batching tank. The requirement for mixers shall follow the same specification as provided in Section 7.3.1.5.

The additional requirements of the dosing tank (s) are given below.

8.1.1. Number and Sizing

There should be a minimum of one (1) dosing tank to maintain dosing continuity. The final number should be determined considering the plant's size, plant's availability and criticality requirements, chemical properties, reliability and maintainability. Where shutdown or failure of reliability, operability and maintainability cannot be tolerated, two dosing tanks should be provided.

When sizing the dosing tank, the design shall consider the following:

1. Dosing tanks should be sized such that they are able to receive an entire chemical batch from a batching tank at the level where a batch transfer is required. The dosing tank should be sized a minimum 100% larger than the batching tank.

2. The dosing tank sizing design should also consider a minimum 2-3 hrs of dosing volume considering the average dose rate at maximum plant flow.
3. The design must consider the maximum residence time that the chemical can remain in the dosing tank(s) without degradation.

8.1.2. Level Devices

Each chemical dosing tank that is filled via an automated transfer system shall include level control and protection. This shall be achieved by the use of:

1. An electronic level transmitter to measure the tank level/quantity. The electronic level transmitter output shall be used for the following control and alarming:
   a. Alarm – Low-low level (LALL) Setpoint: At this level Operator action has been unavailable or unable to correct the low-level event. The process shall be interrupted by stopping the dosing pumps. A further alarm will be triggered, and the Operator notified.
   b. Alarm – Low Level (LAL) – 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.
   c. Batch Transfer Start (or Operational Low Level) – level that starts the batch transfer.
   d. Batch Transfer Stop (or Operational High Level) – level that stops the batch transfer.
   e. Alarm – High Level (LAH) – 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.
   f. Alarm – High-high level (LAHH): At this level Operator action has been unavailable or unable to correct the high-level event. The process shall be interrupted by stopping chemical transfer and the operator notified.
2. Two separate and independent hardwired level devices (sensor 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 LSHH and LSLL
   a. At LSHH measured on the High-High level device, tripping of chemical transfer shall occur.
   b. At LSLL measured on the Low-Low level device, tripping of the chemical dosing pumps shall occur.
   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.
3. Where another sensor (instead of switch) is used for the purpose as stated above, a dissimilar technology to the primary sensor shall be used.
4. A mechanical level indicating device, preferably magnetic coupled type, with appropriate display to provide local level indication can be considered, where needed. 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.

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

8.2. Dosing System Details

The dosing arrangement with positive displacement pumps should be used in most circumstances with 100% duty/standby capability.

The other dosing arrangement referred to as pressurised ring main system is generally not recommended for the four powder chemicals covered in this standard specification. However, the arrangement may be considered where a high line velocity needs to be maintained to avoid settling of solids using a recirculation line. The detailed requirement of pressurized ring main dosing system is not covered in this standard specification. Where needed, Seqwater standard specification SPE-00445 B-SPE-STD-009 Liquid Chemical Storage and Dosing Systems and standard P&ID B-DWG-STD-00016 *Minimum Requirements, P&ID, Liquid Chemical Ring Main Dosing Unloading* can be used as a guideline for the design of a powder chemical pressurised ring main system.

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

1. A manual and actuated isolation valve on the outlet of the dosing tank(s).
2. Where multiple tanks are used, a combined inlet manifold to the dosing pump skid.
3. A dosing skid including the following as a minimum, in order of upstream to downstream relative to a P&ID:
   a. Dosing skid manual isolation valve.
   b. Suction-side calibration cylinder for certain systems, refer to Section 8.2.2.
   c. Suction-side manual isolation valve for each pump.
   d. Suction-side pulsation dampener 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 deliver chemical.
   g. A pressure relief valve for each pump, preferably returning to dosing tank (in addition to any pump internal pressure relief valves).
   h. Discharge-side manual isolation valve for each pump – discharge isolation valve downstream of non-return valve.
   i. Discharge-side pulsation dampener if required or recommended by the vendor. Normally needed for diaphragm type pumps.
   j. A pressure transmitter installed upstream of pressure sustaining valve.
   k. Discharge-side flushing and drainage points for skids and ancillary pipework.
   l. A flowmeter installed upstream of pressure sustaining valve, refer to Section 8.2.7 as in some circumstances, alternate installation locations may be beneficial.
   m. Discharge side pressure sustaining/backpressure valve for certain pump types, refer to Section 8.2.8.

n. Pump commissioning and calibration return line connected to the return line manifold fitted with locked close valve and flushing point.

o. Discharge side flushing points for skids and ancillary pipework.

p. Non-return valve to prevent backflow of service water and chemical dosing.

q. Discharge-side manual isolation valve for each pump. Discharge isolation valve downstream of non-return valve.

r. Inclusion for carrier water may be required for chemical transportation or mixing – refer to Section 8.2.10 for further details.

s. Chemical mixing device arrangement for chemical and carrier water mixing – refer to Section 8.3 for further details.

t. A manual isolation valve at the skid boundary.

u. Two dosing lines for each dosing point fitted with dosing spears and flushing capability.

v. Dosing skid shall be installed in a suitably bunded area, preferably with the applicable chemical building or batching tank or dosing tank bunding area. Any possible spillage from the skid must be contained within the skid bund.

Refer to SPE-00435 M-SPE-STD-010 Chemical Dosing Skids for detailed mechanical requirements of the chemical dosing skid design and construction. Seqwater standards SPE-00430 M-SPE-STD-012 Chemical Dosing Pumps and SPE-00355 M-SPE-STD-013 Chemical Dosing Piping shall also be used in the design and installation of chemical dosing systems.

The remainder of Section 8.2 shall be used to specify further requirements of dosing system components.

8.2.1. Suction Lines

The suction line supplies chemical from each tank to the dosing pumps.

1. Suction lines to the dosing pump shall be kept as short as possible.
2. 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.
3. The design shall ensure flooded suction to the pump centerline under all process conditions.
4. Include a manual isolation valve and an additional actuated valve only where multiple dosing tanks feed into a common header. Both valves should be installed as close as practicable to the dosing tank.
5. Refer Section 4.8 for suction line sizing and velocity requirements.
6. 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.

8.2.2. 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 SPE-00435 M-SPE-STD-010 Chemical Dosing Skids for further detail on calibration cylinder requirements.

8.2.3. Dosing Pumps

A minimum of one (1) duty and one (1) standby pump shall be provided in all circumstances to ensure 100% duty capacity can be maintained. The standby pump shall be capable of fully supporting the duty arrangement. To minimise the risk of chemical overdosing, the control system shall prevent the simultaneous operation of both pumps under all scenarios.

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.

Standard Specification SPE-00430 M-SPE-STD-012 Chemical Dosing Pumps shall be used when selecting pump types based on the application.

For PAC and Soda Ash dosing system, peristaltic hose pumps should be selected. with a safe operating range of discharge acceleration losses. Typically, the peristaltic pump shall be sized to minimise discharge acceleration loss to < 10% of the pump's rated pressure (i.e. < 1.5 bar recommended for a PN16 system), while still maintaining the desired line velocity. Additionally, peristaltic pumps should be fitted with a float type high level switch to trip the pump if the pump internal contents become flooded when the hose bursts.

Diaphragm pumps may be selected for Polymer and Pot Perm systems, provided they suit the design requirements. If a diaphragm pump is selected, Seqwater prefers the use of digital diaphragm dosing pumps unless dosing capacity is a limiting factor.

Progressive cavity pumps are also an acceptable alternative to diaphragm pumps, and Standard Specification SPE-00506 M-SPE-STD-016 Progressive Cavity Pumps shall be followed.

The selected pump shall have a VSD controlled motor to achieve flexibility on the required flowrate. However, the speed shall be limited to a safe range under all conditions, including during manual operation, maintenance, and testing. Additionally, if the pump stroke needs to be adjusted as part of the flow range this functionality should be available via SCADA, while still being limited to a safe range under all conditions as noted previously.

Dosing pumping systems shall be designed to provide duty rotation in accordance with the requirements detailed in SPE-00361 I-SPE-STD-013 Control Systems Design and Construction. The SCADA system shall be capable of displaying each pump's speed (Hz), stroke, and derived flow.

Dosing pumps shall comply with the requirements specified in SPE-00430 M-SPE-STD-012 Chemical Dosing Pumps.

8.2.4. Pressure Relief Valves

External pressure relief valves shall be included on the discharge line of all positive displacement pumps, positioned near the pump outlet.

This requirement also applies to positive displacement pumps with integral pressure relief valves. This is intended to prevent short circuiting of chemical from the discharge port of positive displacement pumps, immediately to a suction port by internal relief valves in case of a blocked discharge.

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:

1. Be installed immediately downstream of the pump discharge and shall not include any isolation valve between the pump and the relief valve.
2. Include provision for the attachment of a hand-held pressure gauge to test the valves operation.
3. 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 at least 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 to ensure pressure relief valves are not subjected to 'chatter'.
4. Include the set pressure recorded on a valve tag attached to the valve. This tag shall be separate from the naming tag.
5. Discharge to the dosing tank. Where a return line to the storage tank may be an excessive length, introduce a process or safety risk, or inhibit safe access, return to the pump suction side will be acceptable.
6. 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).
7. (Should) consider including a flow switch in the discharge line or activation switch on the relief valve to identity the event of a relief. Additionally, a hardwired interlocked for the pump trip should also be considered, especially for peristaltic pumps. This will ensure the functionality is available for local mode operation during hose changing and testing.
8. Be sized for the full flow relief.
9. Be lockable (e.g. locking nut) such that the setpoint pressure cannot accidentally be changed e.g. by vibration in pipelines.

8.2.5. Pulsation Dampeners

A properly sized pulsation dampener shall be provided for diaphragm and peristaltic pumps, following the manufacturers' recommendations. The dampener can be installed either inline or on a branch line from the suction or discharge sides of dosing pumps to reduce pressure fluctuations, as required. Inline pulsation dampeners are particularly recommended for peristaltic pumps. It is essential to maintain the dampener pressure during operation to ensure its effectiveness and integrity.

Refer to SPE-00435 M-SPE-STD-010 Chemical Dosing Skids for further detail on pulsation dampener requirements.

8.2.6. Pressure Transmitter

Pressure transmitter shall:

1. Be installed on the discharge line of each pump.
2. Be installed upstream of pressure sustaining or back pressure valves, where available.
3. Include double block and bleed valve arrangement to allow easy replacement, calibration and maintenance.
4. Include a local indicator/display.
5. Include a chemical barrier diaphragm to protect the transmitter.
6. Be provided with high-pressure alarm for dosing pump interlock.

8.2.7. Flow Meter

Flow meters shall be installed in accordance with SPE-00435 M-SPE-STD-010 Chemical Dosing Skids and comply with the requirements of SPE-00434 M-SPE-STD-009 Flow Meters. Consideration should be given to installing flow sensors near to injection points to provide indication of failed dosing lines. The transmitter should be installed at the dosing skid.

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 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.

If design requires flowmeters to be installed on dosing skids or elsewhere in a dosing line, flow switches should be installed at the dosing point. This will provide a means of detecting flow failure in critical chemical systems, and where dosing lines span long distances.

8.2.8. Pressure Sustaining Valve/Back Pressure Valve

In systems using diaphragm pumps, a pressure sustaining valve (also known as back pressure valve or loading valve) shall be used near to the pump to provide a minimum backpressure for effective pump operation and control, and to assist in providing accurate flow meter readings.

For peristaltic hose and progressive cavity pumps, pressure sustaining valves are generally not required. 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.

Where used, pressure sustaining valves shall:

1. Be installed in accordance with and comply with SPE-00435 M-SPE-STD-010 Chemical Dosing Skids.
2. 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 / system.

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

3. Be operator adjustable while in operation.
4. Be selected with types suitable for the design minimum and maximum flow rates.
5. Include a pressure gauge/transmitter installed upstream to verify operation.

Where the dosing line is long, and chemical injection points are installed with pipework has a negative grade or enters significantly above the injection point, an additional pressure sustaining valve may be considered. This valve should be located close the injection point to help maintain dosing stability during pressure and flow fluctuations in the process line and to reduce the risk siphoning – provided it does not pose a risk of blockage. Generally, this pressure sustaining valve should be set to approximately 50 kPa above the normal operating pressure of the main process line.

8.2.9. Chemical Return Line

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

The chemical return line shall:

1. Enter via the top of the tank. Including a separate flanged nozzle/connection where the dosing tank has a roof.
2. Be minimum of 25 mm to prevent blockage. The small pipe size may cause powder chemical crystallisation and settling and block the line.
3. 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 8.2.4(5)and standard specification SPE-00435 M-SPE-STD-010 Chemical Dosing Skids.
4. Include a section of removable spool to facilitate tank maintenance.
5. Include an arrangement to flush/drain the tank return lines.

8.2.10. Carrier Water

Carrier water may be used at Seqwater facilities to improve transport characteristics of chemicals across distances, or to enhance mixing. Carrier water is used for polymer dosing systems to improve its transport characteristics across distances along with PAC dosing to increase the line velocity.

Where used to increase transfer velocity, carrier water should be introduced into the chemical dosing line at the end limit of the chemical dosing skid or downstream of chemical dosing pump.

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.

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.

Carrier water lines shall generally comply with the requirements provided in Section 7.2.2.3, with exceptions to include:

6. Be fitted with a low and high flow switch and alarm which shall only be active when system dosing is active.
7. Be supplied with a booster pump if the site service water pressure system cannot achieve the necessary dilution ratio.
8. 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 design.

8.2.11. Dosing Lines

Dosing lines include pipework transferring chemical from the dosing skid to the dosing point, a non-return valve, an automatic isolation valve, a manual isolation valve, and a means of leak detection. Dosing lines shall comply with the requirements of SPE-00355 M-SPE-STD-013 Chemical Dosing Piping.

Dosing lines shall:

1. Be kept as short as possible.
2. Be installed to minimise the risk of excess dosing occurring as a result of:
    a. Gravity siphoning effects
    b. Control valve passing
3. Be sized following the velocity requirements provided in Section 4.8.
4. Include a non-return valve installed immediately upstream of the dosing point.
5. Include a manual isolation valve upstream of dosing spears and downstream of the non-return valve to allow maintenance of individual lines/spears without affecting dosing capability.
6. Consider an actuated isolation valve positioned as near as possible to the dosing point for automatic isolation of the dosing line only where potential siphoning has been assessment 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 more 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 chemical gasification or thermal expansion due to the closing of actuated valve and diurnal temperature change. Where needed, the design shall include necessary pressure relief arrangements for such scenarios.
7. 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.

8. Include the ability to flush and drain the lines.
9. Include a retractable dosing spear/quill(s) for dosing into a pipeline with manual isolation valve upstream of and downstream of the non-return valve to allow maintenance of individual lines/spears without affecting dosing capability.
10. 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.
11. 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 SPE-00355 M-SPE-STD-013 Chemical Dosing Piping.
12. Be suitably pressure rated and made of materials immune from chemical corrosion in accordance with SPE-00355 M-SPE-STD-013 Chemical Dosing Piping.

Where the dosing line is long and chemical injection points are installed with pipework of a negative grade or entering significantly above the injection point, a pressure sustaining valve should be considered. This should be near the injection point to provide dosing stability for pressure fluctuations in the main process line and to reduce potential siphoning effects. Refer to Section 8.2.8 for guidance in setting such a pressure sustaining valve.

8.2.11.1. Leak Detection Pit

A leak detection pit or catch pot shall be installed at a low point for a double contained dosing line, except in the following cases:

1. Chemical dosing skid or dosing pit at the lowest point: If the dosing skid or dosing pit is located at the lowest point, the bund or pit itself shall serve as the leak detection pit. If the dosing skid bund is not at the lowest point, and the selected line type allows, it should be assessed for use with the annular space at the opposite end closed, and the dosing skid end opened to the bund for leak detection. This can be monitored using the bund sump level switch.
2. Capillary action and proprietary leak detection mechanism: If the dosing line operates under capillary action and includes a proprietary mechanism capable of generating electrical signals upon leak detection, a separate leak detection pit may not be necessary.

   If a separate leak detection pit is chosen, the double-contained dosing line must be directed to the pit for leak identification and the collection of any leaked chemicals.

Leak detection pit shall:

3. Include a level switch to indicate presence of chemicals and be installed as low as possible to identify any presence of chemical. The leak detection system should trigger a shutdown of the chemical dosing system or, at a minimum, activate an alarm.
4. Be made of materials suitable for the chemicals stored and the surrounding environment. If the pit is below ground, it must meet the requirements outlined for dosing pits in Section 8.4.2.
5. Be sealed to watertight to prevent ingress of rainwater or ground water.
6. Be sized appropriately to accommodate the expected volume of leaked chemicals, based on the line size and length. It must have space for a small submersible pump or an alternative means of draining.
7. Be readily accessible to operators and maintenance personnel as required for inspection and maintenance.

8.2.12. Skid and Dosing Line Draining and Flushing

The requirements for draining and flushing of dosing skids and dosing lines shall generally comply with SPE-00435 M-SPE-STD-010 Chemical Dosing Skids and SPE-00355 M-SPE-STD-013 Chemical Dosing Piping.

The design should include suitable flushing systems for dosing and tank return lines and include the provision to flush dosing lines both from the suction and discharge sides of dosing pumps. Drain lines should be installed near to dosing points to collect flushed water where the flushed water cannot be directed to the process due to adverse impact to water quality.

A risk assessment must be conducted involving each step of the adopted flushing procedure to avoid any inadvertent consequence from line flushing

The design should incorporate an automatic flushing system to clean the dosing lines after use, at periodic intervals, or when the dosing system is offline. This is particularly important for slurry systems to prevent the accumulation of solids within the pipework.

The automatic flushing system should include the following features:

1. Isolation of the Dosing Tank
    a. Close the actuated outlet valve of the dosing tank to isolate it during flushing (applicable to offline systems).
2. Permanent Service Water Connections
    a. Service water should be connected to the suction and/or discharge side of the dosing pump. The connection must include:
        i. A check valve installed immediately upstream of the flushing connection to prevent backflow. Refer to Section 7.2.2.3 for specific requirements.
        ii. A manual isolation valve upstream of the check valve for maintenance and control.
        iii. An actuated valve to enable automated water supply, controlled according to the system design.
3. Automated Drain Valve
    a. An actuated valve should be installed on the drain line to allow automatic opening and closing, enabling controlled discharge of the flushed water.
4. Effective Flushing Point Placement
    a. Flushing points must be strategically located to ensure complete flushing of the intended pipe sections, leaving no residual chemicals in the lines.

The design may consider using the dosing pumps for flushing. 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.

The maximum pressure built up in the piping during flushing must be considered in the design taking into account the site maximum service water pressure.

Check valves on the dosing pump suction lines are generally not recommended to achieve inadvertent service water flow back to chemical dosing tanks during flushing.

If check valves are installed on the suction side, the pump manufacturer should be consulted for suitable valve types. The check valves shall include low pressure springs to reduce pump suction side pressure losses. The spring opening pressure should 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.

8.2.13. Dosing Spears

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.

Dosing spears shall:

1. Include adequate protection with safety chains from being ejected from the pipeline during operation and extraction.
2. 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.
3. Be fitted with a check valve, preferably a spring-loaded valve.
4. Be installed penetrating 25% to 50% of the internal diameter of the line being dosed, measured from the pipe wall.
5. Not be installed immediately downstream of an isolation or modulating valve that may create significant stresses to the assembly during the valve operation.
6. Have open ended discharge to reduce the chance of blockage from scaling (where applicable).
7. 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.
8. Be installed at a suitable location with protection, where necessary, to avoid any debris accumulation when used for raw water applications.
9. 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.
10. Be adequately supported for longer quills or quills in high flow lines to reduce vibration and mechanical stress.
11. 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.
12. 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:

13. 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, provision shall be made to use spray bar or other methods to provide adequate mixing into process water.

8.2.14. Duty Rotation

Dosing systems, including pumps, shall be provided with duty rotation in accordance with SPE-00361 I-SPE-STD-013 Control Systems Design and Construction.

8.3. 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 hydraulic mixing for ensuring uniform dispersion of dosed powder chemicals in water.

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

1. Channel Mixing
2. Static Mixing
3. Recirculation/Jet Mixing
4. Mechanical Mixing
5. Spray 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.

Seqwater also uses spray bars for the distribution of polymer into flocculation basins and upstream of filters. Guidance on the use of spray bars is included in Section 8.3.5.

8.3.1. Channel Mixing

Channel mixing may include:

1. Flume or weir used to produce a standing wave (hydraulic jump)
2. 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 Coefficient of Variation (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.

8.3.2. Static Mixing (Pipe)

Static mixing shall be the preferred method of chemical dosing for dosing systems into pipes. Seqwater primary mode of chemical mixing into the carrier water system is by using in-line static mixing.

Static mixers shall:

1. Be installed downstream of injection points in accordance with the manufacturer/supplier's requirements for upstream and downstream diameter clearances from injection points and other fixings. Proprietary integrated dosing points are acceptable.
2. Be designed to achieve a CoV of at least 0.05 at the mixer outlet across the required process operating range.
3. Be designed to minimise head loss across the mixer.
4. Include flanged connections to facilitate easy removal and maintenance or replacement.
5. Include manual isolation valve upstream and downstream of static mixer for maintenance.

Care should be taken to ensure good dispersion and rapid mixing is achieved when mixing alkalis in (e.g. soda ash) where alkalinity and pH may increase locally. This may result in calcium carbonate scale forming on the mixer vanes.

Seqwater has a history of chemical deposition in static mixers affecting performance. 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.

Additionally, removal of a static mixer may not be possible in cases where a duty only unit is installed and the process flow is critical. Consideration should be given to alternative mixer types or duty/standby arrangements via pipe bifurcation in instances where operation is critical and a duty only mixer would not be easily removed.

Refer to SPE-00367 M-SPE-STD-001 General Mechanical and SPE-00355 M-SPE-STD-013 Chemical Dosing Piping for additional detail on fitting requirements.

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 SPE-00367 M-SPE-STD-001 General Mechanical and SPE-00355 M-SPE-STD-013 Chemical Dosing Piping for additional detail on fitting requirements.

8.3.3. Recirculation/Jet Mixing

This mode of mixing relies on taking a small percentage of the plant flow and 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:

1. Shall be provided with duty/standby capability or with a spare pump on the shelf.

2. Where necessary, should be controlled using a control valve or a variable speed drive for mixing optimization over the full range of flow rates.
3. Shall be capable of isolating the pump suction side from the main process stream if mixing is not required.
4. Shall include a non-return valve on the pump discharge.
5. Shall be protected from low or no flow via a flow switch.
6. Shall be controllable via a variable speed drive for mixing optimisation over the full range of flow rates.
7. 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.

8.3.4. Mechanical Mixing

Here mechanical mixing refers to a vertical type of mixer with motor, possibly a gearbox, shaft and propeller. Mechanical mixers should not be used at Seqwater sites for powder chemical mixing into pipes.

Mixer requirements for tanks are included in Section 7.3.1.5.

8.3.5. Spray Bars

Spray 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 flocculation aid, and pre-gravity filter polymer and in some cases pre-filter sodium hypochlorite dosing. They should not be considered as a preferred method of chemical dosing.

Spray bars are a continuous length of pipe traversing the width of the water body to be dosed with perforations to allow diluted chemical to spray onto the surface of the water body.

Due to the hazards that may be introduced as a result of spraying chemicals, the designer shall consider measures to mitigate and manage these risks and ensure the safety of personnel, plant and the environment.

Spray bars and associated balance of plant shall include the following as a minimum:

1. A continuous, isolatable, and removable pipe manifold installed along the width of the water body, with perforations to allow diluted chemical to be sprayed onto the surface of the water. The spray bar should be removable in manageable sections.
2. A carrier water pump and flowmeter to deliver dilution/carrier water to the manifold. Due to the large volume of carrier water that may be required, clarified raw water should be considered as the source, delivered using a submersible pump. Otherwise, requirements per Section 8.2.10 should apply.
3. A dosing pump and dosing line arrangement to deliver bulk chemical to the spray bar assembly. Injection quills are not mandated in this instance.
4. A backpressure valve, installed at the beginning of the spray bar prior to any nozzles, to provide controlled and consistent chemical dispersal through the spray bar. Refer to Section 8.2.8 for further detail on such valves.
5. A pressure gauge downstream of the backpressure valve to validate operation.
6. 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.

7. Each branched line is recommended to have open ended discharge with 8-10 mm size to reduce the chance of blockage from scaling.

Where applicable, the designer should consider scale formation, as a result of powder chemical addition to raw (or other) water and how it can be mitigated, such as ensuring a suitable carrier water velocity or periodic flushing. Spray 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 materials used shall be rigid, compatible with the chemicals used, and suitable for removal and cleaning on a regular basis by maintenance personnel.

Redundancy requirements (i.e. duty/standby) are not specified for spray bar dosing systems, including chemical and carrier water pumps, dosing lines, and redundant spray bars. However, these redundancy requirements should be assessed on a per-project basis to ensure the required reliability and availability criteria can be achieved.

8.4. Buried Pipes and Dose Pits

Further considerations for below ground assets, including buried pipes and dose pits are discussed in the following two sections.

8.4.1. Buried Pipes

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

1. Be buried for the minimum distance necessary to minimise the risk of identifying and finding leaks.
2. Be double contained. Any double containment pipe or system shall be suitable for burying.
3. Minimise the use of joins as far as practicable to mitigate the potential for leaking.
4. Eliminate low points in the chemical pipe as well as dual containment pipe to prevent chemical pooling.
5. Drain to a sump or pit or where possible, to the dosing skid bund. Pipes shall be run such that dual containment and buried chemical pipes run to a sump or pit and can be freely drained at this location.
   a. Sumps and pits shall include a level switch to indicate a leak event which shall trigger a remote alarm.
   b. Sumps and pits shall be covered and sealed (or installed to eliminate ingress of stormwater) with the ability for operators and maintenance personnel to access and view inside for inspection purposes.
   c. Sumps and pits shall be able to accommodate a small submersible pump or similar for draining, or an alternate means of draining shall be proposed.
6. For both and metallic and non-metallic pipes, include a continuous detectable marker tape placed in the trench 350 mm above the pipe, installed in accordance with the manufacturer's guidance. The tape should indicate the pipe content whether by printing the chemical name on the tape or using an agreed colour coding.
7. It is also recommended to use above ground markings at a suitable interval to identify the buried dosing lines.
8. Buried pipelines design and installation must conform to *AS 2566.1*, *AS 2566.2* and SPE-00355 M-SPE-STD-013 Chemical Dosing Piping.

8.4.2. Dosing Pits

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

Where possible, an alternative design to the traditional dosing pit should be considered. This alternative involves using a vertical riser pipe from the underground main to the ground surface. This design may offer a cost-effective option eliminating the need of a confined space.

For the alternative design, the riser pipe that encapsulates 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 used, dosing pits shall:

1. Be made of concrete (pre-cast or formed in situ), and sealed to provide chemical protection, leak tightness, and water tightness.
2. Be readily accessible to operators and maintenance personnel as required for normal operation.
3. 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.
4. Consider designing the edge of the pit above the normal level of the ground to eliminate the chance of any rainwater ingress.
5. 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.

9. Standard Designs

The following standard Seqwater designs/P&ID drawings shall be used as the starting concept for the design of Polymer, PAC, Pot Perm, and Soda Ash chemical storage, batching and dosing systems. The standard design shall not be used for construction without design reviews, and appropriate technical hazard studies after incorporating project specific process conditions.

Table 11 Standard Seqwater P&IDs for powder chemical dosing systems

Chemical System	Standard Drawing	Description
Polymer, PAC, Pot Perm and Soda Ash	B-DWG-STD-019	Powder Activated Carbon (PAC) Unloading and Storage System
	B-DWG-STD-020	Polymer, PAC, Pot Perm and Soda Ash P&ID Notes
	B-DWG-STD-027	Polymer, Pot Perm and Soda Ash Storage, Batching and Dosing System (Bulk Bag)
	B-DWG-STD-028	Polymer, Pot Perm and Soda Ash Dosing System
	B-DWG-STD-029	Polymer, Pot Perm and Soda Ash Storage, Batching and Dosing System (Small Bag)
	B-DWG-STD-030	Powder Activated Carbon (PAC) Slurry Batching and Dosing System

10. Process Control Requirements

Seqwater Standard SPE-00361 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 powder chemical Unloading, Storage, Batching and Dosing Systems shall be developed to cover control requirements in detail. Functional Descriptions shall use the following standards and templates as necessary:

- SPE-00349 B-SPE-STD-005 Functional Description Documentation
- TEM-00221 I-TMP-STD-001 Functional Description Part A
- TEM-00222 I-TMP-STD-005 Functional Description Part B
- SPE-00361 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 SPE-00361 I-SPE-STD-013 Control Systems Design and Construction.

10.1. Control Modes

Control systems shall support Equipment Control Modes and Dosing Control Modes.

Chemical batching is a form of sequence control, managed through discrete logical steps, and there are no standard batching control modes that rely entirely on PID control.

Equipment control modes are defined as:

1. Local – plant may only be operated in the field independent of the control system. In this mode, only hardware/hardwired interlocks remain active. This mode is beneficial for testing.
2. 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.
3. 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:

4. Fixed Speed – operator inputs the pump speed to a percentage output of the maximum pump speed.
5. Fixed Percentage – (control valves) operator inputs the control valve opening as a percentage of the maximum valve opening position.
6. Fixed Flow – operator inputs chemical flow in L/h. This mode can have the following options:
    a. Fixed flow without any feedback – the controller output as pump flow for calibrated pumps.
    b. Fixed flow with chemical flowmeter feedback – the controller output as pump speed or valve position for non-calibrated equipment with chemical flowmeter feedback.
7. 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. operator input batching or

chemical solution concentration, and main process/water flowmeter. This chemical flowrate set point (L/h) is then used to set up the pump speed with the following options:

a. Flow paced without any feedback.
b. Flow paced with chemical flowmeter feedback (with or without trim limits).
c. Flow paced with analyser trim feedback.
d. Flow paced with chemical flowmeter and analyser trim feedback.
e. Flow paced with chemical flowmeter trim and analyser trim feedback.
f. The analyser trim option above is only applicable for the pH analyser for soda ash.

8. Ratio Control - operator inputs the mass ratio of the chemical to be dosed to another chemical already dosed (Possible implementation: Soda Ash in pH adjustment). 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 as per above Flow Paced control modes.

The tables in the following section summarise the different Control Modes for chemical batching and dosing systems. 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 is set manually/locally.

Equipment and devices shall be programmed to include Disable and Maintenance Functions as described in SPE-00361 I-SPE-STD-013. All instruments shall be programmed to include Instrument Calibration Functions as described in SPE-00361 I-SPE-STD-013 Control Systems Design and Construction.

10.1.1. Chemical Batching System

Table 12 summarises the Equipment and Group Control Modes suitable for batching system.

Table 12 Typical batching system operating and control modes

Equipment Control Mode	Batching Control Mode	Description
Local	N/A	The operator manually starts/stops the screw feeder, service water pump, batching tank mixer, and other batching related equipment as required locally.
Remote Manual	N/A	The operator manually starts/stops the screw feeder, service water pump, batching tank mixer, and other batching related equipment as required remotely.

Equipment Control Mode	Batching Control Mode	Description
Remote Automatic	Automatic	The screw feeder, agitator, bin vibrator, silo/hopper aeration, service water pump, batching tank mixer, and other batching related equipment will operate automatically when the control system initiates a chemical batching process based on the operator specified batching concentration. This process is triggered when the batching tank reaches a predetermined low level or batch start level set by the operator. Once the programmed batching sequence is complete, the screw feeder, agitator, bin vibrator, and silo/hopper aeration system will stop, and thereby ending the chemical batching operation.

10.1.1.1. Gravity Batching Transfer

The batched chemical transfer system may operate either be via a pumped transfer system, or where elevation permits, gravity drain system.

A gravity transfer system will be controlled by the use of batching tank outlet actuated isolation valves. Table 13 summarises the Equipment and Group modes suitable for gravity transfer systems.

Table 13 Typical Gravity Chemical Transfer System Operation and Control Modes

Equipment Control Mode	Batching Control Mode	Description
Local	N/A	The operator manually actuates the isolation valve(s) locally to allow and control batching transfer.
Remote Manual	N/A	The operator manually actuates the isolation valve(s) remotely to allow and control chemical transfer.
Remote Automatic	Automatic	The actuated valve will actuate automatically when a batching transfer is called by the control system. This call will be triggered by an operational low level setpoint or transfer fill level being attained in the dosing tank. When a programmed dosing tank operational high-level or batching tank operational low level is reached, the actuated isolation valve(s) will close and stopping the transfer.

10.1.1.2. Pumped Batching Transfer

Table 14 summarises the Equipment and Group modes suitable to pump transfer systems.

Table 14 Typical Chemical Transfer Pump Operating and Control Modes

Equipment Control Mode	Batching Control Mode	Description
Local	N/A	The operator manually starts/stops the transfer pump as required at the pump location. This mode is beneficial for testing.
Remote Manual	N/A	The operator manually start/stop the pump remotely, as required.
Remote Automatic	Automatic	The transfer pump will start automatically when a batching transfer is initiated by the control system upon completion of a batching sequence. The transfer process begins when the dosing tank reaches a programmed operational low-level or transfer fill level set point. The transfer pump operates at a fixed speed and will stop when the designated dosing tank's operational high-level or batching tank's operational low-level setpoint is reached. Once the transfer is complete, the pump will stop, and the transfer line will be isolated.

10.1.2. Chemical Dosing System

Table 15 summarises the Equipment and Group Control Modes suitable for positive displacement pump dosing systems.

Table 15 Typical Positive Displacement Pump 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 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.
	Fixed Flow	Operator inputs chemical flow in L/h. The controller output as pump flow or pump speed is set as described above.

Equipment Control Mode	Dosing Control Mode	Description
	Flow Paced without any feedback	The operator inputs Chemical Dose Rate (mg/L). The controller then calculates the set point of chemical flow setpoint (L/h) from the input dose rate, batching concentration and the main process/water flow meter reading. Using this setpoint, the controller then determines the pump speed by referencing the calibrated pump curves. The pump curve must be updated whenever there are changes to the stroke length (where applicable). Seqwater favours Flow Paced with *Chemical Flowmeter Trim Feedback* (described below) over this mode when analyser trim is not required.
	Flow Paced with Chemical Flowmeter Feedback	The operator inputs Chemical Dose Rate (mg/L). The controller then calculates the set point of chemical flow setpoint (L/h) from the input dose rate, batching concentration and main process/water flow meter reading. 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 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.

Equipment Control Mode	Dosing Control Mode	Description
	Flow Paced with Analyser Trim Feedback (only applicable for Soda Ash systems)	Operator inputs Chemical Dose Rate in mg/L. Operator also inputs downstream target 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, batching concentration, the pH 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 pH analyser feedback should be limited to ±10% to 20% of operator chemical dose rate. This limitation is necessary due to the relatively low long-term reliability of online analysers in continuous systems. For this mode, the pump curve needs to be updated for any changes in stroke length. The designer should consider linearisation of the pH signal for this control mode if improved stability is needed across a wide range of pH.
	Flow Paced with Chemical Flowmeter and Analyser Trim Feedback (analyser trim only for soda ash)	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 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, batching concentration, 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. 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 pH analyser feedback should be limited to ±10% to 20% of operator chemical dose rate. This limitation is necessary due to the relatively low long-term reliability of online analysers in continuous systems. This is Seqwater's preferred dosing control mode where analyser trim is used.

Equipment Control Mode	Dosing Control Mode	Description
	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.

10.1.3. Isolation Valves

Table 16 summarises the Equipment and Group Control Modes suitable for isolation valves.

Table 16 Typical Isolation Valve Operating and Control Modes

Equipment Control Mode	Description
Remote Manual	The operator will be able to modulate the isolation valve between open and close to isolate systems or tanks.
Remote Automatic	Isolation valves will open and closed based on system demands, faults/alarms, and interlocks.

10.2. Process Control Narratives

10.2.1. Delivery/Unloading System

10.2.1.1. Bulk Truck Unloading System

The following describes a typical process control philosophy for the powder chemical bulk truck delivery, unloading, and storage system. This should also be read in conjunction with Section 5.2 of this document.

Normal Operation

Prior to starting the powder chemical unloading process, an operator may need to enable the LCP in the SCADA if this function is incorporated.

Once a delivery truck is in position, the delivery personnel connect the truck's delivery hose to the storage silo fill line through the camlock fitting. The delivery personnel shall then select the 'UNLOADING/FILLING' switch located in the LCP. Upon conformation from the delivery personnel that the unloading process is requested, an operator will need to initiate the silo filling procedure via SCADA and the control system will check that the following requirements are met:

- Silo load cells are healthy, and no alarm exists.
- Silo high-high level switch is healthy and not active.
- Fan extraction and dust collector system is healthy and starts to operate.
- Dehumidifier stops to operate.
- Compressed air system is available.

Once all the above conditions are met, this will open the fill line actuated valve and enable "Ready" indicator in the LCP. This will also start the dust extractor fan and stop dehumidifier operation (where available).

The delivery personnel should then be able to start the unloading. The filling process shall then be initiated by starting the truck's blower, powered by the truck, to transfer the powder chemical pneumatically into the storage silo. The delivery personnel and site operator shall monitor the silo weight continuously as displayed in the LCP during the filling process.

During the silo filling, an automatic pneumatic reverse pulse cleaning system will clean the filter at the pre-determined interval and end of fill cycle or when the differential pressure across the filter is high, by opening the compressed air solenoid valve.

The silo filling process will need to be stopped (delivery staff stopping the truck blower) if any of the following conditions are met:

- Silo weight reaches to the pre-determined level as displayed in the LCP.
- “Silo Fill Complete” indicator in the LCP is illuminated from the silo weight set point.
- Silo weight or high-high level is detected.
- Fan extraction and dust collection system register fault signal.

Before stopping the truck blower, the delivery personnel shall purge the fill line to clear out any residual powder.

Upon confirmation from the delivery personnel that the filling process is finished, an operator will need to initiate the remaining shutdown sequence from the SCADA which includes the followings:

- Closing of the fill line actuated valve.
- Stopping the fan extractor and dust collection system. The system shall operate for at least 15 minutes after the fill line valve is closed.
- Starting the dehumidifier operation 15 minutes after closure of the fill line actuated valve.

Abnormal Operation

In the event where the silo weight reaches a high-high weight or the silo high-high level switch is activated, a visual and audible alarm is activated in the LCP and signal to SCADA. The delivery personnel will be required to stop the chemical transfer and purge the line clear before advising the control room to initiate the remaining shutdown process. In the event that the fill line actuated valve left open for a predefined period, an alarm should be raised.

Alarm and control systems shall be fail-safe and fail to high-high alarm upon loss of echo or instrumentation failure.

10.2.1.2. Large Bag Transfer

The following outlines a typical philosophy for the large-bag powder chemical delivery and unloading system. This section should be read in conjunction with Section 5.3 of this document.

Normal Operation

The large bag unloading process is initiated locally by a site operator.

The site operator, using suitable lifting equipment, will transfer the powder chemical bag from the storage area to the filling point. The powder chemical bag is then unloaded to the transfer hopper using a remote-controlled gantry crane. The gantry crane can only be operated once the safety gate limit switch is in the closed position and the safety circuit is reset.

Once in position, the site operator will need to open the safety gate and the unloader safety door to access and seal the package bag discharge spout. The unloader door safety switch, when open, will start the dust extractor fan, open the dust extraction line valve and interlock the conveyor system. The motor operation is restarted once the safety door is closed and reset.

Prior to starting the powder chemical unloading process, the operator will select the 'UNLOADING/FILLING' switch located in the LCP. This will trigger the control system to check the same requirements as detailed in Section 10.2.1.1 for silo filling procedure, with the additional requirements which include:

- Unloader safety door and gate must be closed and reset.
- Motors associated with discharge hopper must not have fault signal.

Once all the above conditions are met, the "Ready" indicator will be enabled in the LCP. The operator should then be able to continue with the silo filling procedure.

The unloading process is initiated when an operator presses the "Unload Start" push button on the LCP. This sequence starts the dust extractor, transfer hopper vibrator, the unloader massager solenoid valves, open the dust extraction line solenoid valve and activates the conveyance system. Depending on the conveyance system used, the system will either initiate the screw conveyor for the mechanical conveyance system or otherwise initiate the blower or vacuum generator, hopper airlock rotary valve and opening the filling line actuated valve when pneumatic conveyance is used.

The filling process continues until any of the following process controls are triggered:

1. Transfer hopper reaches Low Level and this triggers the unloading sequence to stop after a time delay to allow for complete transfer.
2. Storage silo/hopper reaches Operational High Weight.
3. Operator initiates manual stop by pressing down the 'Stop' button on the LCP.

Once the filling operation is completed, the operator must deselect 'UNLOADING/FILLING' in the LCP. The operation personnel must re-enter the safety gate and door, detach the bag outlet spout from the clamping arrangement. The gantry crane is then used to manoeuvre the bag off the unloader and onto the floor where it can be removed.

The dust collector filter is automatically cleaned by the actuated reverse pulse air blast at the pre-determined interval and end of fill cycle or when the differential pressure across the filter is high. The dust collection system should run for at least 15 minutes after finishing the silo filling process. The dehumidifier operation (where available) should start 15 minutes after the silo filling process is stopped.

The same unloading procedure as described at the start of this section should be followed for the unloading of another bag.

Abnormal Operation

If the storage silo reaches High-High Weight/Level, a visual and audio alarm will be sounded in the LCP and signal to SCADA. At this condition, the control will interlock the operation of screw conveyor or air blower to stop the unloading process.

The unloading stop sequence can also be triggered by an emergency stop button on the LCP.

Alarm and control systems shall be fail-safe and fail to High-High alarm upon loss of echo or instrumentation failure.

10.2.1.3. Small bag Transfer

The following outlines the typical philosophy for the small-bag powder chemical delivery and unloading system. This section should be read in conjunction with Section 5.4 of this document.

Normal Operation

The small bag unloading process is undertaken locally by a site operator. The operator will transfer the powder chemical small package bag/pail from the storage area to the filling point using a suitable lifting equipment.

The operator will fill the storage hopper/silo by using a vacuum suction wand.

Prior to starting the powder chemical unloading process, the operator will select the 'UNLOADING/FILLING' switch located in the LCP. This will trigger the control system to check that the same requirements as detailed in Section 10.2.1.1 for silo filling procedure, with an additional requirement that motors associated with the vacuum unloader system must not have fault signal.

Once all the above conditions are met, the "Ready" indicator will be enabled in the LCP. The operator should then be able to continue with the hopper filling procedure. The operator will then be able to initiate the unloading process by pressing the "Start" push button on the LCP.

This sequence starts the operation of the vacuum unloader and dust extraction fan. The transfer process will continue for the designed time (usually less than a minute) before it stops automatically, and the dump valve will open simultaneously to allow the collected powder from the collection unit to drop into the silo/hopper. While the dump valve remains open, the solenoid valve in the compressed air line will open automatically for a short time to give a reverse pulse to the filter to dislodge powder from the filter into the silo/hopper.

This cycle will continue until the operator stops the powder transfer by pressing the "STOP" button in the LCP. The LCP will show "Running" indicator when the cycle is running. When the cycle is running, the operator can change the vacuum wand from one pail to another pail.

Abnormal Operation

The same abnormal operation applies as the large bag unloading system in Section 10.2.1.2 except that upon reaching High-High Weight/Level, the control will interlock the operation of the vacuum unloader to stop the unloading process.

The unloading stop sequence can also be triggered by an emergency stop button on the LCP.

10.2.2. Batching System

The following describes a typical process control philosophy for the powder chemical batching with wetting cone and wetting head systems. This should also be read in conjunction with section 7.2 of this document.

The batching and dosing system design is proposed to be a fixed batching concentration with variable dosing flow rates. An operator can vary the batching concentration set point in the SCADA and the PLC will then calculate the required feeder run time from the screw feeder calibration curve.

10.2.2.1. Batching System with Wetting Cone

Normal Operation

Batching sequence will start automatically when the batching tank reaches the "batch start" level and the following conditions are met:

- The batching tank actuated outlet valve is closed (applicable for gravity transfer).
- No fault signals from the screw feeder, agitator, tank level instruments, mixer and water supply line.
- The storage silo weight is higher than the low limit set point.
- Silo discharge chute low level switch is healthy and not active.

Two sources of water will feed the batching tank: one for make-up water (where used); and the other as motive water via the powder feed eductor and wetting cone.

Upon chemical batching initiation, the motive water solenoid valve will open and starting of the booster pump, when applicable, allowing flow of water flow through the wetting cone and eductor system (as applicable). At the same time, the make-up water solenoid valve will open to start filling the batching tank.

When the batching tank reaches a pre-set level, the powder chemical feed system will initiate and trigger the operation of the bin vibrator, silo aeration, agitator and starting the screw feeder at the designed speed and duration.

The controller will calculate the feeder runtime (in seconds) required to achieve the operator input batch strength concentration at a set speed. The volumetric screw feeder will deliver a fixed volume of powder into the batching tank via the wetting cone and eductor system (as applicable) and stop once the calculated feeder run time is reached.

The motive water system will continue to operate for an additional pre-set time to flush the wetting cone and eductor before stopping. The make-up water will continue to flow and the solenoid valve will close once the batching tank reaches the “Stop Batch” level. The mixer will start when the batching tank reaches a pre-set level to avoid splashing and continues to run for a pre-set time, while PAC and Soda Ash system will require the mixer to run until batching transfer occurs.

The operator will be able to calibrate the screw feeder i.e. measure the flow rate, and enter the measured flow rate in SCADA to accommodate derating as chemical clumps up in the screw feeder.

Abnormal Operation

The batching sequence will stop by the interlocking the operation of screw feeder, motive and make-up water system and raise an alarm in SCADA to alert the operator when any of the following conditions are met:

1. Storage silo reaches to Low-Low Weight/Level.
2. Screw feeder fails to operate for the calculated or defined run time.
3. Mixer fails to start/stop within the pre-set time defined.
4. Batching tank reaches high-high Level.
5. Wetting cone reaches high level.
6. Flows to the eductor and wetting cone flowrate deviates by ±10% from the set point.
7. Silo discharge chute reaches low level (if applied).

10.2.2.2. Batching System with Wetting Head

Normal Operation

The batching sequence with wetting head is similar to that of wetting cone system as described above in Section 10.2.2.1 with the following exceptions:

- Unlike wetting cone system, only one water supply line enters the batching tank through the wetting head.
- The blower will start at the same time as the screw feeder. The blower healthy signal is a pre-condition to start the batching sequence.

Abnormal Operation

The conditions to stop the batching sequence with wetting head is similar to wetting cone system except the following:

- Any fault in blower will stop the batching sequence.
- Wetting cone overflow line high level is not applicable.

10.2.2.3. Batch Transfer System

The following describes a typical philosophy for the powder chemical batching transfer system. This should be read in conjunction with section 7.3.2 of this document.

Normal Operation

Chemical slurry/solution transfer from the batching tank is initiated when a batching sequence is completed and the dosing tank level reaches operational low level setpoint.

The level transmitter in the dosing tank will confirm the tank has sufficient capacity to accept a batch and that will not trigger a high level in the dosing tank. Once confirmed, the system will open the transfer line actuated valve for gravity system. For the pumped system, the pump will start to transfer the chemical slurry/solution. It will operate until the dosing tank transfer stop level is reached, or the batching tank low level is reached. Once one of these events is triggered, the actuated valve will close for a gravity system and the transfer pump will stop for a pumped system.

Abnormal Operation

After transfer initiation, if there is no change of level detected in the dosing tank within a pre-set time period, an alarm will be raised and the transfer system shutdown.

Low-low level in the batching tank and high-high level in the dosing tank will also trigger the pump shutdown or close the transfer line actuated valve for gravity transfer system.

10.2.3. Dosing System

The following describes a typical process control philosophy for the powder chemical dosing system. This should be read in conjunction with section 8 of this document.

Normal Operation

Upon initiation of the dosing system, the duty dosing tank actuated isolation valve and duty dosing line actuated isolation valve will open.

When called to start, the controller will calculate the required flowrate (in L/h) required to meet the dosing rate setpoint (entered in mg/L by the operator), based on flow-pacing to the main/process water flowmeter, and accounting for batch concentration. It will then output a pump speed by the particular dosing control mode selected (see Table 15 for details on dosing control modes). The controller will continuously update the calculated values or the required pump speed in order to achieve the calculated values as process parameter changes.

When using diaphragm pumps, the calibrated flow curve and pump speed calculation may need to accommodate for stroke length adjustment, as mentioned in Table 15.

For flow paced with chemical flowmeter feedback system, the dosing skid (or dosing line) flowmeter will typically provide a flow feedback value (process variable, PV, in L/h) to the controller to adjust the pump speed.

A schematic diagram for the flow pace dosing control with chemical flowmeter feedback system is shown in Figure 1.

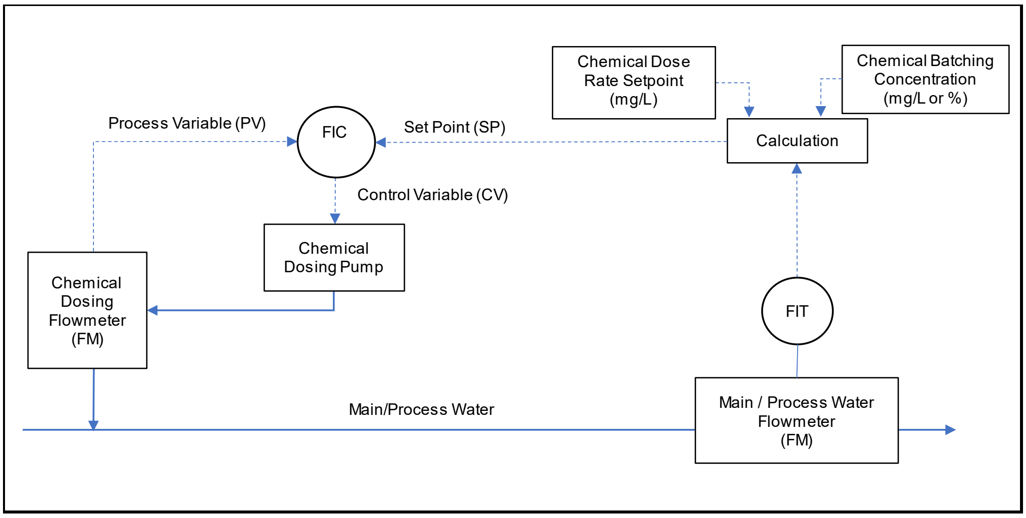

Figure 1 Schematic Diagram for Flow Pace Dosing Control with Chemical Flowmeter Feedback System

When analyser trim is used, the analyser control loop will be used to trim the chemical dose rate setpoint (mg/L) as described in Figure 1

Abnormal Operation

If the duty dosing tank reaches Low-Low Level, its respective outlet valve will be isolated and dosing pump will be stopped. The system shall allow dosing using other dosing tanks, if available.

If the duty dosing line discharge pressure reaches high pressure, the duty dosing pump shall be stopped. The system shall still allow dosing using other dosing pump and dosing line.

The flow meter in the dosing line will identify flow deviations, initiating an alarm in the SCADA if a deviation condition is met. If the chemical flow fails to achieve ±10% of the required flow within a defined period upon triggering a pump speed change, an alarm will be triggered.

In the event of a trip, the pump will stop operating and the dosing line isolation valve 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.

10.3. Batching and Dosing Calculations

10.3.1. Batching Calculations

This section provides the calculation for control systems to calculate the necessary dry powder feeder run time based on operator input batching concentration set point in % w/v.

The dry powder feeder running time is calculated as follow:

$$Feeder\ run\ time\ (s) = \frac{Batch\ concentration\ set\ point(\%\ \mathrm{w/v}) * 10\left(\frac{g}{L}\right) * Batch\ tank\ working\ volume\ (L) * 60\left(\frac{s}{min}\right)}{Chemical\ powder\ purity\ (\%\ \mathrm{w/w}) *\ Feeder\ rate\ \left(\frac{kg}{min}\right) * 1000\left(\frac{g}{kg}\right)}$$

In the above equation, 1% (w/v) batching concentration is equivalent to 10 g/L. Batching tank working volume is the volume associated with the batch start and batch stop tank level.

10.3.2. Dose Rate Calculations

This provides the calculation for control systems to calculate the necessary chemical flow rate (in L/h) based on plant dose rate setpoint in milligrams of chemical per litre of process water (mg/L).

Where a chemical batch concentration is prepared in % (w/v), the following calculation shall be used:

$$Chemical\ flow\ rate\ \left(\frac{L}{h}\right) = \frac{Process\ water\ flow\ rate\ \left(\frac{L}{s}\right) * dose\ rate\ \left(\frac{mg}{L}\right) * 3600\left(\frac{s}{h}\right)}{Batch\ concentration\ (\%\ w/v) *\ 10{,}000\ \left(\frac{mg}{L}\right)}$$

In the above equation, 1% (w/v) batching concentration is equivalent to 10,000 mg/L.

When dosing is based on feed solid mass flow rate (in g/s), which typically used for polymer dosing to thickener and centrifuge. The chemical flow rate (in L/h) set point based on plant dose rate setpoint in kilograms per dry tonnes of solid (kg/tDs) is calculated as follow:

$$Chemical\ flow\ rate\ \left(\frac{L}{h}\right) = \frac{Feed\ solid\ mass\ flow\ rate\ \left(\frac{g}{s}\right) * dose\ rate\ \left(\frac{kg}{tDs}\right) * 3600\ \left(\frac{s}{h}\right) * \left(\frac{1}{1000*1000}\right)\left(\frac{tDs}{g}\right)}{Batch\ concentration\ (\%\ w/v) * 0.01\ \left(\frac{kg}{L}\right)}$$

In the above equation, 1% (w/v) batching concentration is equivalent to 0.01 kg/L.

Where the feed solid mass flowrate is obtained based on the feed flowmeter and feed solid suspended solid meter:

$$Feed\ solid\ mass\ flow\ rate\ \left(\frac{g}{s}\right) = Feed\ flowrate\left(\frac{L}{s}\right) * Feed\ suspended\ solid\ (\%) * 10\ \left(\frac{g}{L}\right)$$

10.4. Alarms

Refer to Seqwater Standard Specifications SPE-00361 I-SPE-STD-013 Control System Design and Construction and SPE-00357 I-SPE-STD-006 Alarm and Event Management which outlines the philosophy that should be applied to the 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 Standard and the above referenced documents.

10.5. Interlocks and Trips

All interlocks shall be defined in the Functional Description, and appropriate CCP protection measures defined in the Hazard Analysis and Critical Control Points (HACCP) Plan.

Refer to SPE-00361 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 SPE-00361 I-SPE-STD-013 Control System Design and Construction 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 B summarizes the recommended typical minimum process, trip and hardwired interlocks to be included in Seqwater Polymer, PAC, Pot Perm and Soda Ash unloading, storage, batching and dosing systems. Trips and interlocks may need to be modified in accordance with design requirements, and additional trips and interlocks may be necessary depending on the specific application, chemical, and design.

11. Testing and Commissioning

All systems shall be tested and commissioned in accordance with the requirements of

- SPE-00346 B-SPE-STD-003 Commissioning Requirements
- SPE-00352 E-SPE-STD-001 Electrical Design and Construction
- SPE-00367 M-SPE-STD-001 General Mechanical
- SPE-00360 I-SPE-STD-011 Control System Testing

Testing shall, as a minimum, include:

1. Storage silos shall:
   a. Be tested for the pressure and static loading.
   b. Be tested to identify any flow obstruction issue due to ratholing, arching, or other blockage related causes.
2. Bin vibrator shall:
   a. Include running time test, to avoid bin vibrator operating too long and causing powder compaction and deflection in the bottom section.
3. Silo aerator shall:
   a. Include running time test, to avoid aerator operating too long and causing powder compaction.
4. 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. If 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 conducted and successfully demonstrated over a minimum of 24 hours.
5. Bunding:
   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.
6. Pipework:
   a. Shall be tested in accordance with the relevant material standards and codes.
   b. Shall be hydrostatic leak tested as per SPE-00355 M-SPE-STD-013 Chemical Dosing Piping.
7. Batching and Dosing systems:
   a. All batching and dosing systems shall be tested and proved first with water prior to the introduction of chemicals:

   i. Across the design dosing range
   ii. Applying all Equipment and Dosing Control Modes.

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.

A risk assessment must be conducted involving each of the adopted testing and commissioning activities to avoid any inadvertent consequence.

12. Performance Testing

Proof of performance testing (POPT) shall be conducted for each system as part of the commissioning following the requirements included in SPE-00346 B-SPE-STD-003 Commissioning Requirements.

As part of performance testing, the contractor shall demonstrate, as a minimum, compliance of the powder chemical system with design intent for the following:

1. Powder feeding system – able to achieve the specified accuracy across the whole operating range of the storage silo.
2. Chemical batch strength – able to achieve the range of specified batch strengths, and able to do so within ±5% of desired concentration.
3. Batch sequencing and timing.
4. Batch volume and transfer to dose tanks.
5. Make-up, motive and carrier water delivery pressure and flow rate (where required):
    a. Batch make up water.
    b. Wetting cone, eductor and wetting head (if applicable).
    c. Carrier water for dosing (typically for polymer only).
6. Chemical dosing:
    a. Desired dose concentration across the specified range can be achieved.
    b. Required dose rate (L/h) can be achieved across the range of concentrations required to be dosed.
    c. Interlocks and trips.

13. Definitions and Abbreviations

Table 17 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 point (setpoint) where failure of standard operation procedure could cause harm to customers, the environment, 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.
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.
Manufacturer/Supplier/Vendor /Original Equipment Manufacturer (OEM)	The entity that manufacturers or supplies equipment to meet the specifications of the Contractor.
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.
HAZOP	A method of study for identifying hazards and operability considerations within chemicals and fuels processing through to electrical and machinery systems.

Term	Definitions
Manufacturer / Supplier / Vendor / Original Equipment Manufacturer (OEM)	The entity that manufacturers or supplies equipment to meet the specifications of the Contractor.
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).
Powder Chemical	In general, chemicals that are delivered to Seqwater sites as powder. For this standard, powder chemical refers to Polymer, Powder Activated Cardon, Potassium Permanganate and Soda Ash.
Process Conditions	Refers to the conditions that assets may be subject to as a result of operating plant and equipment.
REX	Seqwater's electronic document and records management solution (eDRMS) that provides for the capture, management, security, and access to non-controlled documents and records. REX is the location for the creation, preparation and revision of Controlled Documents.
Supervisory Control and Data Acquisition (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 PRO-02205 X-PRO-STD-008 Asset Standards Management and Application Procedure.
Shall/must	Indicates a mandatory requirement.
Should	Indicates a recommendation or guidance.
Site	Refers to the location at which the treatment works exists or is to exist.
Site Conditions	Means any of the ambient conditions, process plant, ground conditions and operating conditions that may be reasonably expected to occur during normal operation.
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 18 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 Variation
DOL	Direct Online
DN	Nominal Diameter
FRP	Fibreglass Reinforced Plastic
GRP	Glass-fibre Reinforced Plastic
HACCP	Hazard Analysis and Critical Control Points
HDPE	High Density Polyethylene
HMI	Human-Machine Interface
IBC	Intermediate Bulk Container
IP	Ingress Protection
LCP	Local Control Panel
LEL	Lower Explosive Limit
MCS	Master Control System
OHL	Operational High Level
OLL	Operational Low Level
OHW	Operational High Weight
OLW	Operational Low Weight
PAC	Powdered Activated Carbon
PLC	Programmable Logic Controller
PPE	Personal Protective Equipment
P&ID	Piping and Instrumentation Diagram
RH	Relative Humidity
SCADA	Supervisory Control and Data Acquisition
SME	Subject Matter Expert
SPO	Special Power Outlet
TSI	Technical Support and Improvement
VSD	Variable Speed Drive
WSAA	Water Services Association of Australia
WTP	Water Treatment Plant

14. Roles and Responsibilities

Table 19 Roles and Responsibilities

Role	Responsibility
Leaders	In addition to the responsibilities of a worker, ensure compliance with this Standard Specification by those they lead.
Workers/Employees	Be aware of and comply with this Standard Specification

15. References and Related Materials

The documents listed in Table 20 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 20 Reference Seqwater Documentation

Description	Location
FRA-00014 Enterprise Risk Management Framework	REX
GDE-00369 E-GDE-STD-001 Energy Metering and Monitoring Guideline	REX
MAN-00391 E-MAN-STD-001 Energy Efficiency Manual	REX
PLN-00393 Seqwater Energy Management System and Plan (EnMSP)	REX
PLN-00402 Powder Chemical Storage and Batching Asset Class Plan	REX
PLN-00452 Corporate Energy Strategy	REX
PRO-00008 Hazardous Chemicals Procedure	REX
PRO-01617 X-PRO-STD-009 Engineering Design, Construction, Operation and Maintenance Procedure	REX
PRO-01872 X-PRO-STD-002 Engineering Drawing Numbers	REX
PRO-01873 X-PRO-STD-001 Asset Standards Document Classification and Naming Structure	REX
PRO-01874 X-PRO-STD-004 Development and Review of Asset Standards Procedure	REX
PRO-02140 X-PRO-STD-013 Engineering Technical Hazard Study Procedure	REX
PRO-02187 X-PRO-STD-007 Drawing & Spatial Data Standards	REX
PRO-02190 X-PRO-STD-006 Equipment Numbering and Naming Convention Procedure	REX
PRO-02205 X-PRO-STD-008 Asset Standards Management and Application Procedure	REX

Description	Location
PRO-02564 Drinking Water Treatment Chemicals - Specifications, Monitoring and Assessment Procedure	REX
REG-00250 Drinking Water Treatment Chemical Supplier Matrix	REX
REG-01074 X-LST-STD-001 Seqwater Preferred Equipment Register	REX
SPE-00320 WTP and Supply System - Process Validation Standard	REX
SPE-00323 M-SPE-STD-003 Valves for Water Applications	REX
SPE-00342 I-LST-STD-001 Control System Prescribed Equipment	REX
SPE-00346 B-SPE-STD-003 Commissioning Requirements	REX
SPE-00348 M-SPE-STD-004 Protective Coatings	REX
SPE-00349 B-SPE-STD-005 Functional Description Documentation	REX
SPE-00352 E-SPE-STD-001 Electrical Design and Construction	REX
SPE-00353 I-SPE-STD-015 Instrumentation	REX
SPE-00355 M-SPE-STD-013 Chemical Dosing Piping	REX
SPE-00356 I-SPE-STD-005 High Priority Alarms and Interlocks Management	REX
SPE-00357 I-SPE-STD-006 Alarm and Event Management	REX
SPE-00358 I-SPE-STD-009 Control Systems Architecture	REX
SPE-00359 I-SPE-STD-010 Control Systems Tag Naming	REX
SPE-00360 I-SPE-STD-011 Control System Testing	REX
SPE-00361 I-SPE-STD-013 Control Systems Design and Construction	REX
SPE-00366 M-SPE-STD-002 Fixed Platforms, Walkways, Stairways and Ladders	REX
SPE-00367 M-SPE-STD-001 General Mechanical	REX
SPE-00395 D-SPE-STD-001 Water Supply Network Planning, Design and Construction	REX
SPE-00430 M-SPE-STD-012 Chemical Dosing Pumps	REX
SPE-00434 M-SPE-STD-009 Flow Meters	REX
SPE-00435 M-SPE-STD-010 Chemical Dosing Skids	REX
SPE-00445 B-SPE-STD-009 Liquid Chemical Storage and Dosing Systems	REX
SPE-00502 Control Systems Cyber Security Standard	REX
SPE-00506 M-SPE-STD-016 Progressive Cavity Pumps	REX
TEM-00221 I-TMP-STD-001 Functional Description Part A	REX
TEM-00222 I-TMP-STD-005 Functional Description Part B	REX
TEM-00224 X-TMP-STD-022 Asset Standards Deviation Request Template	REX

Table 21 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
AS 1000	International System of Units (S.I.) and its Applications
AS 1216	Class Labels for Dangerous Goods
AS 1319	Safety Signs for the Occupational Environment
AS/NZS 1477	PVC pipes and fittings for pressure applications
AS 1418	Cranes, Hoist, and Winches Set
AS 1554	Structural Steel Welding
AS 1657	Fixed platforms, walkways, stairways and ladders - Design, construction and installation
AS 1668	The Use of Ventilation and Air-conditioning in Buildings set
AS 1680	Interior and Workplace Lighting
AS 1692	Steel Tanks for Flammable and Combustible Liquids
AS 1768	Lightning Protection
AS 2118	Automatic Fire Sprinkler System
AS 2312.1	Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings - Paint coatings
AS 2312.2	Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings – Hot dip galvanizing
AS 2359	Powered Industrial Trucks
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 2018, Electrical Installations
AS 3774	Loads on Bulk Solids Containers
AS 3780	The Storage and Handling of Corrosive Substances
AS 3959	Construction of Buildings in Bushfire-prone Areas
AS 3990	Mechanical Equipment – Steelwork
AS 3996	Access Covers and Grates
AS 4041	Pressure Piping
AS 4100	Steel Structures
AS 4326	The Storage and Handling of Oxidizing Agents

Standard/Specification	Document Title
AS 4452	The storage and handling of toxic substances
AS/NZS 4766	Polyethylene storage tanks for water and chemicals
AS 4775	Emergency Eyewash and Shower Equipment
AS/NZS 60079.10.1	Explosive Atmospheres – Classification of Areas – Explosive Gas Atmospheres
AS/NZS 60079.10.2	Explosive atmospheres – Classification of Areas – Explosive Dust Atmospheres
ADG Code	Australian Code for the Transport of Dangerous Goods by Road & Rail
ASTM D1998	Standard Specification for Polyethylene Upright Storage Tanks
BS EN 13121-3	GRP Tanks and Vessels for use above ground. Design and workmanship.
BS EN 14015	Specification for the design and manufacture of site built, vertical, cylindrical, flat-bottomed, above ground, welded, steel tanks for the storage of liquids at ambient temperature and above
WHS Act 2011	Work Health and Safety Act 2011
State Code 21	Planning guideline State Code 21: Hazardous chemical facilities
WSA 01	Polyethylene Pipeline Code V 3.1
WSA 03	Water Supply Code of Australia V 3.1
WSA 201	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.*
AWWA B201-08	Soda Ash
AWWA B453-06	Polyacrylamide
AWWA B600-05	Powdered Activated Carbon
AWWA B603-03	Permanganate
NSF/ANSI/CAN 60	Drinking Water Treatment Chemicals – Health Effects
NSF/ANSI/CAN 61	Drinking Water System Components – Health Effects
DS 72-01	Lime Storage Mixing & Dosing System – Basis of Design (Water Corporation)
The Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers	Recommended Standards for Water Works (2022)

Table 22 Seqwater Standard Drawings

Drawing	Description
B-DWG-STD-00001	Standard Drawing - P&ID Legend - Sheet 1 of 5, Piping, Valve & Fittings Symbols
B-DWG-STD-00002	Standard Drawing - P&ID Legend - Sheet 2 of 5, Instrument & Control Valve Symbols
B-DWG-STD-00003	Standard Drawing - P&ID Typical Details - Sheet 1 of 2, Instrumentation Valve
B-DWG-STD-00004	Standard Drawing - P&ID Typical Details - Sheet 2 of 2, Motor Valve
B-DWG-STD-00005	Standard Drawing - P&ID Legend - Sheet 3 of 5, Material Codes
B-DWG-STD-00006	Standard Drawing - P&ID Legend - Sheet 4 of 5, Major Equipment Symbols
B-DWG-STD-00007	Standard Drawing - P&ID Legend - Sheet 5 of 5, Minor Equipment & Miscellaneous Symbols
B-DWG-STD-00016	Standard Drawing - P&ID Liquid Chemical Ring Main Dosing Unloading
B-DWG-STD-00019	Standard Drawing – P&ID - Powder Activated Carbon (PAC) Unloading and Storage System
B-DWG-STD-00020	Standard Drawing – P&ID - Polymer, PAC, Pot Perm and Soda Ash - Notes
B-DWG-STD-00027	Standard Drawing – P&ID - Polymer, Pot Perm and Soda Ash Storage, Batching and Dosing System (Bulk Bag)
B-DWG-STD-00028	Standard Drawing – P&ID - Polymer, Pot Perm and Soda Ash Dosing System
B-DWG-STD-00029	Standard Drawing – P&ID - Polymer, Pot Perm and Soda Ash Storage, Batching and Dosing System (Small Bag)
B-DWG-STD-00030	Standard Drawing – P&ID - Powder Activated Carbon (PAC) Slurry Batching and Dosing System

16. 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 PRO-01874 X-PRO-STD-004 Development and Review of Asset Standards Procedure. Changes made from the previous version are summarised in Table 23 below.

Table 23 Changes from previous version

Section Number	Change
3.1	Included reference to *B-SPE-STD-009 Liquid Chemical Storage and Dosing*.
3.3	Added additional details on Pot Perm including solubility.
3.4	Added additional details on Sodium Carbonate and including solubility and Solution pHs.
3.5	Minor wording changes and reference to *NSF/ANSI/CAN 60 - Drinking Water Treatment Chemicals - Health Effects*.
4.1.1	Additional references added.
4.3	Additional references added.
4.6	Additional references added.
4.8.1	Additional details on pipe velocity and route requirements.
4.11	Additional references added.
4.12	Additional details and references added.
4.12.1	New Section added outline Instrumentation requirements specific to level sensors and switches
4.15	Additional requirements for safety shower pipework and temperature protection, flow switches and locations added.
4.17	Section re-written to provide greater context on the design philosophy for both slurry and solution systems.
4.18	New section added to provide information on asset redundancy.
5.2.4	Slight modification to local control panel requirements.
5.3.4	Slight modification to local control panel requirements.
5.4	Modification to LCP requirements for small bag unloading.
6.1	Clarification added to include Hoppers in silo requirements.
6.1.2	Slight modification to Silo/Hopper name plate requirements.
6.1.9.1	Additional requirements for dust filter capacity added.
6.1.9.2	Slight modifications to exhaust fan requirements.
6.1.10	Additional details on pressure/vacuum relief device requirements added.
6.1.11	Bin Activator removed as preferred method. Reference remains for when they are selected for use.
6.1.13	Included requirement to consider dehumidifier pressure build up when selecting pressure/vacuum relief device.
6.3.2	Added access requirement for installation or replacement of large equipment.
6.4	Additional information added for small bag transfer
7.2.1	Modified requirements to preference wetting systems installed directly on top of batching tanks.
7.2.3	Updated references.

Section Number	Change
7.3	Updated references.
7.3	Modification to include dosing tank as batching tank for variable concentration systems.
8	Details added to elaborate on both fixed concentration and variable concentration dosing systems.
8.1.2	Modification to instrumentation requirements.
8.2	Slight modification to dosing system requirements.
8.2.1	Modification to suction line requirements.
8.2.2	Wording changed to clarify calibration cylinder requirements.
8.2.3	Modification to dosing pump requirements.
8.2.4	Modification to pump pressure relief valve requirements.
8.2.5	Modification to requirements and preference for inline pulsation dampeners for peristaltic pumps.
8.2.6	Included need for double block and bleed on pressure transmitters.
8.2.7	Added additional flow meter requirements when used.
8.2.8	Added additional pressure sustaining valve requirements.
8.2.9	Slight modification to chemical return line requirements.
8.2.10	More detail around carrier water requirements added.
8.2.11	Additional dosing line requirements added.
8.2.11.1	Additional details for leak detection pits added.
8.2.12	Modification to flushing requirements.
8.2.13	Additional details for dosing spears added.
8.3	General description detailed added.
8.3.2	Modification to static mixer requirements.
8.3.5	Additional Spray bar requirements added.
8.4.2	Additional details for dosing pits added. Change to preference above ground dosing locations.
9	Updates to standards and drawings referenced.
10	General description wording modified.
10.1	Wording modified.
10.1.1	Minor modifications to batching control details.
10.1.2	Changes to dosing control modes including new detail for flow meter trim control.
10.2.3	Small bag vacuum transfer control narrative modified.
11	Additional requirements included.
12	Added reference to Commissioning Requirements standard.
13	Definitions and abbreviations updated.
15	References updated.

Appendix A – Powder Chemical Information and Sample Calculations

The following appendix contains summary data, key information for four chemicals used in water treatment at Seqwater Sites, and flow rate calculations. This section should be read in conjunction with PRO-00008 Hazardous Chemicals Procedure and appropriate chemical safety data sheets.

The following types of powder chemical(s) shall not be allowed to come into contact under any circumstance:

- Potassium Permanganate with Acids and PAC.
- PAC with Sodium Hypochlorite.
- Soda Ash solution with Acids.

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

A.1. Polymer

Chemical Type: Anionic, cationic, and non-ionic polymer

pH: Varies, 6-8 at 10g/L aqueous solution

Density: Varies, approximately 750 kg/m^3

Specific Gravity: 1.0, with a range of 0.7-1.2

Classification: Not classified as Hazardous according to Safe Work Australia and not a Dangerous Good according to the Australian Dangerous Goods (ADG) Code. (to be confirmed with suppliers)

Polymer feeder discharge calculation:

Polymer batch concentration set point = 0.3 % (w/v) = 0.3*10 g/L = 3 g/L (assumption, based on operator input setpoint)

Batching tank working volume = 3000 L (assumption)

Chemical powder purity = 99.5% (assumption, based on product specification)

Feeder rate = 1 kg/minute (assumption, determined through drop test)

$$Feeder\ run\ time\ (s) = \frac{Batch\ concentration\ (\%\ w/v) * 10\left(\frac{g}{L}\right) * Batch\ tank\ working\ volume\ (L) * 60\left(\frac{s}{min}\right)}{Chemical\ powder\ purity\ (\%\ w/w) *\ Feeder\ rate\left(\frac{kg}{min}\right) * 1000\left(\frac{g}{kg}\right)}$$

$$Feeder\ run\ time\ (s) = \frac{0.3 * 10\left(\frac{g}{L}\right) * 3000\ (L) * 60\left(\frac{s}{min}\right)}{0.995\ *\ 1\left(\frac{kg}{min}\right) * 1000\left(\frac{g}{kg}\right)}$$

$Feeder\ run\ time\ (s) = 543\ s \approx$ 9 min

Polymer dosing flowrate for flocculant and filtration aid calculation:

Process water flowrate = 1000 L/sec (assumption)

Polymer dose rate = 0.05 mg/L (assumption)

$$Chemical\ flow\ rate\ \left(\frac{L}{h}\right) = \frac{Water\ flow\ rate\left(\frac{L}{s}\right)*dose\ rate\ \left(\frac{mg}{L}\right)*3600\ \left(\frac{s}{h}\right)}{Batch\ concentration\ (\%\ w/v)*\ 10{,}000\ \left(\frac{mg}{L}\right)}$$

$$Chemical\ flow\ rate\ \left(\frac{L}{h}\right) = \frac{1000\left(\frac{L}{s}\right)*0.05\ \left(\frac{mg}{L}\right)*3600\ \left(\frac{s}{h}\right)}{0.3\ *10{,}000\ \left(\frac{mg}{L}\right)}$$

$$Chemical\ flow\ rate\ = 60\frac{L}{h}$$

Polymer dosing flowrate for sludge treatment (i.e. centrifuge or thickener) calculation:

Feed solid flow rate = 89 L/s (assumption, based on feed solid flowmeter)

Feed suspended solid concentration = 0.2 % = 0.2*10 g/L (assumption, based on feed solid suspended solid meter)

$$Feed\ solid\ mass\ flow\ rate\ \left(\frac{g}{s}\right) =$$

$$Feed\ flow\ rate\ \left(\frac{L}{s}\right) * Feed\ suspended\ solid\ concentration\ \left(\frac{g}{L}\right)$$

$$Feed\ solid\ mass\ flow\ rate\ \left(\frac{g}{s}\right) = 89\frac{L}{s} * 2\frac{g}{L}$$

$$Feed\ solid\ mass\ flow\ rate\ = 178\frac{g}{s}$$

Polymer dose rate = 2 kg/tDs (assumption, based on operator input set point)

Batch concentration = 0.3 % (w/v) = 0.3*0.01 kg/L = 0.003 kg/L (assumption)

$$Chemical\ flow\ rate\ \left(\frac{L}{h}\right) = \frac{Feed\ solid\ mass\ flow\ rate\ \left(\frac{g}{s}\right) * dose\ rate\ \left(\frac{kg}{tDs}\right) * 3600\ \left(\frac{s}{h}\right)\ * \left(\frac{1}{1000*1000}\right)\left(\frac{tDs}{g}\right)}{Batch\ concentration\ (\%\ w/v)\ *\ 0.01\ \left(\frac{kg}{L}\right)}$$

$$Chemical\ flow\ rate\ \left(\frac{L}{h}\right) = \frac{178\ \left(\frac{g}{s}\right) * 2\left(\frac{kg}{tDs}\right) * 3600\ \left(\frac{s}{h}\right)\ * \left(\frac{1}{1000*1000}\right)\left(\frac{tDs}{g}\right)}{0.3 * 0.01\ \left(\frac{kg}{L}\right)}$$

$$Chemical\ flow\ rate\ = 427\frac{L}{h}$$

A.2. Powdered Activated Carbon

Molecular Formula: C

Chemical Name: Powdered Activated Carbon

Atomic Mass: 12.0 g/mol

Specific Gravity: approximately 1.90 – 2.10

Classification: Not classified as hazardous according to Safe Work Australia and Not a Dangerous Good according to the Australian Dangerous Goods (ADG) Code.

PAC batching and dosing calculation (with a simple example):

PAC feeder discharge calculation:

PAC batch concentration set point = 1.2 % (w/v) = 1.2*10 g/L = 12 g/L (assumption, based on operator input setpoint)

Batching tank working volume = 1600 L (assumption)

Chemical powder purity = 99% (assumption, based on product specification)

Feeder rate = 3 kg/minute (assumption, determined through drop test)

$$Feeder\ run\ time\ (s) = \frac{Batch\ concentration\ (\%\ w/v) * 10\left(\frac{g}{L}\right) * Batch\ tank\ working\ volume\ (L) * 60\left(\frac{s}{min}\right)}{Chemical\ powder\ purity\ (\%\ w/w) *\ Feeder\ rate\ \left(\frac{kg}{min}\right) * 1000\ \left(\frac{g}{kg}\right)}$$

$$Feeder\ run\ time\ (s) = \frac{1.2 * 10\left(\frac{g}{L}\right) * 1600\ (L) * 60\ \left(\frac{s}{min}\right)}{0.99\ *\ 3\ \left(\frac{kg}{min}\right) * 1000\ \left(\frac{g}{kg}\right)}$$

$$Feeder\ run\ time\ (s) = 387\ s$$

PAC dosing flowrate calculation:

Process water flowrate = 1000 L/sec (assumption)

PAC dose rate = 5 mg/L (assumption)

$$Chemical\ flow\ rate\ \left(\frac{L}{h}\right) = \frac{Water\ flow\ rate\left(\frac{L}{s}\right)*dose\ rate\ \left(\frac{mg}{L}\right)*3600\ \left(\frac{s}{h}\right)}{Batch\ concentration\ (\%\ w/v)*10{,}000\ \left(\frac{mg}{L}\right)}$$

$$Chemical\ flow\ rate\ \left(\frac{L}{h}\right) = \frac{1000\left(\frac{L}{s}\right) * 5\ \left(\frac{mg}{L}\right) * 3600\ \left(\frac{s}{h}\right)}{1.2\ * 10{,}000\ \left(\frac{mg}{L}\right)}$$

$$Chemical\ flow\ rate\ = 1500\frac{L}{h}$$

A.3. Potassium Permanganate (Pot Perm)

Chemical Formula: $KMnO_4$

Molecular Weight: 158.03 g/mol

Specific Gravity: 2.7

Apparent/Bulk Density: 1.45 – 1.6 g/cm^3

pH: 7.2 – 9.7

Solubility: 65 g/L at 20°C

Classification: Dangerous Goods Class 5.1 (Oxidising), Packing Group II

UN Number: 1490

Permanganate batching and dosing calculation (with a simple example):

Pot perm feeder discharge calculation:

Pot perm batch concentration set point = 1% (w/v) = 1*10 g/L = 10 g/L (assumption, based on operator input setpoint)

Batching tank working volume = 1200 L (assumption)

Chemical powder purity = 98% (assumption, based on product specification)

Feeder rate = 3 kg/minute (assumption, determined through drop test)

$$Feeder\ run\ time\ (s) = \frac{Batch\ concentration\ (\%\ w/v) * 10\ \left(\frac{g}{L}\right) * Batch\ tank\ working\ volume\ (L) * 60\ \left(\frac{s}{min}\right)}{Chemical\ powder\ purity\ (\%\ w/w) *\ Feeder\ rate\ \left(\frac{kg}{min}\right) * 1000\ \left(\frac{g}{kg}\right)}$$

$$Feeder\ run\ time\ (s) = \frac{1 * 10\ \left(\frac{g}{L}\right) * 1200\ (L) * 60\ \left(\frac{s}{min}\right)}{0.98\ *\ 3\ \left(\frac{kg}{min}\right) * 1000\ \left(\frac{g}{kg}\right)}$$

$$Feeder\ run\ time\ = 245\ s\ \approx\ 6\ min$$

Pot perm dosing flowrate calculation:

Process water flowrate = 1000 L/sec (assumption)

Pot perm dose rate = 0.15 mg/L (assumption)

$$Chemical\ flow\ rate\ \left(\frac{L}{h}\right) = \frac{Water\ flow\ rate\left(\frac{L}{s}\right) * dose\ rate\ \left(\frac{mg}{L}\right) * 3600\ \left(\frac{s}{h}\right)}{Batch\ concentration\ (\%\ w/v) * 10000\ \left(\frac{mg}{L}\right)}$$

$$Chemical\ flow\ rate\ \left(\frac{L}{h}\right) = \frac{1000\ \left(\frac{L}{s}\right) * 0.15\ \left(\frac{mg}{L}\right) * 3600\ \left(\frac{s}{h}\right)}{1 * 10000\ \left(\frac{mg}{L}\right)}$$

$$Chemical\ flow\ rate\ = 54\frac{L}{h}$$

A.4. Soda Ash

Chemical Formula: Na_2CO_3

Chemical Name: Sodium Carbonate

Molecular Weight: 105.9 g/mol

pH: 11.3 (10 g/L aqueous solution)

Specific Gravity: 2.53

Apparent/Bulk Density: 0.5 – 0.9 g/cm^3

Classification: Classified as Hazardous according to Safe Work Australia, not considered as a Dangerous Good according to the Australian Dangerous Goods (ADG) Code.

Soda Ash batching and dosing calculation (with a simple example):

Soda Ash feeder discharge calculation:

Soda Ash batch concentration set point = 2% (w/v) = 2*10 g/L =20 g/L (assumption, based on operator input setpoint)

Batching tank working volume = 1200 L (assumption)

Chemical powder purity = 98% (assumption, based on product specification)

Feeder rate = 3 kg/minute (assumption, determined through drop test)

$$Feeder\ run\ time\ (s) = \frac{Batch\ concentration\ (\%\ w/v) * 10\left(\frac{g}{L}\right) * Batch\ tank\ working\ volume\ (L) * 60\left(\frac{s}{min}\right)}{Chemical\ powder\ purity\ (\%\ w/w) *\ Feeder\ rate\ \left(\frac{kg}{min}\right) * 1000\ \left(\frac{g}{kg}\right)}$$

$$Feeder\ run\ time\ (s) = \frac{2 * 10\left(\frac{g}{L}\right) * 1200\ (L) * 60\ \left(\frac{s}{min}\right)}{0.98\ *\ 3\ \left(\frac{kg}{min}\right) * 1000\ \left(\frac{g}{kg}\right)}$$

$$Feeder\ run\ time\ = 489\ s \approx\ 8\ min$$

Soda Ash dosing flowrate calculation:

Process water flowrate = 1000 L/sec (assumption)

Soda Ash dose rate = 5 mg/L (assumption)

$$Chemical\ flow\ rate\ \left(\frac{L}{h}\right) = \frac{Water\ flow\ rate\left(\frac{L}{s}\right) * dose\ rate\ \left(\frac{mg}{L}\right) * 3600\ \left(\frac{s}{h}\right)}{Batch\ concentration\ (\%\ w/v) * 10{,}000\ \left(\frac{mg}{l}\right)}$$

$$Chemical\ flow\ rate\ \left(\frac{L}{h}\right) = \frac{1000\left(\frac{L}{s}\right) * 5\ \left(\frac{mg}{L}\right) * 3600\ \left(\frac{s}{h}\right)}{2 * 10{,}000\ \left(\frac{mg}{l}\right)}$$

$$Chemical\ flow\ rate\ = 900\frac{L}{h}$$

Appendix B – Minimum Typical Trips and Interlocks

Table 24 Unloading and Storage Trips and Interlocks

Device/Instrument	Cause	Action	Process Permissive	Trip Interlocks	Hardware /Hardwired Interlocks
Storage Silo Weight Transmitter for Load Cells	Fault Power Loss High-High Weight	Inhibit silo filling sequence. Bulk delivery – Not to open (if closed) fill line actuated valve Bag unloading – Stop conveyance system		Y	N
	Low-Low Weight	Inhibit batching sequence. Not to open (if closed) knife gate valve		Y	N
Storage silo High-High Level Switch	Fault Power Loss High-High Level	Inhibit silo filling sequence. Bulk delivery - Not to open (if closed) fill line valve. Bag unloading - Stop conveyance system		Y	N
Storage silo Low-Low Level Switch	Fault Power Loss Low-Low Level	Inhibit batching sequence. Not to open (if closed) knife gate valve		Y	N
Storage Silo Dust Extraction Fan	Fault Power Loss	Inhibit filling sequence. Bulk delivery - Not to open (if closed) fill line valve (bulk delivery) Bag unloading – Stop conveyance system		Y	N
Storage silo Vibrator	Fault Power Loss	Inhibit batching sequence		Y	N
Storage silo knife gate isolation gate valve	Fail close during batching	Inhibit batching sequence		Y	N
Large Bag unloading safety gate position switch	Open	Inhibit bag unloading sequence. Stop conveyance system		Y	N

Device/Instrument	Cause	Action	Process Permissive	Trip Interlocks	Hardware /Hardwired Interlocks
Lage Bag unloading discharge hopper safety door position switch	Open	Inhibit bag unloading sequence. Stop conveyance system		Y	N
Large Bag unloading dust extraction line solenoid valve	Close	Inhibit bag unloading sequence. Stop conveyance system		Y	N

Table 25 Batching and Transfer System Trips and Interlocks

Device/Instrument	Cause	Action	Process Permissive	Trip Interlocks	Hardware /Hardwired Interlocks
Storage silo screw feeder	Fault Power Loss High Motor Current Low Motor Current	Screw feeder tripped and stop batching sequence		Y	N
Wetting Cone High Level - Level Switch	Fault Power Loss High Level	Stop batching sequence		Y	N
Wetting Cone inlet Water Flow Transmitter	Fault Power Loss	Stop batching sequence		Y	N
Eductor Motive Water Flow Transmitter	Fault Power Loss	Stop batching sequence		Y	N
Blower for pneumatic conveyance	Fault Power Loss	Stop batching sequence		Y	N
Wetting Head Water Flow Transmitter	Fault Power Loss	Stop batching sequence		Y	N
Batching Tank Make up Water Flow Switch	Fault Power Loss Low Flow	Stop batching sequence		Y	N

Device/Instrument	Cause	Action	Process Permissive	Trip Interlocks	Hardware /Hardwired Interlocks
Batching Tank Level Transmitter	Fault	Stop batching sequence and transfer system		Y	N
	Power Loss				
	Batch Start Level	Start batching sequence	Y	N	N
	Batch Stop Level	Stop batching transfer	Y	N	N
Batching Tank High-High Level Switch	Fault	Stop/do not start batching sequence		Y	N
	Power Loss				
	High-High Level				
Batching Tank Low-Low Level Switch	Fault	Stop/do not start transfer pump. Close or do not open transfer line actuated valve		Y	N
	Power Loss				
	Low-Low Level	Stop/do not start transfer pump. Close or do not open transfer line actuated valve		N	Y
Batching Tank Mixer	Fault	Stop batching sequence		Y	N
	Power Loss				
	High Motor Current				
	Low Motor Current				
Batching transfer line actuated valve (gravity system)	Fault	Inhibit transfer sequence		Y	N
	Power Loss				
	Fail to open				
	Fail to close	Stop/inhibit batching sequence		Y	N

Table 26 Dosing System Trips and Interlocks

Device/Instrument	Cause	Action	Process Permissive	Trip Interlocks	Hardware /Hardwired Interlocks
Dosing Tank Level Transmitter	Fault	Stop dosing and transfer pumps or close transfer line actuated valve		Y	N
	Power Loss				
	Batch Transfer Start Level	Start transfer pump or open transfer line actuated valve	Y	N	N
	Batch Transfer Stop Level	Stop transfer pump or close transfer line actuated valve	Y	N	N
	Low-Low Level	Stop dosing pump (s)		Y	N
Dosing Tank High-High Level Switch	Fault	Stop transfer pump or close transfer line actuated valve		Y	N
	Power Loss				
	High-High Level	Stop transfer pump or close transfer line actuated valve		N	Y
Dosing Tank Low-Low Level Switch	Fault	Stop dosing pump(s), close tank outlet valve		Y	N
	Power Loss				
	Low-Low Level	Stop dosing pump(s), close tank outlet valve		N	Y
Dosing Tank Mixer (only for PAC, Soda Ash system)	Fault	If standby dosing tank is not available, stop all dosing pumps.		Y	N
	Power Loss				
	Low Motor Current				
	High Motor Current				
Dosing Flowmeter	Fault	Stop relevant dosing pump		Y	N
	Power Loss				
Discharge Pressure Transmitter	Fault	Stop the relevant pump and changeover to standby dosing line and pump		Y	N
	Power Loss				
	High Pressure	Stop relevant pump, close actuated valve and changeover to standby dosing line and pump		Y	N

Device/Instrument	Cause	Action	Process Permissive	Trip Interlocks	Hardware /Hardwired Interlocks
Dosing Pump	Fault	Close relevant dosing line actuated valve. Start other dosing pump		Y	N
	Power Loss				
	Stop	Close relevant dosing line actuated valve		Y	N
Chemical Dosing Line Flow Switch	Fault	Stop relevant dosing pump and isolate relevant dosing line		Y	N
	Power Loss				
	No flow but pumps operating				
Dosing Line Actuated Valve	Fault	Stop relevant dosing pump and close valve		Y	N
	Power Loss				
	Fail to Open within time	Do not start relevant dosing pump	Y	N	N
	Fail Close	Stop relevant dosing pump		Y	N