Assets Planning and Delivery Group
Engineering

DESIGN STANDARD DS 112

Electro-chlorination – Basis of Design

VERSION 1
REVISION 4

JUNE 2025

FOREWORD

The intent of Design Standards is to specify requirements that assure effective design and delivery of fit for purpose Water Corporation infrastructure assets for best whole-of-life value with least risk to Corporation service standards and safety. Design standards are also intended to promote uniformity of approach by asset designers, drafters and constructors to the design, construction, commissioning and delivery of water infrastructure and to the compatibility of new infrastructure with existing like infrastructure.

Design Standards draw on the asset design, management and field operational experience gained and documented by the Corporation and by the water industry generally over time. They are intended for application by Corporation staff, designers, constructors and land developers to the planning, design, construction and commissioning of Corporation infrastructure including water services provided by land developers for takeover by the Corporation.

Nothing in this Design Standard diminishes the responsibility of designers and constructors for applying the requirements of Western Australia's Work Health and Safety (General) Regulations 2022 to the delivery of Corporation assets. Information on these statutory requirements may be viewed at the following web site location:

Overview of Western Australia’s Work Health and Safety (General) Regulations 2022 (dmirs.wa.gov.au)

Enquiries relating to the technical content of a Design Standard should be directed to the Senior Principal Engineer, Water Treatment Advisory, Engineering. Future Design Standard changes, if any, will be issued to registered Design Standard users as and when published.

Head of Engineering

This document is prepared without the assumption of a duty of care by the Water Corporation. The document is not intended to be nor should it be relied on as a substitute for professional engineering design expertise or any other professional advice.

Users should use and reference the current version of this document.

DISCLAIMER

Water Corporation accepts no liability for any loss or damage that arises from anything in the Standards/Specifications including any loss or damage that may arise due to the errors and omissions of any person. Any person or entity which relies upon the Standards/Specifications from the Water Corporation website does so at their own risk and without any right of recourse to the Water Corporation, including, but not limited to, using the Standards/Specification for works other than for or on behalf of the Water Corporation.

The Water Corporation shall not be responsible, nor liable, to any person or entity for any loss or damage suffered as a consequence of the unlawful use of, or reference to, the Standards/Specifications, including but not limited to the use of any part of the Standards/Specification without first obtaining prior express written permission from the CEO of the Water Corporation.

Any interpretation of anything in the Standards/Specifications that deviates from specific Water Corporation Project requirements must be referred to, and resolved by, reference to and for determination by the Water Corporation's project manager and/or designer for that particular Project.

REVISION STATUS

The revision status of this standard is shown section by section below:

REVISION STATUS						
SECT.	**VER./ REV.**	**DATE**	**PAGES REVISED**	**REVISION DESCRIPTION (Section, Clause, Sub-Clause)**	**RVWD.**	**APRV.**
1	1/0	10.11.23	All	New Version/Revision	NH	BM
	1/1	08.01.24		1.7.2 – clarified requirements for models of electro-chlorinator that evacuate all hydrogen prior to the storage tank 1.7.3 – revised redundancy requirements 1.7.4 – clarified chlorate management requirements	BB	BM
	1/4	**04.06.25**	**17,19**	**1.7.3 – each storage tank to have a dedicated electro-chlorination system** **1.7.5 – New section on design for drinking water use**	**BM**	**BM**

2	1/0	10.11.23	All	New Version/Revision	NH	BM
	1/1	08.01.24		2.5.3 – added requirement for latching of personnel door 2.5.4 – revised mechanical exhaust rate 2.7 – clarified door design requirements	BB	BM
	1/4	**04.06.25**	**22**	**2.2 – viewing window not required**	**BM**	**BM**

3	1/0	10.11.23	All	New Version/Revision	NH	BM
	1/2	21.03.24		3.3 – clarified plenum floor requirement in saturator.	BM	BM

4	1/0	10.11.23	All	New Version/Revision	NH	BM
	1/1	08.01.24		4.2.1 – clarified CIP requirements 4.4 – revised tank operation specific to chlorate management	BB	BM
	1/4	**04.06.25**	**29**	**4.2.1 – added option for off-site cleaning**	**BM**	**BM**

5	1/0	10.11.23	All	New Version/Revision	NH	BM
	1/1	08.01.24		5.3 – revised requirement for hypo tank plinth	BB	BM
	1/4	**04.06.25**	**34**	**5.4.1 – radar level instrument requirements clarified**	**BM**	**BM**

REVISION STATUS						
SECT.	VER./ REV.	DATE	PAGES REVISED	REVISION DESCRIPTION (Section, Clause, Sub-Clause)	RVWD.	APRV.
6	1/0	10.11.23	All	New Version/Revision	NH	BM
	1/1	08.01.24		6.3.4 – revised requirement for Pressure Relief Valve 6.4.2 – clarified requirement for duty/standby dosing spears	BB	BM
	1/4	**04.06.25**	**39**	**6.3.3 – braided PVC hose requirements clarified**	**BM**	**BM**

7	1/0	10.11.23	All	New Version/Revision	NH	BM

8	1/0	10.11.23	All	New Version/Revision	NH	BM

9	1/0	10.11.23	All	New Version/Revision	NH	BM

10	1/0	10.11.23	All	New Version/Revision	NH	BM
	1/1	08.01.24		Clarified alarm requirements	BB	BM
	1/3	28.08.24		Inserted section 10.1, Hypo Batching Control Philosophy	BB	BM
	1/3	28.08.24		Corrected FCD reference to DS73-02 (not DS73-11)	BB	BM

11	1/0	10.11.23	All	New Version/Revision	NH	BM

12	1/0	10.11.23	All	New Version/Revision	NH	BM
	1/1	08.01.24		12.2 & 12.3 – clarified requirement for hydrogen leak alarms	BB	BM

13	1/0	10.11.23	All	New Version/Revision	NH	BM

14	1/0	10.11.23	All	New Version/Revision	NH	BM

REVISION STATUS						
SECT.	VER./ REV.	DATE	PAGES REVISED	REVISION DESCRIPTION (Section, Clause, Sub-Clause)	RVWD.	APRV.

15	1/0	10.11.23	All	New Version/Revision	NH	BM

16	1/0	10.11.23	All	New Version/Revision	NH	BM

17	1/0	10.11.23	All	New Version/Revision	NH	BM

18	1/0	10.11.23	All	New Version/Revision	NH	BM

DESIGN STANDARD DS 112

Electro-chlorination – Basis of Design

CONTENTS

Section *Page*

1 INTRODUCTION

1.1 Purpose

This document explains the reasoning behind the Water Corporation's design and installation requirements for its electro-chlorination facilities and provides specific information relating to the Corporation's preferences and best practices which have evolved over years of experience.

1.2 Scope

This document applies to on-site generation of chlorine from brine electrolysis and associated sodium hypochlorite storage and dosing systems. This document (DS112) only considers brine electro-chlorination (BEC) systems, whereas design standard DS112-02 describes continuous electro-chlorination (CEC) systems, which produce chlorine from electrolysis of the background chloride concentration in the water.

1.3 Background Information

Electro-chlorination is technology for producing low concentration sodium hypochlorite onsite.

In simple terms:

salt + water + energy → sodium hypochlorite

More technically:

$NaCl_{(aq)} + H_2O_{(l)} + \text{DC electricity} \rightarrow NaOCl_{(aq)} + H_{2(g)}$

Electro-chlorination provides a useful alternative to chlorine gas or bulk sodium hypochlorite in certain treatment applications. The primary advantages of electro-chlorination are:

- Zero offsite risk buffer
- The weak sodium hypochlorite solution generated is low in hazard (an irritant rather than a corrosive)
- Chlorine / hypochlorite is generated on demand with negligible decomposition
- Requires only water, salt and electricity for operation
- Simple to operate
- Suited to remote power supply solar PV systems if batch operation (which is most of the power demand) is scheduled for daylight hours to minimise size of the required battery energy storage system.

The primary disadvantages are:

- Hydrogen gas is generated at the electrodes as a by-product. Explosion risks are managed by a combination of piping/ventilation design (to minimise the risk of the explosive gas accumulating) and instrumented safety systems.
- The electrodes require periodic chemical cleaning.
- The costly electrodes, used in medium/high capacity systems, require replacement at 5 to 7 year intervals[1].

Commercially supplied Sodium Hypochlorite (NaOCl) solution (usually ~12.5% concentration) is corrosive and a strong oxidiser and is mainly used in water treatment as an alternative disinfectant to chlorine gas. Although chlorine gas is highly effective as a disinfecting agent and relatively inexpensive, it has inherent risks. Safety concerns associated with potential gas leaks makes chlorine gas unsuitable

[1] Low capacity electrode cells from some suppliers are purposely designed with a service life of 2-3 years and a much lower replacement cost. They can we swapped out within a few minutes. Larger electrolyser cells have a service life of 7+years.

where there is insufficient separation to residential and public access areas. Sodium hypochlorite solution is less hazardous and easier to handle, and is a viable alternative to gaseous chlorine.

Sodium hypochlorite disassociates in water to form hypochlorite ions (OCl^-) and hypochlorous acid (HOCl) according to the following equations:

$$NaOCl_{(aq)} \leftrightarrows Na^+_{(aq)} + OCl^-_{(aq)}$$

$$OCl^-_{(aq)} + H_2O_{(l)} \leftrightarrows HOCl_{(aq)} + OH^-_{(aq)}$$

The hypochlorite ion (OCl^-) exists in equilibrium with hypochlorous acid (HOCl). The relative concentration of these two disinfectant species depends on pH.

Figure 1-1 illustrates this equilibrium. Hypochlorous acid is the stronger disinfecting species. The equilibrium favours hypochlorous acid at pH less than 7.5.

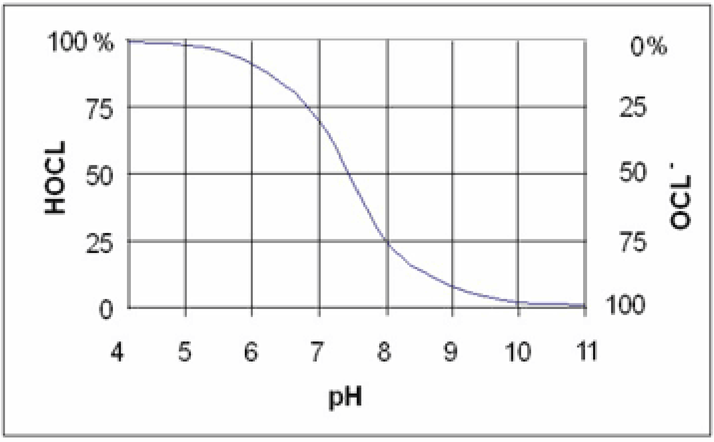


Figure 1-1: Equilibrium of Hypochlorite Ion & Hypochlorous Acid

Sodium hypochlorite is not without its problems. It is highly corrosive to most metals and also oxidises many plastics and elastomers. It is relatively unstable over time and has the potential to crystallise in delivery lines, form scale on water system components, and releases gas (oxygen) which may cause "gas locking" and which may rupture piping and valves. These problems may be mitigated by good engineering design and correct material selection, and by using dilute sodium hypochlorite (i.e. below 5%), which is one of the design principles used in this Standard. Sodium hypochlorite degrades over time reducing the available chlorine content and producing undesirable by-products such as sodium chloride, sodium chlorate, and oxygen. Factors that influence the rate of sodium hypochlorite degradation include solution strength, pH, temperature, UV light exposure, contaminants in solution, and contact with many metals.

Material selection for sodium hypochlorite service is critically important. For piping and valves, typically plastics such as uPVC (alternative is ECTFE) are used. It is recommended that gaskets, o-rings and elastomeric seals be made of FPM (also known as FKM and Viton). Water Corporation no longer permits the use of peroxide-cured EPDM due to past instances of sulphur-cured EPDM being inadvertently used and then subsequently failing causing leaks.

Another factor that complicates material selection is that some metals offer good corrosion resistance but cause accelerated decomposition of sodium hypochlorite. When sodium hypochlorite decomposes it produces oxygen gas which can cause significant problems with vapour-locking of dosing pumps or achieving consistent control with dosing systems. Experience has shown that a seemingly minor detail, such as the wrong metal spring in a pressure sustaining valve or dosing pump check valve, can result in a dosing system failure. Direct exposure to stainless steels, duplex stainless steels and Hastelloy results in rapid decomposition of sodium hypochlorite solution and causes equipment failure.

Sodium hypochlorite solutions react vigorously with most acids to release toxic chlorine gas. In general, sodium hypochlorite must not be mixed with other chemicals or any organic compounds, including oils, fuels, and grease, unless known to be compatible.

1.4 Process Selection

Brine electro-chlorination, at any capacity, is potentially cost-competitive on a whole-of-life basis with chlorine gas or bulk 12.5% sodium hypochlorite. A disadvantage relative to gas or 12.5% hypo systems is the increased complexity due the hypochlorite generation being in addition to the storage and dosing system; hence, brine electro-chlorination has relatively high capital but very low operating costs if electrolysers are selected that can use washed crude salt (i.e. as supplied by WA Salt Supply, which also has not been iodised and without anti-caking agents). Electro-chlorination has the advantage of avoiding the transport and storage of dangerous goods, therefore minimising safety risks. A further advantage for small systems is not having to manage the logistics of storing containers of sodium hypochlorite that lose strength over time and generate chlorates, especially if not stored under cool conditions.

An alternative approach is in-line electro-chlorination (also known as continuous electro-chlorination) which may be practical in instances where there is sufficient background concentration of chloride in the water. It must be noted however that although in line electro-chlorination requires no salt to be purchased, the operating costs can be high because chlorine generation is less electrically efficient at the low chloride concentration in fresh water. For this reason, potential in-line electro-chlorination applications will generally be limited (mostly to smaller installations) because whole-of-life costs are typically higher than for brine electro-chlorination. It may also provide advantages from oxidative treatment of the water, which could reduce the need for other treatment chemicals.

Brine electro-chlorination systems produce dilute sodium hypochlorite solution (<1.0 % m/v concentration) with nominal production strengths typically in the range of 0.6 to 0.8% m/v depending on electro-chlorinator supplier (note that 0.8% m/v is equivalent to 8 g/L or 8,000 mg/L). Unlike 12.5% sodium hypochlorite, the relatively low concentration (0.8%) of sodium hypochlorite is not vulnerable to gas-locking of the dosing system, and the lower concentration significantly reduces the rate of strength degradation and reduces amount of chlorate formation.

1.4.1 Salt grade

There is an important distinction between salt that is food grade and table salt: it is imperative that salt used for electrolysers has not been iodised and has no anti-caking agents, which contain material such as iron that may irreversibly foul the specialty anode coating in electrolysers.

The salt should not[2] contain more than:

- 0.25 mg Iron (Fe)/kg of salt; and
- 0.50 mg Manganese (Mn)/kg of salt

Low bromide concentration is important for limiting potential to generate bromate.

Cost of salt will be a combination of the product cost and the delivery cost. Delivery sizes will require consideration of the storage time limitations (related to caking risk), which are specific to each grade of salt, before the salt is loaded into the brine saturator. Caking risk is a function of initial moisture content and the form of the salt. For a given moisture content, fine grain salt is the most prone to caking, with coarser salts experiencing lower rate of caking, or ease in breaking apart. Salt Pellets or tablets offer significant resistance to caking, and can last significantly longer in storage, plus avoid problems with salt hang up in brine saturators; however, the tablets are the most expensive form of salt and are not produced locally.

[2] DIN EN16370 and DIN EN 14805 suggests a maximum iron level of 2 mg/kg. Gaffey electro-chlorinator product information indicates their maximum iron level is 10 mg/kg.
Manganese is also a potential contaminant that could impair the anode coating. Maximum manganese level is 1 mg/kg.
Bromide should also be at a minimum.

The descending cost-effectiveness (indicative pricing current as of January 2024) of various grades of salt is:

Washed Crude Salt

- Bulk washed crude salt (e.g. delivery as a truck load of loose product) – product cost ~$150/tonne plus delivery cost
- Washed crude salt (bulki-bags) – product cost ~$300/tonne plus delivery cost

A constraint on the use of washed crude salt is that it has a moisture content of about 2% which results in it tending to stick/cake together if stored more than a couple of weeks before loading into a brine saturator. A reason to consider longer storage times is primarily because delivery costs can be a significant proportion of the overall cost for a small number of bulki-bags (e.g. delivery cost is minimised at ten tonnes per delivery). A secondary reason to consider on-site storage in bulki-bags is where it is not feasible to have a larger brine saturator or brine storage tank.

Water Softener Salt

- Water Softener Salt (bulki-bags) – product cost ~$354/tonne (based on delivery to Woodman Pt) plus delivery costs.

Water softener salt has larger crystal sizes than washed crude salt, so although it has similar moisture content it is feasible to store in bulki-bags for up to two months.

Flossy Salt

- Flossy Salt (bulki-bags) – product cost ~$400/tonne plus delivery costs.

Although fine-grained, this is kiln-dried salt (i.e. flossy salt) which provides storage times up to six months, and is suitable where long storage times are necessary.

High Purity Salt

- Pharmaceutical Grade Salt (bulki-bags) – product cost >$1,000/tonne plus delivery costs. Note that this is an imported product, so is vulnerable to supply chain disruption.

Storage time: Granular dried salt can be stored for up to six months. Shelf-life before caking occurs may be influenced by humidity in the storage area.

Although high purity salt minimises Clean-In-Place frequency, the high cost premium for this salt grade may not justify the reduction in CIP chemical costs.

High purity salt is also available in tablet form, which provides advantages in handling and avoiding hang up in salt saturators. Note that Soft-Sel Pluss salt tablets is an imported product, so is vulnerable to supply chain disruption.

- Soft-Sel Pluss salt (round tablets) in 10 kg bags available from WA Salt Supply - product cost $16/bag i.e. $1,600/tonne plus delivery costs.
- Soft-Sel Pluss salt (round tablets) in 1,000 kg bulkibags available from WA Salt Supply - product cost $1,350/bag i.e. $1,350/tonne plus delivery costs..

Storage time: Salt tablets can be stored for greater than six months.

1.5 Related Drawings

Refer to section 15.

1.6 Water Corporation's Level of Service (LOS)

Disinfection treatment process is critical and mandatory to the production of safe drinking water. Redundancy provisions are therefore critical and are covered in section 1.7.3.

For primary disinfection sites, a failure of the sodium hypochlorite dosing system shall initiate automatic stoppage of flow in the water main being dosed.

1.7 Design Philosophy

1.7.1 Process selection

Water source quality - Brine electro-chlorination (BEC) results in a small increase in salinity and sodium concentration of the recipient water. This may require care with operation of the wider system such as adopting borefield operating strategies that ensure bore combinations within salinity and sodium targets after making allowance for the additional salinity and sodium contributed by the sodium hypochlorite dosing. A relative advantage of in-line/continuous electro-chlorination (CEC) is that it does not increase salinity or sodium content.

Note that a DAR template for chlorination projects (Nexus # 45587152) is available for use in selecting the preferred form of chlorine.

Capital cost estimation – Factors potentially in favour of CEC are relatively small footprint for equipment and no need for salt deliveries and associated brine batching facilities.

Operating cost estimation/electricity – The electrical efficiency of electro-chlorination is proportional to the chloride concentration in the feed to the electrolyser. Since BEC uses brine, electrical efficiency is high (4.1 – 4.4 kWh/kg Cl_2) whereas CEC using background chloride has relatively low electrical efficiency (of the order of 20 kWh/kg Cl_2).

Operating cost estimation/salt – The grade of salt selected will impact on operating cost and on shelf-life of the salt. Design shall optimise whole-of-life costs for the capacity of the salt storage area (within the constraint of the shelf-life for the grade of salt) and the brine storage capacity (larger capacity allows batching more salt into brine thereby overcoming the shelf-life constraint of the salt).

1.7.2 Hydrogen Gas

Hydrogen gas is generated as a by-product of electro-chlorination and shall be vented outside of the building to atmosphere in a location above roof height, away from likely sources of ignition. Some models of electro-chlorinator evacuate all hydrogen (i.e. fully de-gas the hypochlorite solution) prior to the storage tank. For all other electro-chlorinator models, the safest place to separate hydrogen gas from the hypochlorite solution is the hypochlorite storage tank, where enough ventilation can be provided to remove not only the bulk hydrogen gas, but also the entrained and dissolved hydrogen over time. Small capacity electro-chlorinators present a lower hydrogen explosion risk because the quantity of hydrogen is relatively small, though the same principles are applied for managing the hazard. A Hazardous Area dossier and drawings shall be included in the design in compliance with Water Corporation Hazardous Area Management System (HAMS) requirements.

Hydrogen gas risk mitigation includes a venting system, inclusion of hydrogen gas sensors within electro-chlorinator rooms (number and location of sensors to be based on potential sources of hydrogen leaks) and definition / management of defined hazardous areas zones.

Room ventilation shall be provided in accordance with section 1.7.2.5 to avoid risk of accumulating hydrogen gas leaks to a potentially explosive concentration.

An external red strobe light shall be provided for indication of hydrogen leak detection.

1.7.2.1 Electro-chlorinator Cells

The gas exiting the electro-chlorinator cells is less than 3% hydrogen, combined with air and oxygen—also produced by the cell. This is just below the lower explosive limits (4.0% v/v in air and is 4.65% v/v in oxygen).

To eliminate explosion risk, this concentration must be reduced further, either by venting directly in the exit pipework or removal via a storage/degassing tank.

Cell design and installation must ensure that hydrogen cannot accumulate in the cell. All vent piping must be such that it prevents any entrapment of hydrogen gasses during or after operation. Low air flow rate though the vent system shall trigger an alarm and shutdown sequence. Low water flowrate through the cell must trigger shutdown and an alarm if below threshold setpoints.

Good cell design also reduces hydrogen masking of the electrodes. Masking will reduce overall efficiency of the system.

For optimal safety, the generation cycle shall end with a softened water flush to purge all hypochlorite and hydrogen from the electrolyser cell. The preferred arrangement for introduction of dilution and flushing water should avoid penetrations of the cell housing to reduce risks of leaks developing over time.

1.7.2.2 System Piping Design

Models of electro-chlorinator that evacuate all hydrogen prior to the storage tank may use pipework that slopes down towards the storage tank. For all other models of electro-chlorinator, the solution must flow from the cells to the product tank in straight outlet piping, at least 2% inclined, with no isolating valves, to avoid hydrogen traps.

1.7.2.3 Storage tank

The minimum requirement is passive ventilation of the hypochlorite storage tank to safely exhaust any hydrogen to outside the building.

Blowers are required for electro-chlorinator models that do not evacuate all hydrogen prior to the storage tank. The blowers shall be used to ensure that the hydrogen concentration does not accumulate to an explosive level in the vapour space of the hypo storage tank. While it is expected that passive ventilation may outpace the rate of hydrogen generation in very small capacity systems, the requirement for blowers is conservatively applied to all systems to ensure safety. The electrolysers shall be interlocked so that they only run when the blowers are in operation. To save electricity, the blowers should only run while hydrogen is expected to be present; run-on time of the blowers after the electrolysers have stopped shall be sufficient to purge any remaining hydrogen from the hypo storage tank. An airflow sensor on the vent line must be fitted to initiate a standby blower or shut down the electro-chlorinator if the flow is interrupted. Redundancy in the form of installed duty/standby blowers shall be provided for medium/large capacity electro-chlorination systems unless it can be demonstrated that downtime of the chlorination system during repair/replacement of a blower is acceptable. Small capacity systems may provide redundancy as a spare non-installed blower to minimise complexity and footprint.

Backup power is not considered necessary for the blowers i.e. explosive concentration of hydrogen is not expected to accumulate on power failure because the electrolysers would stop generating hydrogen and passive ventilation due to low density of hydrogen would be sufficient to remove the remaining hydrogen through the tank vent.

Tank ventilation by blowers provides fail safe, positive air displacement and dilution by pushing fresh air into and then out of the tank and vent lines. An air blower usually provides tank headspace dilution of 50 to 100 times. The tank headspace usually provides at least three minutes detention. By contrast, hydrogen removal by venturi (i.e. vacuum) is not fail safe. For example, a vent line failure between the venturi and tank is possible without being detected by the air sensor.

1.7.2.4 Hydrogen Vents

The hydrogen ventilation must ensure high dilution (so that hydrogen concentration remains well below the Lower Explosive Level).

1.7.2.5 Electro-chlorinator Room Ventilation

The electro-chlorinator room must have effective ventilation in accordance with section 2.5.

1.7.2.6 Hydrogen Leak Detection

A hydrogen gas detector must be installed in accordance with section 4.3.

1.7.3 Redundancy

Continuity of dosing is necessary to providing continuity of water supply. Potable water systems are generally required to have on-line duty/standby equipment for all critical equipment (pumps, electrolysers and dose panels) – this requirement shall be identified/confirmed in the ARB.

The ARB should also identify the preferred redundancy strategy:

- Spare equipment (typically preferred for small capacity systems) –For small systems where the hypo storage tank volume is sufficient for the time to mobilise maintenance personnel, it may be more practical and cost effective to provide spare equipment for the brine and hypo batching systems rather than installing duty/standby pairs. Use of non-installed spares minimises footprint, complexity and cost.
- Duty/standby trains (typically preferred for medium and large capacity systems) – Simplicity of pipework, valving and control functionality is achieved by providing redundancy in the form of two parallel trains (i.e. 2 x 100%, which normally operate as duty/standby) from the electrolyser through to and including a hypo storage tank dedicated to that train. This simplicity reduces cost compared to full duty/standby equipment, but introduces single points of failure into each train, and so does not provide the same level of availability as each item of equipment being duty/standby. The hydrogen management control philosophy of some electro-chlorinator suppliers may be based on hydrogen removal in a "primary" tank, which may favour use of dedicated duty/standby trains because this avoids the requirement for thorough testing of non-standard control logic to verify operation of safety features with duty/standby equipment.
- Duty/standby equipment – Providing duty/standby equipment achieves the highest level of availability though has the disadvantage of requiring more complex control functionality. This approach also increases cost, complexity and footprint due to the compounding effect of having duty/standby blowers for each hypo tank.

Redundancy (backup) of the brine saturator, softener, chiller, electrolyser package (including proprietary control panels) and hypochlorite storage tank shall be determined during the Approved Requirements Baseline (ARB) workshop with consideration of the following:

- What is the consequence (i.e. outage duration and impact of an outage of that duration) if the equipment becomes a single point of failure in the electro-chlorination system?
- Is the installation for a Primary or Secondary disinfection site?
- What is the criticality of the site?
- What is the duty cycle of the electro-chlorinator?
- How many days storage of dilute sodium hypochlorite at peak demand (weekly) will be required (bearing in mind that weak (i.e. ~0.8%) sodium hypochlorite has a much longer shelf life than 12.5% solution).
- Other available mitigations / contingencies against long term outage of an electro-chlorinator (e.g. cost and practicality of making provision for batching from 12.5% sodium hypochlorite[3], critical spares availability and holdings).
- The decision on level of redundancy for reuse systems shall be based on acceptable downtime of the effluent disposal system (e.g. upstream risks such as effluent storage overflow; downstream risks such as turf dying).

The minimum redundancy requirements include:

- Chiller - Redundancy requirements shall be based on advice from the electrolyser supplier of the expected performance consequences from unmitigated temperature of the make-up water

[3] This would generally not be cost-effective except at sites where a bunded chemical tanker unloading area already exists.

(i.e. a standby chiller may not be required if the supplier confirms it is tolerable for short-term operation without a chiller while a new chiller is procured).

- Softeners - duty/standby - Consider economics of alternatives such as 2 x 100% versus N+1 e.g. 3 x 50%, 4 x 33%, etc. Dispensation for single duty may be sought (from the Senior Principal Engineer - Water Treatment) if it is demonstrated that it is acceptable to incur the extended downtime for repair/replacement of this equipment. In addition to redundancy benefits, twin softeners are preferred because it allows regeneration/backwashing to occur without disruption of electro-chlorinator operation.
- Brine pumps - duty/standby - to deliver brine to the electrolysers. Redundancy of brine pumps for small electro-chlorination systems is best achieved with a non-installed spare pump. Note that systems which use an ejector on the softened water supply to deliver brine to the electrolysers, should similarly be provided with non-installed spare equipment such as automatic valves.
- Electrolysers - duty/standby Consider economics of alternatives such as 2 x 100% versus other ways of providing N+1 e.g. 3 x 50%, 4 x 33%, etc.
- Hypochlorite tanks – preferably, at least two[4] - Redundancy of product tanks is desirable to provide continued operation while one tank is unavailable (during pipework repairs or tank replacement) or offline for cleaning (if required as part of chlorate management), except at sites where it is tolerable for the hypochlorite dosing to not be operational during the typical duration of activities such as tank replacement or cleanout. Where two hypo storage tanks are provided, they shall be supplied by separate electro-chlorination systems, which avoids potential hazardous area classification of a three-way valve (that alternates feed of hypo into each tank).
- Dose panels - duty/standby – providing only a duty panel may be considered in very low criticality applications such as reuse sites if they can tolerate the expected outage duration.

Apart from the infrequent requirement for pipework repairs or tank replacement, redundancy of hypochlorite tanks facilitates maintenance such as cleaning out the tank and allows minimising chlorate formation by full utilisation of tank contents in an alternating sequence rather than continually topping up tanks that are close to full. A disadvantage of drawing down the duty tank is that the available reserve storage is less than if the product tank is continually topped up, so this strategy should only be adopted where necessary to remain within chlorate guideline levels (refer to section 1.7.4). For all other equipment, ensure spares are locally available and that the design and layout suits easy replacement (including for tank replacement) with minimal disruption of other equipment and pipework.

1.7.4 Chlorate

The Australian Drinking Water Guidelines (ADWG) do not (as at 2023) provide a guideline value for chlorate. For chemical substances where an Australian drinking water guideline is not available, ADWG recommends selecting a relevant national or international guideline for guidance on a suitable value. The most relevant guideline is the WHO provisional guideline value for chlorate of 0.7 mg/L though the European Union directive[5] on the quality of water for human consumption requires aiming for 0.25 mg/L where feasible.

Design of electro-chlorination systems for drinking water plants shall minimise chlorate formation as far as reasonably practical. The Water Corporation's Criteria for Drinking Water Supply document requires to "Plan, design and operate treatment plants to reduce chemical concentrations to 80% of the current health guideline"; hence, the design target for water supplied to customers is to not exceed a

[4] Requests to use a single hypochlorite tank (e.g. at sites with low chlorate risk due to low chlorine dose rate or intermittent operation such as reuse disinfection), together with proposed alternative strategies for maintenance such as cleaning out the tank, shall be provided to the Senior Principal Engineer Water Treatment.

[5] The European Union requires Member States by 12 January 2026 to comply with 0.25 mg/L chlorate, though allows 0.7 mg/L chlorate where the disinfection method generates chlorate and states that where possible, without compromising disinfection, Member States shall strive for a lower value. Link to European Union directive on the quality of water for human consumption

chlorate concentration of 0.56 mg/L (i.e. 80% of 0.7 mg/L). This design target needs to consider the cumulative chlorine dose (including potential impact of chlorination upstream and re-chlorination downstream) and the potential accumulation of chlorate every time the water is chlorinated or re-chlorinated (for example, there are schemes where water may be chlorinated five times between source and customer, including a high initial dose for oxidation of iron and manganese).

Chlorate formation in a 0.6% (6,000 mg/L) sodium hypochlorite solution is typically less than 300 mg/L; hence, risk of chlorate concentration in the drinking water is approximately 5% of the applied chlorine dose. Sites that use high chlorine dose rates (e.g. for oxidation of iron and manganese) may require careful management (such as drawing down duty product tank to avoid mixing new and old hypochorite, and tank cleaning to remove any sediment) to minimise chlorate formation and thereby remain below the 0.56 mg/L maximum chlorate concentration.

Typically, if the cumulative chlorine dose (from water source to customer) is below 11.2 mg/L (since 0.56 mg/L÷5% = 11.2 mg/L), then it is unlikely that the 0.56 mg/L maximum target chlorate concentration would be exceeded, and thus the design would not need to include features to minimise chlorate formation.

1.7.5 Design for Drinking Water Use

For any plants where the sodium hypochlorite is used as part of a potable water treatment process, all materials that may encounter the sodium hypochlorite or its generation (i.e. brine batching, softener, chiller, electrolyser, hypo storage tank, hypo dosing) shall be compliant with AS4020. Materials without AS4020 approval but recognised to an equivalent international standard (e.g. NSF-61) will only be accepted if listed as Approved Materials in Schedule 5 of the WA Department of Health document Materials, products and substances in contact with drinking water.

1.8 Standards

This design standard refers (directly or indirectly) to the following standards and regulations:

1.8.1 Australian & International Standards

AS 1111.1	ISO metric hexagon bolts and screws – Product grade C – Bolts
AS 1112.3	ISO metric hexagon nuts – Product grade C
AS 1170	Structural design actions – General principles
AS 1214	Hot–dip galvanized coatings on threaded fasteners (ISO metric coarse thread series)
AS/NZS 1170.1	Structural design actions – Permanent, imposed and other actions
AS 1158.3.1	Lighting for roads and public spaces – Pedestrian area (Category P) lighting – Performance and design requirements
AS 1318	SAA Industrial safety colour code
AS 1319	Safety signs for the occupational environment
AS 1345	Identification of the contents of pipes, conduits and ducts
AS 1657	Fixed platforms, walkways, stairways and ladders – Design, construction and installation
AS 1680.2.4	Interior Lighting – Industrial tasks and processes
AS 1688.2	The use of ventilation and air-conditioning in buildings – Part 2: Ventilation design for indoor air contaminant control
AS 2032	Installation of PVC pipe systems

AS 2293.1	Emergency escape lighting and exit signs for buildings – System design, installation and operation
AS 2634	Chemical plant equipment made from glass fibre reinforced plastics (GRP) based on thermosetting resins
AS 3500	National plumbing and drainage code (provision of backflow prevention devices)
AS 3780	The storage & handling of corrosive substances
AS 3879	Solvent cements and priming fluids for PVC (PVC-U and PVC-M) and ABS pipes and fittings
AS 3953	Construction of buildings in bushfire-prone areas
AS 4020	Testing of products for use in contact with drinking water
AS 4041	Pressure piping
AS/NZS 4087	Metallic flanges for waterworks purposes
AS/NZS 4680	Hot-dip galvanized (zinc) coatings on fabricated ferrous articles
AS/NZS4766	Polyethylene storage tanks for water and chemicals
AS 4775	Emergency eyewash & shower equipment
AS 5240	Cranes – access guards and restraints
ASME RTP-1	Reinforced Thermoset Plastic Corrosion-Resistant Equipment
BS EN 13121-3	GRP Tanks and Vessels for use above ground. Design and workmanship.
BS 4994	Design & Construction of Vessels & Tanks in Reinforced Plastics
DVS 2205	Design Calculations for Containers & Apparatus Made of Thermoplastics
DVS 2207	Welding of Thermoplastics

1.8.2 Water Corporation Standards

DS 20	Electrical Design Process
DS 22	Ancillary Plant & Small Pump Stations – Electrical
DS 24	Electrical Drafting
DS 26	Type Specifications - Electrical
DS 27	Regulating Valve Control
DS 28	Water and Wastewater Treatment Plants - Electrical
DS 30	Mechanical General Design Criteria & Glossary
DS 31-01	Pipework
DS 31-02	Valves & Appurtenances
DS 32	Pump stations
DS 33	Water Treatment Mechanical Design Standards
DS 35	Ancillary Plant Mechanical Design Standards
DS 40	Design Process for SCADA Works
DS 40-06	Software Change Control
DS 40-08	Standard for the Control of Chemical Dosing

DS 40-09	Field Instrumentation
DS 62-01	Site Security, Public Safety and Emergency Treatments
DS 78	Chemical Dosing
DS 79-01	Design of Chemical Systems - Legislative Requirements and General Principles
DS 79-02	Emergency Safety Showers and Eyewash Stations
DS 79-03	Chemical Barrier Protection
DS 79-04	Chemical Signage Labelling and Markers
DS 79-05	Small Chemical Storage & Dosing Systems – Basis of Design
DS 80	WCX CAD Standard
DS 81	Process Engineering
DS 95	Standard for the Selection, Preparation, Application, Inspection and Testing of Protective Coatings on Water Corporation Assets
DS 100	Suspended Flooring (Grid Mesh and Chequer Plate)
SPS 498	GRP Chemical Storage Tanks
WS-2	Welding & Joining Specification – Thermoplastics
	Strategic Products Register

2 CHEMICAL BUILDING

2.1 General

The most economical approach for small and mid-sized electro-chlorination systems is typically to factory build them within a pre-fabricated building. General requirements that apply to pre-fabricated treatment modules can be found in the template construction specification, PTM (Nexus # 101394855). Note that PTM is an editable template and requires customisation for the type of treatment/chemical specified.

- Action: Designer/Specification author to customise the PTM template for the project.

Although housing treatment facilities in sea containers can be accepted for emergency treatment units that are designed to be frequently re-deployed to multiple sites, they have limited asset life; hence, all other pre-fabricated treatment modules shall be constructed in pre-fabricated buildings, not in sea containers.

The function of the building is:

a) To protect the equipment inside from UV degradation and excessive temperature;

b) To exclude rainfall from the bund, therefore eliminating the need to size the bund with additional capacity for rainwater;

c) To safeguard the assets in line with the Corporation's security principles[6].

d) To shield the stored sodium hypochlorite from heat and UV light, thus minimising its degradation rate;

[6] DS62 Site Security, Public Safety and Emergency Treatments.

2.2 Layout and Design

To maximise electrical safety and equipment life, the electrical switchboards and OIP/control cabinet shall be in a separate room from the storage and dosing area. For proprietary systems that include a control panel within the electrolyser skid, then if the control panel is not readily relocatable to the switch room then this is acceptable on the basis that the supplier will have engineered their system (i.e. to partition electrical equipment from the hydraulic section) to minimise risks to electrical safety and equipment life.

Considering the relatively low risk posed by 0.8% sodium hypochlorite, a viewing window is not required between the control room and dosing room. This allows more wall space (in both the switchroom and the dosing room) which provides opportunity for a more cost-efficient design.

The internal layout shall be as uncluttered as possible with all piping located around the periphery of the building to give a tidy arrangement with good access to all components for operation and maintenance. The internal walls of the room shall be designed to minimise the number of protrusions and thereby provide as much flush wall space as possible to facilitate wall mounted equipment, instruments, switchboards (where the Senior Principal Engineer Water Treatment has approved switchboard installation in the chemical storage room), control panels and simplify pipe and cable routing. The piping shall also be appropriately located to allow easy access to equipment and valves and facilitate unobstructed cleaning of the work areas. It is preferred to design layout to avoid ramps; however, where this is not practical then include ramps at changes in floor level for easy moving of equipment in and out of the building.

The design and layout of the facility shall include consideration of section 7.2.1 of AS 3780. This shall include sufficient space between bund walls, storage areas and other structures to allow access for maintenance and during emergencies. Specifically for maintenance access, an unobstructed clearance of not less than 1.0 m shall be provided in front of the dosing pump/panel and other equipment, with a minimum 2.1 m head clearance.

The building, inclusive of doors, windows and ventilation openings shall be designed to withstand bushfires in accordance with AS 3959.

The building shall also be designed to exclude wildlife, insects, and vermin. Measures shall include door seals, tropical midge mesh on ventilation openings, and brushware around the edges of roller shutters to impede the ingress of vermin.

The building shall be designed so that the brine tank, electrolysers and storage tank(s) can be removed and replaced through a doorway (e.g. roller door for large tanks). For facilities with two or more storage tanks, the design shall allow for replacement of any tank while the others remain in operation. To minimise costs related to building size, alternatives for large systems may include outdoor brine storage though this may make it more difficult to ensure feed to the electrolyser is within the desired temperature range. Locating hypochlorite tanks outdoors incurs multiple disadvantages such as temperature control for chlorate management and maintenance burden related to rainwater and wind-borne debris in bunds. While locating hypochlorite tanks outside is not recommended for drinking water applications, these issues may potentially be tolerable at some sites such as large wastewater plants.

2.3 Materials of Construction

Areas that may be exposed to accidentally spilt salt or brine (e.g. lower parts of building walls) shall be suitably protected (e.g. shielding - such as plastic skirting - or coating, and use of raised edges to contain salty washdown within a bund) to avoid corrosion.

Various materials of construction may be appropriate for the salt storage/brine batching/sodium hypochlorite room e.g. metal clad, concrete, or masonry walls. Choice of building materials will need to consider the corrosive properties of salt, spilled salt washdown, brine and sodium hypochlorite (including fumes), as well as architectural and security requirements at the site. Consideration should be given to materials of wall panels, roof and doors including their insulation features and seals to minimise transfer of outdoor heat into the storage and dosing room.

2.4 Lighting

Internal lighting and external entry lighting shall be provided, all with easy and safe access for lamp maintenance. These lighting levels and other characteristics shall be designed to the requirements of DS28. The building shall be equipped with internal emergency lighting with battery backup.

2.5 Ventilation

Ventilation rationale and requirements are described in the following sub-sections.

2.5.1 Hydrogen explosion risk mitigation

It is essential that the electro-chlorinator room has effective ventilation to reduce risk that potential hydrogen leaks accumulate to an explosive concentration.

2.5.2 Sodium hypochlorite degradation

Sodium hypochlorite degrades faster at higher temperatures, although the rate of degradation of 0.8% solution is substantially lower than 12.5% solution. Sodium hypochlorite should be stored in rooms that are kept cool or at least well-ventilated.

2.5.3 Chlorinous fumes

Sodium hypochlorite fumes are considered Type A effluent as defined in AS 1668.2. If no leaks are present in the system and any spills are cleaned up thoroughly, then natural ventilation complying with AS 1668.4 will be sufficient to manage chemical fumes and corrosion within the chemical storage room. However, switchable mechanical exhaust systems shall be provided and used whenever personnel are in attendance, plus the personnel door shall be latched open whenever the electro-chlorination room is attended.

2.5.4 Ventilation system design

Ventilation shall be accomplished in accordance with the Water Corporation's mechanical standards (refer DS30-02). Natural ventilation is preferred over mechanical ventilation for continuous ventilation requirements as it does not require redundancy considerations, nor does it incur running costs; hence, the mechanical ventilation will normally only operate while the room is occupied.

The ventilation system design shall comply with the requirements of AS 1668 and should incorporate the following key features:

a) The minimum total area (wall and roof vents combined) of natural direct ventilation external openings shall be 10% (based on a Class 8 building) of the floor area in the room to be ventilated.

b) Openings for natural ventilation should be positioned on opposite sides of the room to maximise cross-draught. Consideration should be given to enhancing natural ventilation rate by positioning inlet vents on the side of building exposed to prevailing winds. Openings shall consist of louvred vent panels to exclude rain and minimise dust ingress with tropical midge mesh inside to prevent vermin ingress.

c) Openings for natural ventilation shall be provided at high and low levels to maximise the benefits of thermal effects and to minimise heat accumulation. The high-level vent shall not be located any lower than 0.5 m from the ceiling and be as high as possible (the higher the better) in order to avoid accumulating hydrogen gas at any level in the room.

d) Natural ventilation may be supplemented by well positioned whirlybird(s) to remove any trapped hydrogen in the ceiling space.

e) The mechanical exhaust system shall be designed to achieve the greater of

   - 5 L/sec per m^2 of floor area (based on Plant Room enclosure type in AS1668.2); and

- ensure hydrogen concentration in the room cannot exceed 2%.

f) The exhaust fans shall be located near the floor (to remove chlorinous fumes which are denser than air, whereas the high-level natural ventilation outlets will remove hydrogen gas) and air shall be discharged vertically at a high level above the building with a discharge velocity not less than 5m/s to prevent further contamination of the storage areas. The discharge outlet shall have tropical midge mesh to prevent vermin ingress and be designed to prevent entry of wind-driven rain.

The mechanical exhaust system shall be interlocked to automatically operate when the building security system is disarmed and able to be manually activated by a switch located in the entry vestibule/electrical room. Consideration could be given for the exhaust fans to be controlled by a temperature switch located inside the building so that the fans would automatically operate to cool down the Hypo storage tank area when a temperature setpoint is reached.

At sites where ambient temperature is normally high (sufficient that stored hypochlorite temperature is expected to exceed 30 degrees Celsius for months at a time), the use of air-conditioning or other means[7] of cooling the tank contents may reduce the chlorate formation rate. However, the swapping between duty/standby storage tanks will assist minimising chlorate formation, which may limit this issue to potable water production sites most vulnerable to chlorate concentration supplied to customers because high chlorine dose rates are used (e.g. total dosage for oxidation and for chlorination). If this is to be considered it will require cost analysis on a project-by-project basis. Ventilation requirements would then be determined (and may possibly deviate from above) based on the temperature management strategy and HVAC design.

2.6 PPE and First Aid Storage

The facility shall include generous room to store the PPE and first aid equipment that is required for use in the chemical store and/or dosing room. This space may be provided in the control room, but it shall be near the chemical store and/or dosing room. An exception to this requirement may be granted for systems located in operating regions where operators carry chemical PPE and first aid kits in their vehicles.

2.7 Personnel Doors

Personnel doors shall be designed to meet the required fire rating. They shall open outwards, and the travel path of the doors shall not be restricted by external features on the building or any other structure. A hydraulic-operated door anti-slam closer/dampener shall be provided for each door leaf.

When determining the location of personnel access doors to the storage/dosing room, the required separation and segregation distances outlined in AS 3780 must be maintained. If the floor area is greater than $25m^2$ then two means of access/egress are required.

Doors for the electro-chlorination/sodium hypochlorite room (i.e. with potential for chlorine gas fumes) shall normally be held open with hooks for the duration of personnel working inside, and therefore do not require crash-bar emergency exit hardware. Switchboard/control rooms shall have crash-bar emergency exit hardware fitted to all hinged doors (internal and external entry doors).

Normal entry to each room shall be by personnel doors, which will provide access to open any roller doors from the inside wherever practical. This is to avoid having external locks on roller doors.

Each personnel door is to be a structurally reinforced, steel sheet faced, waterproof security door with three heavy duty hinges, either recessed or with non-knockout pins, and security hinge bolts. Provide a leading edge for entire height of door for protection of the tongue and strike plate, plus to exclude opportunity to use a lever to force the door open (i.e. anti-jemmy edge).

[7] E.g. insulate storage tank, and if necessary also recirculate tank contents through a chiller.

The door shall be fitted with a heavy-duty stainless steel dead-latch keyed to the Water Corporation's specification, and catches for holding the door in the open position. Rebound rubbers shall be provided externally to prevent the doors swinging fully open and knocking the walls. Pull handles shall not be installed on the outside of the door (due to risk they may be used by unauthorised intruders to lever open the door).

Each door shall have a single action stainless steel (Lockwood 002) door handle on the inside, which shall be lever action for safe egress purposes. External handles are not to be used; instead, flush-mounted keying cylinders shall be used to open the doors from outside. On double-doors, there needs to be a strap bolt or top bolt top and bottom of the fixed leaf. With over-sized doors there needs to be a single bolt mechanism that simultaneously engages top and bottom on the fixed leaf.

Personnel doors shall be Lietzke Security 1 Door or equivalent approved with Colorbond finish to match external and internal wall panels.

Door framing shall be Lietzke Flange Fit Steel Frames or similar approved, finished to match wall panels.

2.8 Door to Storage/Dosing Room

Door access shall be provided to allow salt deliveries to the brine batching area. The doorway width shall be sufficient to also allow movement of equipment (i.e. including tank replacement) into and out of the storage/dosing room.

Where used, roller shutters (rather than single curtain sheet roller doors) shall have thermal insulation in the interlocking slats. The operation of these doors shall be automated using heavy duty motors and they shall be equipped with manual override. These doors shall be industrial strength with galvanised fixtures and guides.

2.9 Platforms and Stairways

Platforms and stairways shall comply with DS30-02, DS100, AS 1170, and AS 1657 and be constructed from FRP when present in the storage/dosing room.

Any cut-outs provided to allow operation of valves below the platform shall not create a tripping hazard or obstruct access/egress ways. Where cut outs are required in the FRP grating, for access to equipment such as valve spindles or for intersection of pipework, proper strengthening and support of the modified grating shall be carried out by qualified designers and installers to ensure its integrity is not compromised. Any open holes in the grating as the result of the cut out shall be covered with a removable cut-to-shape FRP grating panel securely supported and clipped. All modification work to the grating shall comply with the prevalent OSH requirements for safe access of Grid Mesh Landings.

Equipment and valve spindle ends shall not protrude out of the FRP grating where it could cause a tripping hazard.

2.10 Accessibility

A minimum clearance of 1m shall be provided around all sides of equipment that require maintenance access (i.e. the 1 metre clearance is only required on the sides that personnel need to be located during maintenance – in many instances this will only be on one side of the equipment), plus consideration given to a greater clearance where maintenance activities require it.

All valves and instruments shall be accessible without having to enter the bund. Bund sump instruments and equipment may be permitted to have bund access if approved. Pipework in the bund shall be arranged to be readily accessible by minimising length of pipework that requires removal of gridmesh flooring to repair the pipework (refer section 5.1).

3 BRINE BATCHING REQUIREMENTS

Brine solution is batched from dry salt for two purposes:

- as the feed to the electrolyser cells to produce the dilute hypochlorite; and
- as the solution that is periodically fed to the softener units to regenerate the softener resin.

3.1 Salt deliveries

Consider how the salt will be off-loaded:

Large sites - Bulk deliveries of loose product

To minimise Operator involvement with product loading, the preferred delivery format (if available) is pneumatic unloading whereby the product is blown into a storage silo. The salt conveyance pipe should be manufactured from a high-grade stainless steel with long-radius elbows and an air/water flushing connection for clearing line blockages or salt accumulation. Alternatively, tip truck delivery into a below ground vat could be used. The vat would need to be designed to not accumulate anything else such as rainfall/runoff, dust, dirt, etcetera.

Medium sites - Bulki-bag deliveries

- Does the site have a tele-handler or forklift?
- Will the delivery company need to bring a forklift?
    - If using a forklift, then a firm surface (bitumen or concrete) is required for forklift operation.
- Will the site have a gantry crane that can unload salt directly from the truck?

Small sites - Deliveries in small (15 kg) bags

- Will the delivery company have provision to offload a pallet of salt bags?
- Will the pallets be stored in the electro-chlorination building or elsewhere? Consider how to move the pallet in and out of the electro-chlorination building (e.g. smooth hard surface suitable for operation of a pallet jack).

3.2 Salt storage

Cost of salt is a combination of the cost for the salt itself and the delivery costs; hence, large but infrequent salt deliveries can minimise overall cost; however, delivered salt has a shelf-life before it becomes caked together. It is important to batch the salt into brine within the shelf-life. Provision of a larger brine storage tank provides the opportunity to batch the salt into brine shortly after delivery, thereby minimising potential for caking of the salt during storage. Prompt batching avoids shelf-life constraints which provides opportunity to use a lower cost grade of salt.

Metropolitan and large town systems

- The preference is for bulk delivery and unloading by the supplier/delivery contractor without requiring operator attendance. Examples are:
    - tip truck delivery of salt to a below ground vat for very large capacity sites; and
    - pneumatic delivery of salt into a FRP silo or brine batching tank.

By contrast, bulki-bags delivered with a tail-lift truck are least preferred because:

- Operator attendance is required to crane the bulki-bags into position;
- The system of gantry crane, hopper, screw conveyor is complex and, since the gantry lift requires taller buildings, the building height and equipment complexity increase capital cost;

- The bulki-bags are a waste stream (which ideally should be avoided).

<u>Small capacity systems</u>

- Salt storage shall be in a secure area. Salt shall be kept out of direct sunlight, in a cool, dry, location to prevent solidifying of product.
- Salt is delivered in 15 kg bags on a pallet.

3.3 Saturator tank

The saturator tank configuration is important to avoid salt "hang-up" (design the tank so that there is nothing for the salt to "sit on" which stops it moving downwards to mix with the water) and ensure consistent brine quality to the electrolyser. A tank incorporating a gravel layer above a plenum floor (with filter nozzles) underdrain system is preferred due to the more consistent brine solution produced and because it is less vulnerable to damage during salt loading and avoids risk of salt clogging underdrains and plumbing. Plenum floor style underdrains are significantly less vulnerable to damage than other configurations such as laterals, and plenum floors provide optimal flow distribution which reduces the likelihood of preferential hydraulic pathways (also known as "ratholing") forming through the salt. Soft water shall be added through a ring distribution header to spread the water evenly over the dry salt.

Mechanical aids shall be provided for loading salt into the saturator tank e.g.

- cranes for lifting bulki-bags;
- augers and chutes to convey salt from a hopper into the saturator tank;
- At small facilities, a wheeled loader (see photo below) shall be provided to assist operators in loading the salt saturator (i.e. to reduce manual handling risks).

Brine storage shall be a minimum of 30 days operation for peak flow capacity at typical dose rates.

Provide appropriate venting on the tank vent to control dust generated during tank filling, including use a dust collector bag.

3.4 Brine make-up water

Scale deposition on the electrodes will reduce efficiency of the electrolytic cell – it increases the required electricity usage and salt consumption. Softeners and chillers maximise the life of the electrolyser cell(s) while enabling efficient operation of electrolysers and shall be provided unless specific circumstances of the site provide make-up water with low hardness and temperature in the optimal range. Chillers also assist to minimise chlorate formation (refer section 0).

For sites where water with very low hardness is available (e.g. raw water with very low hardness, or a desalination plant with a reverse osmosis permeate stream - refer water quality requirements in section 3.4.1.1), then using this very low hardness water for brine batching can be considered (since it will require minimal or nil softening) to reduce costs of softening.

3.4.1 Water Softener

The water softener will usually be supplied as part of an electro-chlorinator package. Typically, the softening process will use ion exchange to absorb calcium and magnesium, then later be regenerated by exposure to the high concentration of sodium ions in the brine.

3.4.1.1 Water quality requirements

Water supplied to the softener typically should be potable quality and must meet requirements of the softener supplier or if that information is unavailable then the following criteria. After softening, the water hardness must be less than 17.1 mg/l as $CaCO_3$ (based on Selcoperm specification).

Parameter	***unit***	***maximum***
manganese	mg/L	0.02
iron	mg/L	0.20
fluoride	mg/L	2.00
turbidity	NTU	4
colour	TCU	20
maximum particle size	µm	100
		range
pH (range)		6.5 to 10.0

Table 3.1: Softener - feed water requirements

3.4.2 Softener regeneration waste disposal

Provide waste disposal that meets the requirements of section 5.6.

3.4.3 Water Chiller

The temperature range for the make-up water varies between electro-chlorinator suppliers (e.g. 13-25.5 degrees Celsius for large electro-chlorinators by Evoqua; 5-30 degrees Celsius for Gaffey's iSEC product range and optimal range is 16-21 degrees Celsius for Evoqua). These temperature ranges are considered optimum based on minimising scale formation in the electrolyser and minimising chlorate production. Some models of small capacity electro-chlorinators tolerate a wider temperature range. If the make-up water exceeds the supplier-recommended range at any time of year, then thermostat-controlled chillers shall be provided. Redundancy requirements for the water chiller shall be determined based on consideration of advice from the electrolyser supplier of the expected performance consequences from unmitigated temperature of the make-up water (i.e. a standby chiller may not be required if the supplier confirms it is tolerable for short-term operation without a chiller while a new chiller is procured).

The chiller shall be downstream of the softener.

4 HYPOCHLORITE BATCHING REQUIREMENTS

4.1 Brine pumps

Positive displacement diaphragm or peristaltic pumps are preferred where pumps are used for brine delivery because they consistently and accurately provide a stable brine flow for the electro-chlorination process. Some electro-chlorinators (e.g. Gaffey) don't use brine pumps as brine is drawn into the cell by vacuum (venturi)

4.2 Electrolyser(s)

Information on supplier brochures/websites may indicate that the electrolysers require high purity salt. However, the key issue is instead whether the guarantee will be valid with other grades of salt. If the impurities are moisture (which is of no significance once batched into brine) or calcium and magnesium hardness (which is recoverable by Clean-In-Place) then some suppliers will accept the salt is suitable if it does not contain other contaminants such as iron that may cause irreversible fouling. Note that use of salt with these higher hardness levels will require more frequent CIP than indicated in electro-chlorinator supplier literature.

Note that salt usage will be a significant component of the whole-of-life cost of the electro-chlorination system except for extremely small capacity systems. Consequently, the grade of salt used has a significant impact on the economics of the electro-chlorination system.

Select electrolysers that are suitable for use with washed crude salt (refer APPENDIX C: WASHED CRUDE SALT - SPECIFICATION SHEET). Note Wanneroo brine electro-chlorination investigation (Nexus #143280925) is a useful reference. Washed crude salt is the most economic and is a local product which means that the supply chain is shorter and therefore less vulnerable to interruption.

Lay out facilities with sufficient/reasonable spare space to provide inter-operability of electrolysers (to allow swapping brands of electrolysers) to provide flexibility in case this is ever required.

Electrolyser capacity – ensure operability and maintainability by providing sufficient capacity to achieve require hypo production volume under the most onerous condition (i.e. electrolysers near end of life AND nearly due for Clean-In-Place (CIP) because of scale build-up) plus with enough capacity to accommodate downtime for maintenance (such as for CIP).

4.2.1 Clean-In-Place System

CIP of the electro-chlorinator cell is performed to remove scaling contributed from the salt used for the brine and from the make-up water. Removing the scaling is required both to achieve the needed hypochlorite production rate and to minimise electricity costs (by restoring efficient operation of the electro-chlorinator). Whole-of-life NPV cost analysis may be used to assess whether CIP is justified for small electro-chlorination systems where the salt and make-up water hardness level is sufficiently low (i.e. compare capital and operating costs for the CIP system with the reduction in costs for the electro-chlorinator due to longer cell life and electricity savings from maintaining optimal efficiency). Where CIP is justified, it may be desirable to undertake more frequently to minimise electricity costs.

If a CIP system is deemed to be required, a permanently installed Clean-In-Place (CIP) system shall be provided for de-scaling of the electrolysers. To minimise risk of Operator exposure to hazardous chemicals, Clean-in-Place (CIP) of the electrolysers shall be achieved using a CIP sequence which operates fully automatically when manually selected from the Operator Interface Panel. Use of an automatic sequence minimises Operator exposure to chemicals and reduces opportunity for human error.

CIP is performed with a dilute hydrochloric acid solution (typically 4% strength). The acid storage container shall be housed in a simple bund (e.g. a plastic tub) and the dosing/recirculation pipework barrier protected in accordance with DS79-03. The CIP sequence must start and finish with a softened water rinse to avoid the safety concerns from potentially generating chlorine gas if 0.8% sodium hypochlorite and 4% hydrochloric acid were to mix.

An alternative strategy is centralised off-site cleaning, which may be considered if the cleaning interval is sufficiently long for off-site cleaning to be practical and there are similar capacity electro-chlorinators in the same district to provide opportunity for economies-of-scale. A "common spare" electrolyser cell could be used to replace the "scaled" electrolyser cell that is removed from site for cleaning e.g. cleaning facility at the district depot.

4.3 Hydrogen Leak Detection and Alarming

A hydrogen gas detector must be installed above the electro-chlorinator and any other equipment that are potential sources of hydrogen leaks. If the hypo storage tank is not in the vicinity of the electro-chlorinator, then a hydrogen detector shall also be installed above the storage tank. Since hydrogen is much less dense than air, the gas detector should be located at the local high point such as the ceiling or at the highest point in the room.

Alarms and shutdown interlocks are described in sections 12.2 and 12.3.

4.4 Hypochlorite Tank Operation

Hypochlorite degrades over time and continual topping up will increase rate of chlorate formation. For sites which require chlorate management, the hypochlorite in the storage tank shall be drawn down to the Low Level ("refill level") at each electro-chlorination batch cycle. Ordinarily, this would result in the two hypo tanks swapping between duty and standby ("filling") modes at intervals of three days during peak season. If chlorate management is not required, then the hypochlorite tank may instead be operated through continual top-up from the electro-chlorination system.

5 CHEMICAL STORAGE REQUIREMENTS

Irrespective of the exemptions for minor storage facilities stipulated in AS3780 (the storage and handling of corrosive substances) and the Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations 2007, the Water Corporation requires sodium hypochlorite storage and dosing systems to be designed and operated in accordance with the information provided within this standard.

5.1 Bund

The preferred arrangement (i.e. at sites with capacity and bund size large enough to accommodate a stairway) to access the bund sump is a FRP stairway down to the bund floor level from the FRP grating platform over the bund. At all sites, pipework shall be arranged to that as much as practical it is accessible without removal of FRP grating platform panels i.e. just under the edge of the platform area so that it can easily be reached for maintenance, but by being below the platform it provides the benefit of not being underfoot when walking on the open section of the bund floor.

For small facilities (in which the bund is not large enough to accommodate a stairway into the bund), the minimum requirement is that the FRP grating panel over the bund sump be easily removable to allow access for maintenance of the bund sump (e.g. cleaning/hose out). This also requires that there be no equipment immediately above the bund sump so that the grating can be easily removed and easy access to the entire sump is possible when the grating is removed. Similar to the concept for larger bunds (which have stair access to bund floor level), a corridor shall be designed (1.0 metre wide) with gridmesh supported either side on ledges but without crossbeams so there is a clear corridor when the gridmesh panels are lifted, and the pipework shall be arranged so that is easily reached for maintenance by being just under the edge of the platform adjacent this corridor.

Penetrations of FRP grating should not be used where they will hinder removal of the FRP grating. Pipework penetrations should be positioned in between two grating panels or go through a cutout from the edge of a grating panel. Cut-out holes for accessing valve spindles are acceptable provided there is no obstruction to removal of the grating panel.

5.1.1 Bund Capacity and Design

A bund of at least 110% of the volume[8] of the storage tank shall be provided. The bund volume is the net available containment capacity and shall not include the volume occupied by foundations and other items within the bund. The AS3780 tan theta / crest locus limits apply to tank bunds, and shielding shall be used to direct any leakage into the bund if the tank is located closer to the bund wall than the tan theta limit. There shall be no penetrations through the bund wall (if this is not practical, then design shall ensure the bund seal is not compromised), other than the drain pipework for the bund. Incompatible goods shall not be kept within the bund.

5.1.2 Bund Construction Materials

Bunds for small (i.e. up to 1,000 Litres) Sodium Hypochlorite tanks shall be constructed from compatible plastic materials (e.g. polyethylene). All other bunds shall meet the Bund Linings and Coating requirements of DS79.

Commissioning Plan Information
A 24-hour hydrostatic leak test shall be conducted on a bund prior to the filling of its associated storage tank(s) with chemical.

5.1.3 Bund Valve

The bund outlet shall be designed to achieve complete drainage of the bund sump; hence, the preferred outlet location is through the base of the bund sump (though there may be practical limitations on casting this into the pre-stressed slab of a pre-fabricated transportable building). A bund outlet pipe shall lead to site drainage outside the Sodium Hypochlorite building. The manually-operated lockable bund drain valve shall be left locked in the closed position until drainage is required (Use “Valve Locked in Closed Position” sign DS WCSS172).

5.1.4 Bund High Level/Conductivity Alarm

A bund high level/conductivity alarm is not necessary for small[9] electro-chlorination systems (due to the low hypo concentration) and in circumstances where the consequences of a leak are minor (e.g. if no environmentally sensitive waterway is at risk), and where the tank low level alarm would alert an operator to the potential loss of chemical inventory / dosing.

Where a bund high level/conductivity alarm is considered necessary, or where the possibility of a significant water leak exists, a conductivity sensor (toroidal-type) installed at the lowest practical level in the bund is appropriate. In such cases the alarms shall be linked to the plant control system and SCADA. A high conductivity alarm shall be configured to indicate water in the sump (since conductivity of water is high relative to air), and a high high conductivity alarm to indicate chemical is in the sump.

Suggested high conductivity alarm setting = 0.2 mS/cm (approx. 150 mg/L TDS water)

Suggested high-high conductivity alarm setting = 85 mS/cm (approx 0.5% NaOCl).

5.2 Product tanks

For sites where chlorate needs to be managed, tank cleaning is necessary because sediment accelerates chlorate formation.

[8] Proprietary electro-chlorinator package designs with hypo tank not exceeding 1,000 Litres where the bund volume matches the tank volume (rather than at least 110%) can be accepted given the low hazard presented by 0.8% hypochlorite.
[9] Applies to small hypo tanks not exceeding 1,000 Litre volume of the largest tank.

Brine electro-chlorination installations shall include bunding of the hypochlorite solution (both for the tank and dosing system). Self-bunded tanks shall not be used due to constraint on hydrogen venting from between skins.

5.2.1 Contingency Supply

Where sites have existing facilities for bulk chemical solution deliveries (such as load-in bays), then it may be relatively low-cost to make provision for emergency deliveries of 12.5% sodium hypochlorite into the dilute hypo product tank plus provision for dilution with softened water. At small capacity sites, transfer from a carboy or drum could be achieved using a drum pump. However, this is generally viewed as an unnecessary contingency because other water utilities report never having used these arrangements even though they were installed.

5.2.2 Tank Sizing

Hypochlorite storage tank sizing shall consider the criticality of the scheme and the ability to provide disinfection of water for the duration[10] that the brine batching or electrolyser may be unavailable. The storage inventory in the product storage tank is an important component of the redundancy of the brine electro-chlorination system as it allows dosing to continue during an interruption to refill of the product storage tank. Minimum operating volume of each tank shall be:

- equivalent to three (3) days operation at the recipient main flow rate (maximum flow capacity) and typical dose rate, which means that all times there will be at least three days of hypo stored. Additional storage volume is required, equivalent to hypo usage during the estimated potential duration to reinstate hypo production, if the plant redundancy strategy makes use of spare equipment (or procurement of replacement equipment) rather than installed standby equipment.
- sized to allow normal operations (i.e. when operating at N-1, it is sufficient to meet normal dosing requirements and not necessary to provide capacity for peak or infrequent conditions) to continue when one tank is not available.

5.2.3 Tank Materials

The storage tank shall be constructed of a material that is resistant to sodium hypochlorite with a concentration of 1.0% w/v (1.0 grams of available chlorine per 100mL of solution i.e. 10,000 mg/L) which practically excludes most metals except titanium. The Corporation prefers glass-fibre reinforced plastic (GRP) tanks (designed to SPS 498) to store sodium hypochlorite, but the Corporation may consider (i.e. requires approval from Senior Principal Engineer – Water Treatment) sheet-fabricated HDPE tanks designed to SPS497 for tanks in pre-fabricated treatment buildings (i.e. relatively small capacity facilities) if doorways and layout are designed to suit readily replacing tanks as frequently as every 5 years[11]. Rotationally moulded polyethylene tanks shall only be considered[12] for temporary installations with a life expectancy of no greater than 2 years (requires approval from Senior Principal Engineer – Water Treatment). PVC tanks are generally not considered suitable for various reasons including that they are brittle and should only be considered for tanks less than 100 Litres if HDPE tanks are unavailable.

The tank shall be installed inside a building to avoid deterioration of the sodium hypochlorite from heat and UV light. The specific design and construction requirements associated with each material are listed below.

---

[10] This duration would be the combined total of time to place an order for replacement equipment, supplier lead time, freight of equipment to site, time to repair/re-install, and time to test/commission the replacement equipment.

[11] This average replacement interval reflects the relatively high occurrence of premature replacements, rather than the design life of the tank.

[12] No rotationally moulded tank can be modified with any welding as it does not meet the Water Corporation's welding standard WS-2 requirements of welding materials with different melt flow indexes (MFI). Rotationally moulded resins have a ten times higher MFI compared to high density fittings and welding wire therefore causes cracking after a short service life.

5.2.3.1 Glass-Fibre Reinforced Polyester (GRP)

a) GRP tanks shall be designed and constructed to SPS 498.

b) GRP tanks shall have a design life of at least 20 years.

c) GRP tanks have been adopted for the following reasons:

- GRP tanks are stiffer than HDPE tanks, so they have a decreased thickness for the same application which makes them lighter;
- Their maximum life is not adversely affected by high temperature;
- Their design life tends to be longer than HDPE tanks for chemical storage applications; and
- They are not as prone to leaking at the nozzle welds as HDPE.

5.2.3.2 High Density Polyethylene (HDPE) where approved.

a) HDPE tanks shall be designed and constructed to DVS 2205, DVS 2207 and SPS 497.

b) HDPE tanks shall have a design service life of at least 15 years in sodium hypochlorite service and shall be inspected at year 5, 7, 9 & 10 and then annually until replaced or decommissioned.

5.2.4 Tank Design

Each tank shall include as a minimum the following nozzles and fittings:

a) One (1) flanged tank fill point inlet nozzle on the top of the tank.

b) One (1) flanged process outlet nozzle on the side of the tank located in a low position.

c) One (1) flanged tank overflow nozzle.

d) One (1) flanged tank blower air inlet nozzle (only required if there is a blower i.e. if the hypochlorite is not fully de-gassed before the storage tank) above overflow level.

e) One (1) flanged tank vent nozzle at the highest point of the tank.

f) One (1) flanged scour outlet nozzle on the bottom of the tank; and

g) Sufficient lifting lugs as necessary, and fixing lugs to secure tank to the plinth.

Nozzles shall have a minimum diameter of DN50 (smaller sizes are impractical to weld). All connections shall be flanged (threaded connections are impractical because they are difficult to seal for complete prevention of sodium hypochlorite weeping, and if a thread gets stripped then it may be necessary to replace the tank). Tanks of capacity not exceeding 1,000 Litres may use threaded connections instead of flanged connections.

Valves connecting to tank nozzles may use solvent-weld connections where the valves are PVC ball valves (i.e. use a pipe flange with shortest practical pipe length before the isolating PVC ball valve), whereas all other valves connecting to tank nozzles are to be directly flanged to the tank nozzle flange.

Each tank shall be designed for the following criteria:

a) Contents: 0.8% weight/volume sodium hypochlorite solution. (0.6 - 0.8% typical; product strength is variable in range 0.5-0.9% depending on electro-chlorination model; 1.0% maximum)

b) Operating & design temperature: range as appropriate to the site.

c) Operating & design pressure: atmospheric (plus blower pressure) and hydrostatic. Tank must be airtight (i.e. if all nozzles were closed) to ensure no hydrogen gas leakage into the building.

Adequate fixings at the base of each tank shall be provided for stability.

The designer should provide drawings to the tank supplier which clearly shows the desired location and size of all connections and fittings on the tank.

Commissioning Plan Information
Prior to delivery to site, all tanks shall be hydrostatically tested using clean water filled to the overflow level. The full static head is to be held for a minimum of 12 hours. Once installed, the tanks shall be hydrostatically tested to the full static head again to check for any damage which may have occurred during transportation or installation[13]. All tanks shall be transported with capped/covered nozzles to prevent dust and vermin entering.

Testing, transportation, quality assurance, and other design and manufacturing requirements for GRP tanks are specified in SPS 498. For HDPE tanks this is covered in SPS 497.

5.3 Tank Plinth or Stand

Dose pumps should be positioned as low as possible relative to the storage tank outlet to minimise suction lift for the dosing pumps which mitigates unwanted gassing and air-locking. For sites with multiple hypochlorite storage tanks, consider providing a plinth or tank stand so that each tank's automatic tank outlet valve (or automatic three-way valve) remains above the 110% bund level. This may not be practical with height limitations inherent in transportable buildings and may also be limited in practicality for electro-chlorinator that which gravity feed to the hypochlorite tank.

Pumps shall be located either outside the bund, or in the bund above the 110% fill level. If the dose panel is located outside the bund, but with drip tray below the top of the bund wall (to locate the dose pumps as low as possible), then a level switch in the dose panel drip tray can initiate opening a motorised drain valve when required to drain the drip tray into the bund sump.

5.4 Tank Instrumentation

5.4.1 Tank Level Transmitter

An externally mounted level transmitter shall be provided to measure liquid level in the storage tank. The signal from the level transmitter shall be used to calculate the amount of sodium hypochlorite in the tank and to generate level alarms. This quantity shall be displayed on the OIP and HMI. The preferred display quantity unit is litres for sodium hypochlorite.

The level alarms and their set points are discussed further in the relevant sub-sections of sections 10 and 11.

Tank level instrumentation shall comply with Field Instrumentation design standard DS40-09.

Radar level transmitters are the preferred level instrument type except for tall tanks where the alternative of pressure transmitters may be considered to avoid working at heights.

Level measurement using radar level transmitters has the advantage of direct measurement of fluid level and not being in contact with the corrosive chemical fumes or the hydrogen byproduct if mounted above the tank roof. Consideration needs to be given to the minimum range (deadband) that the sensor can detect and the beam angle. By not being exposed to the tank atmosphere, the radar level transmitters will have negligible maintenance requirement and be operated to failure with no need to access the tank roof for maintenance. Since the radar level transducer is operated to failure, permanent access to the top of the tank is not required. The transducer head shall be installed above the tank measuring through the roof or through a plastic blank flange on the roof, while the transmitter shall be installed where it can safely be accessed from ground level. The instrument shall be configured to filter out "false" echoes from the roof and any condensation on the roof.

Level measurement using a pressure transmitter has the advantage of avoiding working at heights, but disadvantage of inferring level which is reliant on calibration with the specific gravity of the solution,

[13] Water used for testing tanks at site can then be discharged through the scour valve to test the bund as well.

though that is of minor significance with such dilute hypochlorite. A disadvantage of pressure transmitters is the risk of exposure to hypochlorite during maintenance.

Since it is preferable to eliminate safety hazards, ultrasonic sensors shall not be used because they have the disadvantage of needing to be specified as intrinsically safe because the presence of hydrogen creates potential for a hazardous area/atmosphere within the tank headspace, and more frequent maintenance requirement due to exposure to chemical fumes inside the tank.

5.4.1.1 Pressure Transmitters for Level Measurement

For tall tanks, where access to a top mounted level instrument is difficult, a pressure transmitter with impulse line and diaphragm seal may be considered as an alternative to a radar level instrument. The impulse line connecting the tank to the pressure transmitter shall be from the scour outlet and the diaphragm seal wetted material shall be titanium. Impulse lines shall be glycol filled. An isolation valve shall be provided at the connection point to the scour line. The pressure transmitter shall be mounted on a sturdy bracket at a convenient location.

When pressure transmitters are used to derive a level in the tank it is important that the specific gravity of the sodium hypochlorite is known when setting up and calibrating the pressure transmitters and level indicator. Note that the specific gravity of 0.8% w/v hypochlorite is 1.02.

Given that the storage tank is filled as part of an automatic batch process rather than by a load-in operator then there is not a requirement for diversity of level measurement (i.e. there is no requirement for diverse redundancy in the form of a sight tube or magnetic level gauge).

5.5 Storage System Pipework

Pipework shall meet the requirements of section 8.

5.5.1 Fill Line

Fill lines shall be DN15 minimum and sized to suit the required electrolyser flow rate. The fill line into the tank should be located diametrically opposite the outlet pipe to minimise the possibility of any air entrainment during filling from interfering with the operation of the dosing pump. The fill line shall enter the tank above the overflow level.

For electro-chlorinator models that do not exhaust all hydrogen gas prior to the hypochlorite storage tank, the fill line shall rise continuously (to minimise risk of hydrogen accumulating in any section of the fill pipework) from the electrolyser which also requires side entry of the tank i.e. fill nozzle near the top of the tank wall. Avoid entrapment of hydrogen in pipework. To ensure that all hydrogen makes it to the tank and is properly diluted, the piping connecting the electrolyser to the hypochlorite tank must:

- Maintain a minimum 2% (1 to 50) upward slope toward the tank.
- Avoid any points of potential hydrogen accumulation (downward pipe)
- Minimise points of potential leak (unions, elbows, tees, valves etc.)

Commissioning Plan Information
Prior to commissioning the electrolyser(s), the filling line shall be hydrostatically pressure tested in accordance with AS 4041 to 1.5 times the operating pressure of the brine pump and held for a minimum of 30 minutes. Note: The tank shall not be subject to the test pressure as it is only rated for static head up to the overflow level.

5.5.2 Air Inlet Line

To minimise risk of hydrogen entering the air inlet pipework, it needs to avoid being a local high point in the tank; hence, the air inlet line requires side entry of the tank above overflow level and near the top of the tank wall.

5.5.3 Vent Line

Each tank shall have a vent line (whose diameter shall be a minimum of 1.5 times the larger of the fill pipe, the blower air inlet pipe and the scour pipe e.g. a DN25 scour would require a DN40 vent) to allow venting of fumes during tank filling, blower operation and vacuum relief during tank emptying. The vent line shall be sized to ensure adequate air flow out of the tank during filling at the same time as blower operation and adequate air flow into the tank whilst the dosing pump is operating or the tank is being drained/scoured, without exceeding the maximum allowable operating stresses of the tank.

The vent line shall continuously rise between the storage tank and the vent outlet to ensure passive dissipation of hydrogen in event of a power outage and should be positioned in a location where it is unlikely that any drips will fall on personnel. The vent discharge point shall be to open atmosphere outside of the building and shall be weather-proofed and fitted with a "tropical midge wire" insect screen. The vent outlet shall be located such that it is possible to gain access to it for maintenance purposes.

The vent line shall be securely supported to prevent excessive stress on the tank roof. The vent pipework shall be configured so that condensation of vapours is directed back into the tank. It is important to ensure the vent line is not blocked at any time.

5.5.4 Scour Line

There shall be a DN25 minimum scour outlet line from the bottom of the tank to the bund and shall also be sized to minimise drainage time (ideally not exceeding 10 minutes) during cleanout of tank. A DN25 minimum manual isolation valve shall be installed as close to the nozzle flange as possible. Size of the scour outlet shall be selected to provide adequate scour flow to achieve cleaning of the tank, and to allow discharge of the tank contents within a reasonable timeframe during a maintenance visit to the site.

5.5.5 Process Line

The tank outlet line shall be DN25 minimum commencing from the tank outlet isolation valve. After the tank outlet isolation valve the line size may be reduced.

To minimise retention time in the piping, the line to the dosing pump shall be kept as short as possible. The piping from the storage tank shall be graded downward to allow gases in the solution to be released back into the tank. At the dosing panel, the piping shall be graded up towards the calibration tube which acts as a vent tube to purge any gas bubbles prior to entering the dosing pump.

For sites with multiple hypochlorite storage tanks, the process lines from each tank shall have an automatic isolation valve on the tank outlet nozzle and then connected to a pipework manifold that allows the duty tank to supply any of the dose panels. To avoid risk of two tanks being on-line (which may be a relevant concern if the bund is sized based only on the largest tank), a potential solution is instead of each tank having automated outlet valves to use an automated three-way valve so that only one tank can be on-line at a time.

5.5.6 Overflow Line

Each tank shall have a DN25 minimum overflow pipe (whose diameter shall be a minimum of 1.5 times the fill pipe) which terminates in a water-filled seal pot (to prevent sodium hypochlorite fumes entering the room). No valves or equipment which could potentially cause blockages shall be installed in the overflow lines. Care shall be taken on the overflow line design to ensure that no liquid can be drawn back into the tank under any conditions.

5.5.7 Return Line

Provide a return line from the dosing panels back to the tank (can be connected into the tank vent line at a location where that line drains back to the tank). This line acts as:

1) a gas escape route for the gas purge column (i.e. calibration tube); and
2) the dosing pump priming vent / return line

5.6 Environmental

The 0.8% hypochlorite storage and dosing system does not require a waste holding tank; instead, the bund can be used to contain any spillage so that if there is a large spill then a waste disposal contractor can pump directly out of the bund, whereas minor spills can be neutralised and then discharged to the environment, such as by a soakwell.

Brine electro-chlorination systems include an ion exchange type water softener to remove scaling ions (calcium and magnesium) from the process water. All projects shall gain environmental approval/guidance on disposal of softener regeneration waste.

- Action: Designer to characterise waste volumes, concentration and frequency. Design Manager to then liaise with Environment Business Unit (e.g. for Environmental Risk Assessment and to determine suitable risk controls plus to identify any external approval requirements).

Disposal of the softener regeneration waste would normally occur into a soak well, unless there is risk of negative impact on a sensitive environment such as a nearby surface water body, in which case a waste containment tank might be necessary.

6 DOSING SYSTEM

6.1 General Considerations

The rate of sodium hypochlorite degradation and gassing off (oxygen formation) is exacerbated by temperature, light and most metals. Experience with 12.5% m/v sodium hypochlorite is that the gassing-off bubbles in the suction piping tend to stay locked in suspension and over time, cause vapour-locking problems in the diaphragm dosing pump. Oxygen gas produced will also build up pressure in the pipework to the point of catastrophic failure if there is no outlet for the trapped gas to escape. Sodium hydroxide (caustic soda) in the sodium hypochlorite tends to precipitate and leave a crusty residue which can cause ball valves to stick making them inoperable.

The dosing system must therefore incorporate measures to mitigate the effects of gas build-up. Use of dilute sodium hypochlorite (such as the dilute 0.8% hypochlorite solution produced by BEC) is the most effective mitigation method. This low concentration also has the benefit of reducing degradation during storage.

Other measures for limiting gas-locking (which wherever practical shall also be applied to dilute hypochlorite systems, even though gas-locking is much less than for 12.5% hypo) include installing the dosing pipes with gradients that vent gases back to the storage tank and/or gas purge columns. Pipe lengths are to be kept short and over-sizing of the piping, valves and pumps is to be avoided to minimise detention time in the system. Dosing pipes should ideally be sized to maintain a flow velocity of 0.5 m/s to 2 m/s to reduce gas accumulation, but this is not always possible. The pipes are usually selected to keep the size as small as the flow rate will allow. To maintain flow velocity, the number of obstructive fittings such as bends, tees and reducers should be kept to a minimum.

Ball valves shall have pre-drilled balls to prevent trapping of sodium hypochlorite in the cavity between the valve body and the ball.

6.2 Materials of Construction

All materials of construction used in any part of the process system that encounters sodium hypochlorite will have to be compatible with the chemical (refer section 1.3 for guidance on materials selection). Incompatible materials that encounter sodium hypochlorite will result in accelerated degradation of the chemical and formation of oxygen gas. Care must be taken to select equipment for use in the dosing system as incompatible metals such as stainless steel, aluminium, brass or copper which are often found in pumps, pump seals, check valve springs, electrodes in magnetic flow tubes, and diaphragm seals for gauges, switches and transmitters. Generally, all metals should be avoided except for titanium, tantalum, silver, gold and platinum.

6.3 Dosing Pumps and Dosing Panels

Separate duty and standby dosing pumps and dosing panels shall be provided. Each pump and dosing panel with its associated equipment shall be capable of operating independently and automatically. They shall rotate duty each day.

The pumps and dosing panels shall be enclosed within a barrier protection cabinet in compliance with DS 79-03. Enclosure of the pumps and dosing panels with a transparent front cover (e.g. PVC cabinet) enables the panel to be viewed during operation, at the same time as protecting personnel from any chemical spray or leak. It also allows maintenance to be safely done on one dosing system while the other is in operation. This approach to design achieves the occupational safety objectives and the continuity of dosing objective of the Water Corporation.

Minimising complexity in small dosing systems assists with achieving reliable dosing performance at very low flows. Consequently, for small/medium systems it is preferred to use a digital dosing pump which has:

- Flow Control Measurement instead of a miniature magflow meter;
- an automatic deaeration feature instead of a de-gassing valve; and
- a controlled discharge stroke duration instead of a pulsation dampener.

6.3.1 Strainers

To prevent pipework shavings, silica scale, or other solid impurities from blocking or damaging the dosing pump internals or the pressure sustaining valves, each dosing system has a PVC in-line Y-body strainer installed upstream of the dosing pump before the calibration tube. As a minimum the strainer shall be fitted with a cylindrical mesh having 0.5mm perforations. As duty/standby panels are recommended there is no need to provide a bypass around the strainer. However, for single panel systems a bypass[14], complete with standby strainer, will be necessary to keep the panel running whilst the blocked strainer is taken out for service.

6.3.2 Calibration Tubes and Pump Suction Piping

The calibration tube/gas purge column on the dosing panel serves two functions.

As a calibration tube, it is used for fault finding and for calibrating the performance of new or refurbished dosing pumps during commissioning and after maintenance. The calibration tube shall have sufficient capacity to allow a single calibrating run of at least two minutes with the dosing pump at full design flow rate.

The tube also serves as a bubble-trap or gas purge column where gas from solution can be vented out just prior to entering the dosing pump head to prevent vapour lock. The suction piping before the pump should be configured in a specific manner to allow for this disengagement of the gas bubbles to occur.

[14] Single isolation is generally considered sufficient risk mitigation for leakage during strainer removal because the pipework pressure is only under the gravitational head of the hypo storage tank.

As it enters the dosing panel, the pipe conveying the sodium hypochlorite shall slope up towards the calibration tube to allow gases to rise and expel into the vertical column before continuing to the pump. The short section of the pipe from the calibration tube leading to the pump suction connection should also slope back to the column for the same reason. It is important to keep this section of pipe as short as possible. Suitable flexible tubing may be used for this section of piping from the calibration tube to the pump, which also enables the pump to be replaced quicker. The vent line from the top of the column is directed back to the storage tank through the tank roof vent pipework.

The calibration tube/purge column should cover the full height of the storage tank to provide full usage reading. The calibration tube shall be constructed out of clear PVC or similar plastic. Glass tube is not suitable as the caustic in the sodium hypochlorite will react with it, eventually making the glass opaque.

The isolation valve below the calibration tube shall always remain open except during flushing to allow gas to escape even when the system is shut down. It will need to be closed during flushing to prevent water getting into the calibration tube and into the sodium hypochlorite storage tank(s).

Camlock couplings shall not be used in dosing pump suction piping (between the chemical storage tank and dosing pumps).

6.3.3 Sodium Hypochlorite Dosing Pumps

There shall be a dosing pump for each dosing panel. Digital dosing pumps shall be used in the Corporation's small hypochlorite facilities. They can be configured to have a long duration discharge stroke (and quick suction stroke) with the result that pump output is sufficiently steady to avoid the requirement for pulsation dampeners. Each pump shall comply with the requirements of the Water Corporation's Mechanical standard DS32 (refer section on Chemical Dose Pumps). Pumps operating at less than 20 L/h flowrate shall have an integral de-gassing capability.

Materials of construction for wetted parts of the pump in direct contact with hypo shall be compatible and resistant to the solution. Metals such as stainless steel, aluminium, Monel®, brass or copper must be avoided. Suitable diaphragm materials are Teflon® or Viton® stabilized with carbon black.

Each pump shall be mounted on a PVC plinth attached to the dosing panel, so that the pump can be adequately accessed from all sides for adjustment and servicing.

Measures recommended to reduce vapour locking of the pumps include ensuring pumps are operated with flooded suction. Pumps are preferred to be installed below the storage tank lowest operational level for this reason, but at the same time, should not be installed below the top of the bund wall level to avoid submergence during a major spill. The suction pipeline should be made as short as possible.

Peristaltic pumps are not recommended for dosing.

Dosing pumps may require short lengths of flexible hose or tubing at the pump suction and discharge ends. Flexible hose material shall be compatible with the chemical.

The preferred hose type is braided clear PVC (potential for leaks is minimised by procuring the hose and matching connectors as a system e.g. as offered by the pump supplier as accessories for the pump) with AS4020 approval or international equivalent[15]. Hoses shall be protected from direct sunlight.

Where there is a need to use hoses outdoors (such as for the dose line[16]), approval shall be sought from the Senior Principal Engineer, Water Treatment who will require information concerning temperature de-rating, material compatibility and sun shading as a minimum.

Set up the dosing pumps to change over automatically on an adjustable set period e.g. daily. This will help ensure the pumps have similar operating hours and are not offline for long periods.

---

[15] AS/NZS 4020, an Australian and New Zealand standard for testing materials and products in contact with drinking water, has international equivalents such as NSF/ANSI 60 and 61 in the United States, BS 6920 in the UK, and DVGWW270 in Germany. These standards are designed to ensure that materials and products used in drinking water systems do not negatively impact the water's quality, taste, or appearance.

[16] Example of braided PVC hose claiming AS4020 approval is Boston for 10 mm (50 m roll) and 19 mm (25 m roll) ID hose

6.3.4 Pressure Relief Valves

Note also use of an external pressure relief circuit together with a digital dosing pump using Flow Control Measurement (FCM) may have the effect of confounding the FCM i.e. the maximum pressure on the DDA-FCM control variant must be set below the setting of the pressure relief valve.

Pressure relief valves shall be set to open on failure (fail open).

Commissioning Plan Information
Safety relief valves shall be fitted with carseals to protect against unauthorised adjustment. The pressure setting of safety relief valves shall be recorded on a red traffolyte tag (labelled PSV82***) attached to either the valve body or the carseal.

6.3.5 Pressure Gauges

A glycerine-filled stainless steel pressure gauge with a minimum display diameter of 63mm (2.5”) shall be provided with sufficient range to allow setting of each pressure sustaining valve and to assist in continuous monitoring of correct pump performance. The pressure gauge shall incorporate a diaphragm barrier seal of suitable material as recommended by the instrument supplier to prevent sodium hypochlorite coming directly into contact with the gauge components. The gauge scale shall be sized so that the maximum operating pressure will not exceed 75% of full scale.

6.3.6 De-aeration

It is preferred to use the automatic de-gassing feature on the digital dosing pump rather than having a de-gassing valve on dosing systems, especially given the relatively low concentration of the sodium hypochlorite solution. In addition, start pump at full speed for a pre-set period of time (e.g. typically 10 – 20 seconds, adjustable) to assist clearing the line before the dose pump reverts to a speed suited to the required dosage.

6.3.7 Flow Measurement

It is preferred to select a digital dosing pump with Integrated Flow Measurement (rather than miniature magflow meters whose small bore is prone to blockage from scale build-up) for small dosing systems. Although occasional failure to detect loss of flow may occur, the chlorine analyser will trigger swap over to the standby system. Resumption of operation of the faulted system will involve a short period of operation at full pump speed which generally clears the problem. Consequently, this occasional minor problem self corrects.

Flow measurement by the pump is used to monitor and record the dosing pump discharge flow rate, and totalise the amount dosed. A low flow alarm (configurable) would indicate a dosing hydraulic fault such as blockage at the dosing spear and would initiate shutdown of the duty dosing system and changeover to the standby system.

6.3.8 Pressure Sustaining Valves

A pressure sustaining valve (which shall be tagged as a Pressure Control Valve, PCV) automatically holds a steady pre-set upstream pressure, within close limits. The main pressure sustaining valve installed on the dosing line on each panel improves the accuracy of dosing by providing and maintaining the necessary discharge pressure required by the dosing pump to work against. It shall be set at a pressure which optimises pump accuracy as per the pump manufacturer’s recommendation. The pressure setting shall be recorded on the valve tag.

A normally-closed vent line upstream of the PCV allows the pump to be primed and allows the system to be de-pressurised prior to maintenance, should the PCV become blocked or fail.

For dosing lines longer than 10 metres, an additional pressure sustaining valve[17] and pressure gauge shall be provided near the dosing point to provide stable dosing control and prevent diffusion of chemical from the chemical line into the water main during idling periods (refer to section 5.4.3). This second PCV is typically set at a low pressure (100 - 200 kPa). Setting this second PCV at too high a value can result in surging of the chemical dose rate due to the control valve's hysteresis causing expansion and contraction of the chemical dose line piping. There may be some circumstances where the PCV is not required but approval for its deletion shall be obtained from the Senior Principal Engineer Water Treatment.

Provision shall be made (e.g. a valved tapping point) to allow a hand-held gauge to test the pressure on each PCV.

6.4 Dosing

The sodium hypochlorite which leaves the panel and exits the sodium hypochlorite building is then dosed into the recipient water main via a dosing spear/sparger arrangement. The design of the dosing system downstream of the dosing panel is described in more detail in the chemical dosing design standard DS78. Dosing control should be based on the dosing aspects of the standard hypochlorite Functional Control Specification, DS73-02.

6.4.1 Dilution Carrier Water

Sodium hypochlorite is preferably dosed "neat" (e.g. at 0.8% (w/v) concentration) into the recipient water main. In some installations, a dilution carrier water stream may be required to increase the velocity of the chemical in the feed pipe to assist rapid mixing of the sodium hypochlorite into the recipient water main. It is important that full mixing is achieved in the recipient water main prior to the sample point because otherwise the feedback trim of the dose pumps will be based on erroneous feedback.

The main issue with using a carrier water stream is that the sodium hydroxide (caustic soda) in the sodium hypochlorite will react with the calcium and magnesium hardness in the carrier water to induce scale formation in the immediate area of the mixing point. If included as part of the system, the carrier water shall be softened or demineralised to reduce the formation of scale. Alternatively, a sequestering agent such as Calgon - sodium hexametaphosphate (SHMP) can be introduced into the carrier water before diluting the hypo. The Calgon interferes with calcite crystal growth, thereby preventing deposition of scale on surfaces.

Dilution carrier water for chemical dosing is described in more detail in design standard DS78.

6.4.2 Dosing Diffusers & Valves

Duty and standby dosing diffusers shall be provided, except for systems where a prolonged outage of dosing is tolerable in which case a duty only dosing diffuser may be considered. The design details and marking requirements of the dosing diffusers/spears are described in DS78.

Blockage of pipework and spear orifices caused by scaling is a major problem especially if the recipient water or hypo carrier/dilution water (for small system with low dose flow) contains an elevated concentration of alkalinity and hardness.

Design of the dosing diffusers and/or mixing devices are site-specific and reference shall be made to DS78 Chemical Dosing Standard for guidance.

[17] Major leakage from the chlorine dose line is likely to be detected as low chlorine residual by the chlorine analyser, but minor leakage might not be detected by the analyser. If environmental sensitivity at a particular site makes monitoring dose line pressure a priority, then the designer may consider the alternative of instead locating the main PCV in the field at the dose point (i.e. just have one PCV) because the PCV location may affect some of the Grundfos pump analytics i.e. with two PCVs a fault on the dosing line won't be detected by the pump as it won't see a low discharge pressure. However, this approach is not generally preferred because the absence of a PCV in the dose panel limits the ability to thoroughly factory test the dose panel.

Dosing spears should pass through a gate valve so that the recipient water main can be operated even when that spear is not in place. A non-return valve shall be provided on each dosing line close to the dosing spear to ensure the recipient water does not back-feed up the dosing line when the spears are not in operation. Non-return valves are not required where a pressure sustaining valve is proposed to be installed near the injection point (ref. 6.3.8). Isolation ball valves shall also be provided to enable the individual spears to be isolated from the sodium hypochlorite and removed for maintenance whilst the other spear is in operation.

For long dosing lines (more than 10m in length), a suitable pressure sustaining / control valve (PCV) and pressure gauge (PI) shall be installed near to the dosing diffuser. Refer section 6.3.8 for more details).

6.4.3 Pressure Gauge

The pressure gauge shall be constructed of materials suitable for contact with sodium hypochlorite similar to those provided at the dosing panels (refer section 6.3.5).

6.5 Flushing Water System

Flushing water valves and connections shall be provided to manually flush sodium hypochlorite from the storage and dosing system pipework prior to equipment removal or maintenance. The flushing connections shall be located strategically so that the entire sodium hypochlorite line, right back to the tank outlet, can be flushed. The valve below the calibration tube must be closed during flushing to prevent water entering the sodium hypochlorite storage tank. It is important that the calibration tube isolation valve shall be re-opened prior to returning the system to service. A sign with instruction to close the calibration tube valve (during maintenance) shall be displayed next to all the flushing points.

Flushing should take place in preparation for maintenance or if sodium hypochlorite has been left in the system for more than 7 days. It should not necessarily occur simply when changing from one operating mode on a system to another (e.g. Dosing Mode to Stopped Mode), or when changing over from one dosing system (duty) to another (standby). Routine or excessive flushing of the sodium hypochlorite system with un-softened water will result in scaling in the pipelines, so it should be avoided.

Drainage points should be provided at various locations on the dosing pipeline for draining of the flushing water (to the bund sump) when required. However, when flushing the sodium hypochlorite system, the flush water should preferably be directed to the dose point as this is the safest and easiest disposal route.

Site service water is generally used as the flushing water supply, and it shall have sufficient head to flush water through both the sodium hypochlorite dosing pump and pressure sustaining valve of the dosing system. If the site service water supply has insufficient flow or pressure to carry out flushing, then a dedicated flush water booster pump will be required. Alternatively, if the site water supply has excessive flow and pressure, which could cause damage to valves and equipment (and push a slug of hypochlorite through to the dose point very quickly, causing a spike in dosed concentration) then a flow or pressure control valve may be required to limit the flushing flow and pressure.

If the same site service water supply is used to supply the safety shower(s) then the flushing water off-take shall be located downstream of a reduced pressure zone device (RPZD) with the safety shower(s) being supplied from upstream of the RPZD.

7 WATER SAMPLING AND ANALYSIS

Most sites will have single duty sample point, and if a sample pump is required it would be single duty, and a single duty chlorine analyser. Redundant sampling and analysis equipment should be considered for sites where it is critical to ensure continuous water production. Failure of the sampling and analysis system should trigger flow paced only mode using the last recorded chlorine residual.

7.1 Sampling Point

The chlorine sampling point is located downstream of the sodium hypochlorite dosing point after the sodium hypochlorite has had the opportunity to be mixed thoroughly in the recipient water (refer DS78 for design guidance to achieve thorough mixing). The sampling point should not be too far downstream from the dosing point as this can result in excessive lag time for the dosing control loop.

Care shall be taken in the design of the water sample system to ensure that all analysers receive consistent sample water flow and pressure that is within the analyser manufacturer's specified requirements. The sample water system design shall also aim to minimise the travel time from the sample point to the water quality analysers. The designer shall consider the following design features to optimise the sample water system and analyser performance:

- Need for a sample booster pump.
- Sample booster pump type - centrifugal or positive displacement. The Corporation has had recent good experience with use of microgear pumps in sample water systems.
- Sample water bypass flow to reduce the sample water travel time to analysers.
- Requirements for pressure control valve(s).
- Manual or automatic flow control valves.
- Minimising ambient temperature and solar impacts on the sample line, especially for longer sample lines.

A rotameter fitted with a low flow switch monitors the feed to the chlorine analyser.

Supply of other services from the sample water line often results in flow and pressure fluctuations at the water quality analyser(s) that adversely impact their performance. It is therefore highly desirable to supply such services from another location that does not result in significant hydraulic impact to the sample water system.

Normally a sample spear with an open end that projects half-way into the main is used for sampling. The holes/orifices on the spear should face towards the direction of flow (i.e. orifices on the upstream side of the spear).

Sample water should be returned to the recipient pipe where it is feasible to do so.

DS78 Chemical Dosing Standard provides further details and requirements on the sampling system.

7.2 Chlorine Analyser

Chlorine analysers shall be used for potable water treatment but are not preferred in reuse systems because of the high maintenance requirement due to susceptibility to clogging and biological growth (though they may be required for Department of Health approval of some reuse schemes). A chlorine analyser is used to continuously monitor the chlorine concentration of the treated water and provide feedback residual trim control of the sodium hypochlorite dose rate. The analyser shall be connected to the plant control system to generate High High, High, Low and Low Low alarms when the concentration strays outside of acceptable limits. The High and Low alarms are also used to initiate changeover to the standby system. If the standby sodium hypochlorite dosing system is called and then the High High or the Low Low chlorine residual alarms are active for a given time a "Water Quality Poor" alarm is raised. The standby Hypochlorite system should continue to run – it should not shut down. A "Water Quality Poor" alarm should shut down the recipient water main source to prevent delivery of poor quality water to consumers. The loss of mains flow will shut down the sodium hypochlorite dosing system, thus maintaining the disinfection (although potentially compromised) into the main. The Water Safety Plan (WSP) of the particular site should provide all the alarm set-points and the required action to take.

The analyser should be installed on a sampling panel in a sampling room, laboratory or other covered area suitable for instrumentation. Sites that do not have a sampling room or laboratory will have the analyser sampling panel located in the dosing room. Analyser performance is notably improved when it is installed in a relatively stable temperature environment. This may be achieved by room insulation, shading and/or room HVAC. The analyser shall be selected from one of the suppliers on the Water Corporation's SCADA Approved Equipment List and it shall be approved by the client prior to purchase. This is to ensure the selection complements other analysers operated and maintained in the client's region to promote uniformity, familiarity, and to reduce spares holdings.

8 PIPEWORK AND VALVES

8.1 Pipework Requirements

The requirements of Small Chemical Storage and Dosing Systems design standard DS79-05 sections 8.1 to 8.7 shall be adhered to for pipework. Provide barrier protection for the pressurised portion of the dosing system in accordance with Chemical Barrier Protection design standard DS79-03.

8.2 Valves

All valve components including handles, actuators, balls, ball seals and O-rings shall be constructed of materials suitable for contact with sodium hypochlorite. Natural rubber, as well as other rubber-like elastomeric materials, including Nitrile and Buna N (NBR), shall not be used for seals, O-rings and gaskets. Plastic valves made of uPVC with Teflon ball seals and FPM (also known as FKM and Viton®) O-rings such as the Georg Fischer Type 546 uPVC ball valves have historically provided satisfactory performance.

Valves shall have tags for identification and to indicate whether they are "normally open" or "normally closed". For critical valves, a sign should also be displayed alongside.

Ball valves inherently have a cavity between the body and the ball inside the valve where sodium hypochlorite can be trapped when it is in the closed position. Gases released from the trapped hypochlorite can increase the pressure inside the valve potentially to the point of catastrophic failure. Crystallisation of the caustic as the hypochlorite decomposes may cause valves to jam making them difficult to operate. To avoid this situation, ball valves with a pre-drilled small-diameter vent hole on the upstream side of the ball shall be used for hypochlorite applications (vented ball valves). This modified ball effectively vents the gases while keeping inner valve surfaces constantly wetted, eliminating the conditions required for gas accumulation and caustic crystallisation. The vent hole should be drilled and deburred by the valve manufacturer or a competent person as rough burrs left on the hole will damage the valve seat when the valve is later operated.

Ball valves of sizes DN50 or smaller generally perform well in sodium hypochlorite application. Larger ball valves are more prone to freezing up due to the formation of crystallite salts on the sealing surfaces of the valves. At locations where larger valves are required, butterfly and diaphragm valves can be considered as alternatives.

8.3 Flanges and Gaskets

All flanges shall be drilled in accordance with AS/NZS 4087 for pressure class PN16, unless a different flange standard has been adopted for the site for consistency. All flanges shall be provided with galvanised steel backing plates and 3mm full face gaskets at the flanged interfaces. The backing plates shall be hot dipped galvanised in accordance with AS/NZS 4680.

Gaskets shall be FPM (also known as /FKM and Viton®) material stabilised with carbon black[18]. Natural rubber, nitrile, EPDM and buna N (NBR) are not suitable to be used in sodium hypochlorite service.

[18] DS 33 Clause 15.6.3

8.4 Fasteners

All fasteners shall comply with AS 1111.1 and AS 1112.3. Fasteners and anchorage bolts shall be hot dip galvanised[19] in accordance with AS 1214.

9 ANCILLARIES

The requirements of DS79-05 Section 9 shall be adhered to for Ancillaries.

Where building cranes are provided, they shall each have a maintenance platform with permanent rung ladder (including ladder cage/hoop guard) access. Rung ladders are the preferred means of access because the crane inspection and maintenance requirement is infrequent and it minimises capital and maintenance cost and minimises footprint (and building cost).

[19] 316 stainless steel fasteners are considered to have no advantage over galvanised steel fasteners due to risk of stress corrosion cracking and problem with galling.

10 PROCESS CONTROL

10.1 Hypo Batching Control Philosophy

As described in section 4.4, at sites which require chlorate management, the hypochlorite in the storage tank shall be drawn down to the Low Level ("refill level") at each electro-chlorination batch cycle. This would determine the start and stop levels in the hypo storage tank used to control operation of the electro-chlorinator. Other considerations of when to schedule operation of the electro-chlorinator are:

- If the site power supply is based on or supplemented by a solar PV system, then schedule hypo batch operation (which is most of the power demand) for daylight hours to minimise size of the required battery energy storage system (if standalone solar PV) or minimise electricity costs (if grid connected).
- Site-specific opportunities e.g. where a site has a large power load such as a bore that does not need to run continuously and the electrolyser can complete its batching in the portion of the day when the bore is not running, then scheduling the batching and bore operation to occur separately (and interlock to ensure they are separate) will minimise the peak power load from the site, which may avoid the cost to upgrade the site power supply and switchboards and/or allow a lower power tariff (as this may be based on peak power requirement). Note that much of the power load in a brine electro-chlorination system occurs during hypo batching because the water chiller, electrolyser and storage tank blowers are in operation during hypo batching. Given that this opportunity constrains operation, it should only be pursued if the constraint is accepted by the client region and if the cost savings are considered to outweigh the disadvantage of constraining when the batching can run.

10.2 Dosing Control Philosophy

The required sodium hypochlorite dose rate (in mg/L) is determined by the output of a PID controller that receives the measured chlorine residual as its process variable and a target chlorine residual setpoint from an operator input. The output of the chlorine residual PID controller is scaled across an appropriate dose rate range in mg/L. This dose rate is then multiplied by the measured flow in the recipient water main (L/s) and multiplied by 3.6 (which changes the units to kL/hr) to arrive at the required equivalent chlorine mass flow rate in g/hr. The g/hr mass flow is then divided by the sodium hypochlorite solution strength (typically 0.8% w/v i.e. 8g/L) to give the required sodium hypochlorite flow rate in L/hr which is sent to the duty dosing pump.

If there are any problems with the above automatic control mode (e.g. suspected faulty analyser), then the control can be reverted to flow paced only by placing the residual feedback PID controller in manual and then manually setting that PID controller's output.

All the above is visible at both the local OIP and UWSS/SCADA. PID controller mode changes and setpoint adjustments can be made by operations personnel at the OIP (when in local control mode) or via UWSS/SCADA (when in remote control mode).

A schematic of the control loop for the duty dosing system is shown in Figure 10-1 below.

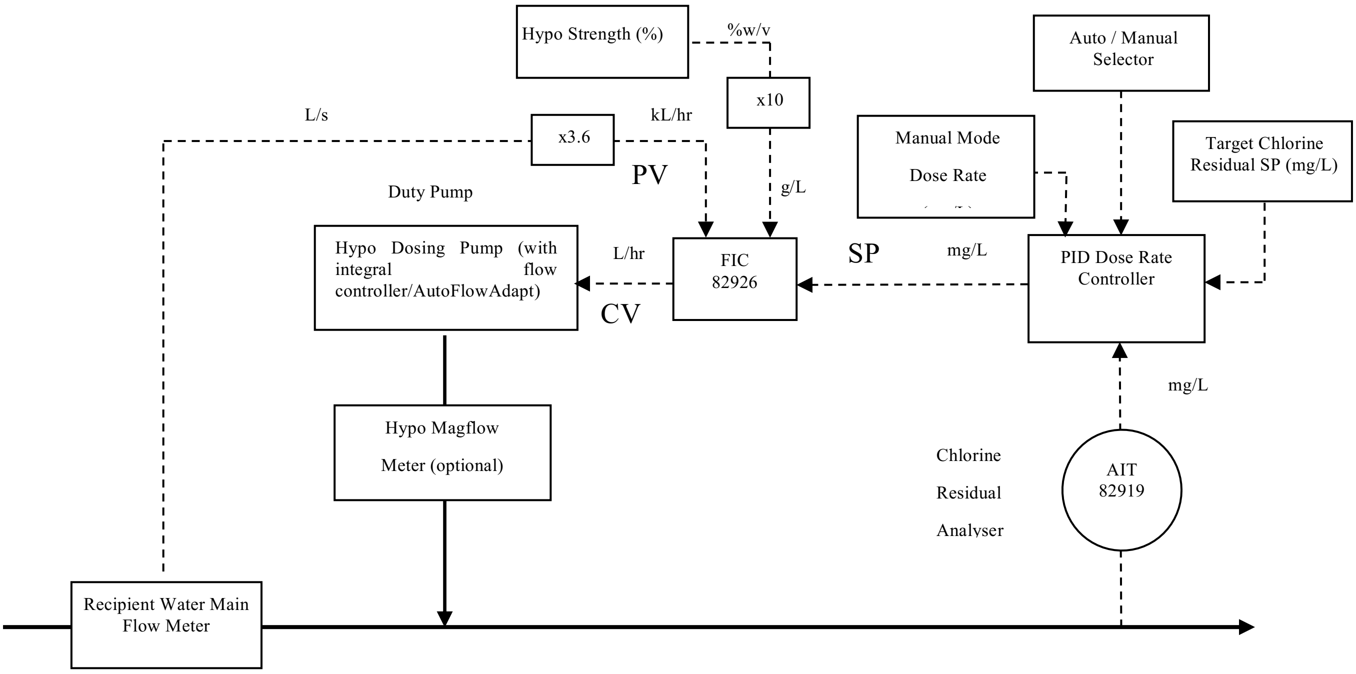


Figure 10-1: Dosing Control schematic for the duty Dosing System

When the duty dosing system is in ‘Ready’ mode, the dosing pump will remain idle until a minimum set point flow rate is achieved in the recipient water main. Similarly, the dosing pump will stop running and the system will sit idle in the ‘Ready’ mode when the flow rate in the recipient water main drops below the minimum set point.

If the selected duty dosing system is ‘Not Available’ or failed then the standby system will automatically commence operation, providing it is in the ‘Ready’ mode operational state. The failed system will not be available for selection until the alarm condition is acknowledged and reset (i.e. the failed system will be latched out). The standby system will be allowed a period (e.g. 6 minutes, configurable) for operation before any faults shuts it down too. Latching out of the failed system prevents changing back and forth between the duty and standby system.

In the event of a plant power failure during sodium hypochlorite dosing, the system shall resume dosing automatically following restoration of power and return of the permissive conditions such as the minimum set point flow rate in the water main. The low chlorine level in the treated water or other fault directly due to the plant power failure should not immediately trigger an alarm (i.e. an adjustable delay timer shall allow the chlorine residual to return to normal) as this could cause shutdown or system changeover when the power is restored. However, if the system is in ‘Fixed’ mode, it shall revert to the ‘Stopped’ (off) mode in the event of a power failure, and thus the equipment shall remain off when power is restored.

- Chlorination is initiated once the mains flow rate is above the ‘Initiate chlorination’ flow and the system has previously been off for two minutes or more.
- On ‘initiate chlorination’, the duty dose pump will start and run at maximum speed for a given time to purge the dose line of gas and to achieve the required pressure in the dose line for injection into the water main. The dose pump should return to the requested hypochlorite dose flow when the max speed timer has expired. Operation on maximum speed at start-up should also occur for the standby dose pump when it is called.

- For critical or primary chlorination sites, a chlorination failure shall automatically stop the water flow in the recipient water main (either by interlocking relevant pumps or closing an automated valve in the line).
- There should be no confusion between the "dose rate" (concentration) measured as mg/L and hypo "flow rate" (volumetric rate) measured as L/h which is a flow measurement of the hypo that should be annotated as "Hypo Flow Rate".
- The hypochlorite strength is an adjustable value in the range of 0.5 to 1.0% concentration; hence, hypochlorite flow rate required is calculated as:

  Hypo flow rate (L/h) = Mains flow rate (m3/h) * dose rate (mg/L) / (hypo strength (%) * 10)
- Dose pump flow rate monitoring shall preferably be a derived flow rate as determined by the dose pump (i.e. Integral Flow Measurement) rather than determined from a miniature magflow meter.
- The standby dose pump should start on one of the following conditions:
  - Duty dose pump failed to start or is unavailable,
  - Duty dose pump hypo flow rate is less than 50% of the hypo flow rate required (i.e. low hypo flow fault),
  - The chlorine residual is high or low for a given time (i.e. dosing fault).

Refer to section 12 for process safeguarding requirements. Except for the equipment differences noted in this standard (DS112), the control philosophy for the duty/standby dosing system shall be similar to the Bulk Sodium Hypochlorite Storage and Dosing System standard Functional Control Specification DS73-02.

10.3 Control Location

The Sodium Hypochlorite storage and dosing system may be controlled from the following locations:

a) Operator Interface Panel (OIP) – Full automatic and manual control is possible from this panel located in the viewing room. Any operational mode can be selected from this panel. Operation from the OIP requires prior approval from the Operations Centre (OC).

b) Human Machine Interface (HMI) –The full dosing system is monitored from the UWSS / Statewide SCADA Operations Centre at John Tonkin Water Centre.

c) Control functionality from the OIP and HMI shall be identical unless stated otherwise in the functional control specification.

10.4 Tank Level Low Alarm

In systems with multiple hypochlorite storage tanks, the Sodium Hypochlorite Tank Low Level Alarm shall be set to initiate at a level which corresponds to the tank being sufficiently empty (refer section 5.2.2) to receive a batch of sodium hypochlorite. This is also known as the refill level. This alarm should initiate:

1) the other storage tank to be brought on-line (tank outlet valve to open); then
2) this storage tank to be taken off-line (tank outlet valve to close); then
3) this tank inlet valve to open; then
4) sodium hypochlorite batching to refill the tank.

Note that proprietary electro-chlorination system controllers may use tank level to initiate electro-chlorination batching, whereas use of tank level to control the hypo tank outlet valves will be managed in the PLC.

10.5 Tank Level High Alarm

The Sodium Hypochlorite Tank High Level Alarm shall be set to initiate at a level which corresponds to 1 minute before a tank would commence overflowing during a filling/batching operation (or for slow filling tanks where 1 minute of filling is a very small level change, use a level slightly below the overflow level). This alarm will initiate shutdown of the batching system.

10.6 Blower Low Flow Alarm

An airflow sensor must be fitted to shut down the electro-chlorinator if the air blower dilution flow is interrupted. The air flow sensor shall be mounted near the end of the vent line as this ensures any air leak upstream is monitored. This alarm will initiate shutdown of the batching and swap over to the standby system.

10.7 Chlorine Residual Low Alarm

The setpoint chlorine concentration for this alarm is operator adjustable. If this alarm remains continuously active for an adjustable delay period (e.g. 6 minutes) and a standby dosing pump is available, then automatic changeover to the standby dosing pump is initiated. If a standby dosing pump is not available, then no control action is taken.

10.8 Chlorine Residual High Alarm

The setpoint chlorine concentration for this alarm is operator adjustable. If this alarm remains continuously active for an adjustable delay period (e.g. 6 minutes) and a standby dosing pump is available, then automatic changeover to the standby dosing pump is initiated. If a standby dosing pump is not available, then no control action is taken.

10.9 Required Dose Rate Low Alarm

This alarm is displayed on OIP and SCADA screens. “Required dose rate low” is initiated when the required chlorine dose rate is less than or equal to the lower dose rate limit continuously for 30 minutes. This alarm flags a possible problem with the dosing process. When this alarm is triggered, the dose rate becomes limited to the lower dose rate limit.

10.10 Required Dose Rate High Alarm

This alarm is displayed on OIP and SCADA screens. “Required dose rate high” is initiated when the required chlorine dose rate is greater than or equal to the upper dose rate limit continuously for 30 minutes. This alarm flags a possible problem with the dosing process. When this alarm is triggered, the dose rate becomes limited to the upper dose rate limit.

11 Hazardous Area Management

A preliminary evaluation that identifies hazardous areas (Hazardous Area Assessment) shall be produced in concept design.

To manage risk of explosive atmospheres, a Hazardous Area Classification report shall be produced during detail design of the brine electro-chlorination facility. It shall include address of the hydrogen gas produced as a by-product of electrolysis.

In addition to automatic shutdown of electro-chlorination on detection of a hydrogen leak, any electrical equipment - that is located within a Zone 2 hazardous area classification - will need to be either relocated outside the hazardous area or alternatively be replaced with equipment suitable to operate in a Zone 2 hazardous area.

Suitable earthing and static protection as detailed in Australian standards such as AS/NZS 3000 and AS/NZS 1020 shall be undertaken and tested by suitable electrical contractors.

12 PROCESS SAFEGUARDING

This section details the process safeguarding controls that are implemented to protect personnel, equipment and the environment. PLC and/or RTU code associated with these process safeguarding controls shall be separated and clearly identified in the PLC/RTU and denoted within the code as subject to strict Management of Change (MoC) procedures.

Strict Management of Change requires both of the following procedures to be followed:

1) Safety & Wellbeing MoC procedure
   https://nexus.watercorporation.com.au/otcs/cs.exe/app/nodes/58727880
2) DS40-06 – Software Change Control standard

12.1 Hydrogen

Explosive atmosphere hazard (due to hydrogen) shall be managed using alarms with interlocks including:

- Leaks - On any High High atmospheric hydrogen gas detection, all electrolysers shall shutdown. This critical safety interlock shall be hard-wired such that it is independent of the Plant Control System. Critical alarms shall be announced to SCADA and initiate external warning strobe and audible alarm (the latter only if the building security is disabled).
- Electrolyser - Low flowrate through the cell must trigger shutdown and an alarm. Some cells also have a level sensor, and in the case of low level will trigger shutdown and an alarm.
- Blower – For systems that do not exhaust all hydrogen prior to the hypo storage tank, an airflow sensor (refer section 10.6) must be fitted to shut down the electro-chlorinator if the air blower dilution flow is interrupted.

12.2 Hydrogen Leak High Alarm

The system shall continuously measure the concentration of hydrogen in the atmosphere. The purpose of the Hydrogen Leak High Alarm is to warn of a hydrogen gas leak well before it reaches the Lower Explosive Limit concentration.

The hydrogen gas sensor shall activate the visual and audible alarm when hydrogen gas levels in the batching room reach 0.2 vol%, concentration in air[20].

The setpoint for this alarm shall be either a factory-set relay output from the detector cell or hard-coded into the PLC and not adjustable from the OIP or SCADA.

12.3 Hydrogen Leak High-High Alarm

The purpose of the Hydrogen Leak High-High Alarm is to halt further hydrogen generation and mitigate risks of electrical equipment operating in a hazardous area well before reaching the Lower Explosive Limit concentration.

The hydrogen gas sensor shall automatically shut down the electro-chlorinator system (regardless of whether running in automatic or manual mode) when hydrogen gas levels in the batching room reach

[20] If the hydrogen gas sensor has reduced accuracy of measuring at such low concentrations, then an alternative acceptable alarm concentration is 0.4 vol%. Conversely, lower setpoints may be used if the gas sensor can accurately measure them.

0.4 vol%, concentration in air[21] for longer than 5 seconds. Also, to mitigate risk of electrical equipment operating (which may be a potential ignition source) while a potentially explosive concentration of hydrogen is present, it is necessary to shutdown that equipment e.g. if the batching room has an air conditioner, then it shall also be shut down at high-high hydrogen alarm. Shutdown shall be achieved using hard-wired interlocks (independent of the PLC).

To allow the electro-chlorinator operation to recommence, this condition must be reset by the operator which may only be done once no hydrogen leak alarms are active. Reset capability shall be available at the local OIP and remotely via UWSS.

The setpoint for this leak alarm shall be either a factory-set relay output from the detector cell or hard-coded into the PLC and not adjustable from the OIP or SCADA.

12.4 Sodium Hypochlorite Tank Low-Low Level Alarm

The purpose of the Sodium Hypochlorite Tank Low-Low Level Alarm is to protect the sodium hypochlorite dosing pumps from running dry and to prevent air from being entrained in the suction pipework. Therefore, the set point for the Low Low level alarm should be just above (e.g. 25 mm above) the obvert level of the process outlet on the tank.

On initiation of the Sodium Hypochlorite Tank Low-Low Level Alarm, immediately initiate the Water Quality Poor Alarm and after 60 seconds, inhibit operation of all sodium hypochlorite dosing pumps.

The setpoint for this alarm shall be hard-coded into the PLC and not adjustable from the OIP or SCADA.

12.5 Sodium Hypochlorite Tank High-High Level Alarm

The High-High level alarm should indicate imminent overflow of the tank and should be set at a level which corresponds to 20 seconds before tank overflow.

On initiation of the Sodium Hypochlorite Tank High-High Level Alarm, trip the batching system and raise an alarm on the OIP and SCADA.

The setpoint for this alarm shall be hard-coded into the PLC and not adjustable from the OIP or SCADA.

Redundancy of tank level instrumentation for 0.8% solution is not normally considered necessary because the consequence of overflow is relatively minor, plus the bund high level alarm provides a backup trip signal for the batching system.

12.6 Sodium Hypochlorite Bund High Level Alarm

Section 5.1.4 discusses whether a Bund High Level Alarm is necessary to alert of a sodium hypochlorite or water spill.

On initiation of the Sodium Hypochlorite Bund High Level Alarm, shutdown the batching system and raise an alarm on the OIP and SCADA. Note: A Bund High Level Alarm does not initiate automatic shutdown of the hypo dosing system.

12.7 Low Sample Water Flow Alarm

On low sample water flow an alarm is raised to the OIP and HMI and the residual feedback PID loop is automatically placed in manual with its output set at the last recorded healthy dose rate. This safeguard protects against potential over-dosing or under-dosing of sodium hypochlorite due to incorrect chlorine residual analyser reading (which would occur if the analyser is receiving inadequate sample flow). If the sample flow becomes healthy again then the interlock with the PID controller self-resets (the controller is returned to automatic mode) after a pre-set time (default = 300 seconds).

[21] If the hydrogen gas sensor has reduced accuracy of measuring at such low concentrations, then an alternative acceptable alarm concentration is 0.8 vol%. Conversely, lower setpoints may be used if the gas sensor can accurately measure them.

12.8 Chlorine Residual Low Alarm

If low concentration registered continuously for 6 minutes (configurable), triggers alarm and shuts down duty dosing system operation and initiates standby dosing system if it is available.

12.9 Chlorine Residual Low-Low Alarm

The Low-Low Chlorine Residual Alarm protects against the supply of inadequately disinfected water. The alarm is initiated if the measured chlorine residual is continuously less than the low-low limit for 60 seconds after changeover (i.e. both dose panels have triggered Chlorine Residual Low Alarm).

Once triggered, if this alarm persists for 30 seconds, then the "Water Quality Poor" alarm is triggered. This will initiate shutdown of the recipient water main which will then stop the sodium hypochlorite dosing system.

The setpoint for this alarm shall be adjustable from SCADA only (not from the OIP) with supervisor or higher access required.

12.10 Chlorine Residual High Alarm

If high concentration registered continuously for 6 minutes (configurable), triggers alarm and shuts down duty dosing system operation and initiates standby dosing system if it is available.

12.11 Chlorine Residual High-High Alarm

The High-High Chlorine Residual Alarm protects against the supply of over-chlorinated water. The alarm is initiated if the measured chlorine residual is continuously higher than the high-high limit for 60 seconds after changeover (i.e. both dose panels have triggered Chlorine Residual High Alarm).

Once triggered, if this alarm persists for 30 seconds, then the "Water Quality Poor" alarm is triggered. This will initiate shutdown of the recipient water main which will then stop the sodium hypochlorite dosing system.

The setpoint for this alarm shall be adjustable from SCADA only (not from the OIP) with supervisor or higher access required.

12.12 Water Quality Poor Alarm

A Water Quality Poor alarm is triggered on any of the following conditions (following a 30 second delay):

- Sodium Hypochlorite Dosing System is initiated and:
  - Neither dosing pump is running; or
  - Turbidity high alarm (where turbidity analyser is installed); or
  - Turbidity analyser failure (where turbidity analyser is installed); or
  - Inlet chlorine residual high-high alarm; or
  - Inlet chlorine residual low-low alarm; or
  - Chlorine residual analyser failure; or
  - Flowmeter (on recipient main) fault (or fault in its analogue input); or
  - Mains Flow Discrepancy alarm (adjustable timer, default value 120 seconds).

For critical or primary disinfection sites, the water quality poor alarm shall be interlocked to stop flow in the recipient water main.

The "water quality poor" alarm must be manually reset either locally or remotely (unless self-reset on power restore) before the system can be returned to operation.

12.13 Safety Shower High Flow Alarm

Operation of the safety shower or eyewash shall initiate an alarm on the OIP and SCADA to alert operations personnel of a possible personnel emergency requiring medical assistance. It shall include a 120 second delay to mask testing of the safety shower/eyewash unit.

13 DECONTAMINATION

The design of the sodium hypochlorite dosing facility shall accommodate the following decontamination methods.

13.1.1 Spills Within Bund

For small spills, neutralisation can be accomplished by dilution and hosing down with water within the bund. For larger spills, the bulk of the spill should first be pumped into a sealable container for correct disposal. The spill area should then be thoroughly flushed with water.

13.1.2 Dosing Pump and Piping Decontamination

A flushing water system as described in section 6.5 shall be used for flushing and decontamination of the dosing pump, dosing pipe and pressure sustaining valve prior to disassembly. The flushing will reduce the possibility of occupational exposure to sodium hypochlorite.

Additionally, a wash down trough should be located close to the dosing pump(s). This facilitates further decontamination of the dosing pump within the bund once the pump has been removed from its mounting for maintenance.

14 PLACARDING, LABELLING AND SAFETY SIGNAGE

All the following safety signs and placards shall be provided for any sodium hypochlorite storage and/or dosing facility:

a) A Sodium Hypochlorite Facility sign (<1%) (DS WCSS003-5) shall be posted on the outside wall of the Sodium Hypochlorite building near the salt unloading area and next to the personnel door to the viewing room. These signs shall be displayed to be clearly visible from the normal direction of approach.

b) A Sodium Hypochlorite Storage Tank sign (<1%) (DS WCSS003-6) shall be posted on each tank in the sodium hypochlorite storage room. This sign(s) shall be displayed to be clearly visible from the normal direction of approach.

c) Storage Tank Identification & Volume Labels (DS WCSS404) indicating the tank number and size shall be posted on each tank. These labels shall be displayed at a level so that they are visible from the normal direction of approach.

d) Emergency Shower & Eyewash Signs (DS WCSS306) shall be posted on the wall next to the safety shower unit or attached to the rear of the shower. These signs shall be displayed to be clearly visible from the normal direction of approach.

Pipe Identification Markers (DS WCSS452) shall be posted on all pipework to indicate pipe contents and flow direction. These markers should be prominently displayed on the pipework to ensure the observer can clearly read the information.

Commissioning Plan Information

All signs and placards shall comply with the requirements of DS 79 - 04 Safety Signage, Labels and Markers.

Where a sign is fitted onto or near a door, the sign shall be easily visible with the door either open or closed. This may require identical signs to be fitted to both sides of the door.

15 DRAWINGS

The appropriate process area for electro-chlorination is 82; hence, P&IDs shall use sheet 82.

General arrangement drawings should be numbered as <asset specific planset>-070-82.

Any civil drawings for the electro-chlorination module should be numbered as <asset specific planset>-006-82.

15.1 Example Drawings

The Water Corporation's existing electro-chlorination sites pre-date this design standard, and so are not entirely consistent with the requirements of this design standard. Example drawings of General Arrangements will be included in a future revision of this standard once they become available.

P&IDs

Action: Designer to copy the JD71 drawings and re-number as <Site Planset number>-60-82.

- Hypochlorite tanks - JD71-60-82.6 (from small hypochlorite design standard DS73-10) is relevant for the hypochlorite storage tank and bund, but requires amendments including:
    - the load-in pipework shall be adapted to instead show the product supply coming from the electrolyser(s). It shall be shown as sloped continuously upwards and enter the upper side wall of the tank.
    - the vent line shall rise continuously upwards.
    - a blower inlet line is required.
    - level transmitter preferred as ultrasonic, mounted above the tank roof.
    - tank outlet shall have an automatic isolation valve.
    - second tank shall be shown on a similar but separate part sheet P&ID.
- Dose panels - JD71-60- 82.7 to 82.9 (from DS73-10) will be relevant for all systems.
    - Dose panel 1 (JD71-60- 82.7)
    - Dose panel 2 (JD71-60- 82.8)
    - Dose point and sampling (JD71-60- 82.9)

16 APPENDIX A: 0.8% SODIUM HYPOCHLORITE PROPERTIES AND SAFE HANDLING REQUIREMENTS

16.1 Properties

0.8% hypo - pH approximately 9 (versus 13 for 12.5% NaOCl)

<u>0.8% hypo</u>

specific gravity = 1.020;

stored concentration (m/m) = 0.82% NaOCl;

stored concentration (m/V) = 0.84% NaOCl

<u>1.0% hypo</u>

specific gravity = 1.026;

stored concentration (m/m) = 1.02% NaOCl;

stored concentration (m/V) = 1.05% NaOCl

16.2 Safety Data Sheet

The following pages have a Safety Data Sheet produced by Grundfos (an electrolyser supplier).

Safety Data Sheet

according to Regulation (EC) 1907/2006 (REACH)
Product name: Sodium hypochlorite solution, 0,8% Cl
Version: 1.0 / EN

GRUNDFOS
Print date: 17.04.2015
Revision date: 17.04.2015

SECTION 1: IDENTIFICATION OF THE SUBSTANCE/MIXTURE AND OF THE COMPANY/UNDERTAKING

1.1 Product identifier

Product name: Sodium hypochlorite solution, 0,8% Cl

1.2 Relevant identified uses of the substance or mixture and uses advised against

Identified use: Disinfectant

1.3 Details of the supplier of the Safety Data Sheet

Supplier:	Grundfos Water Treatment GmbH Reetzstraße 85 D-76327 Pfinztal
Telephone number:	0049 7240 61 0
Fax:	0049 7240 61 177
E-mail-Address:	gwt@grundfos.com

1.4 Emergency telephone number

0049 7240 61 0 (only available during office hours)

SECTION 2: HAZARDS IDENTIFICATION

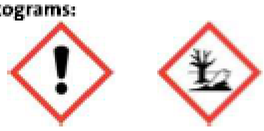
2.1 Classification of the substance or mixture

Classification according to Regulation (EC) No 1272/2008 [CLP]
Skin Irrit. 2
Aquatic acute 1

2.2 Label elements

Labelling according to Regulation (EC) No 1272/2008 [CLP]

Hazard pictograms:



Signal word:
CAUTION

Hazard statements:
H315 Causes skin irritation.
H400 Very toxic to aquatic life

Precautionary statements:
P264 Wash hands thoroughly after handling.
P280 Wear protective gloves/protective clothing/eye protection/face protection.
P302 IF ON SKIN: Wash with plenty of water/soap
P273 Avoid release to the environment.
P501 Dispose of contents/container in accordance with local and national legislation

2.3 Other hazards

The mixture does not meet the criteria for PBT or vPvB substances.

SECTION 3: COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Mixtures

Description of the mixture:
Aqueous solution of sodium hypochlorite and other inorganic components.

Page 1 of 10

Safety Data Sheet

according to Regulation (EC) 1907/2006 (REACH)
Product name: Sodium hypochlorite solution, 0,8% Cl
Version: 1.0 / EN

GRUNDFOS
Print date: 17.04.2015
Revision date: 17.04.2015

Hazardous ingredients:

Name CAS No	EG No REACH Reg. No	Concentration (%)	Classification according to Regulation (EC) No 1272/2008 (CLP)
Sodium hypochlorite solution, ...% Cl 7681-52-9	231-668-3 01-2119488154-34-XXXX	~ 0,8	Met. Corr. 1, H290 Skin Corr. 1A, H314 Aquatic Acute 1, H400

Additional information:
Full text of H -phrases: see section 16.
Substances, which are listed at the so-called „Candidate List of Substances of Very High Concern (SVHC) for authorisation" of the European chemical agency (ECHA), are not part of this product.

SECTION 4: FIRST AID MEASURES

4.1 Description of first aid measures

General notes:
Remove contaminated, saturated clothing immediately.

Following inhalation:
Following inhalation of aerosol or released chlorine gas:
Under self-protection of the first aider, bring affected person from the danger area to fresh air. Bed down the injured person comfortably, protect from undercooling. Seek medical advice immediately.

Following skin contact:
Rinse the affected skin areas at least 10 to 20 minutes under running water.
Remove contaminated clothing, mind self-protection.

Following eye contact:
Rinse eye under protection of uninjured eye for 10 minutes under running water with eyelids held open wide. Get medical advice / attention by an eye specialist afterwards.

Following ingestion:
Rinse the mouth thoroughly and spit out.
If the person is conscious, drink plenty of water. Seek medical advice.

Self-protection of the first aider:
Mind self-protection. Wear personal safety equipment, see section 8.

4.2 Most important symptoms and effects, both acute and delayed

Shortage of breath
Cough
Irritation and caustic effect

4.3 Indication of any immediate medical attention and special treatment needed

No further relevant information available.

SECTION 5: FIREFIGHTING MEASURES

5.1 Extinguishing media

Suitable extinguishing media:
Co-ordinate fire-fighting measures to the fire surroundings..
CO_2, extinguishing powder or water spray. Fight larger fires with water spray or alcohol resistant foam.

Unsuitable extinguishing media:
For this mixture no limitations of extinguishing agents.

5.2 Special hazards arising from the substance or mixture

Non-flammable.

Hazardous combustion products:
Hydrochloric acid (HCl)
Chlorine
Carbon monoxide and carbon dioxide

5.3 Advice for firefighters

Special protective equipment:
Wear a self-contained breathing apparatus

5.4 Additional information:

Fire residues and contaminated fire extinguishing water must be disposed of in accordance with official regulations.
Suppress escaping vapours with water.
Do not allow run-off from fire-fighting to enter drains or water courses.

SECTION 6: ACCIDENTAL RELEASE MEASURES

6.1 Personal precautions, protective equipment and emergency procedures

Do not breathe gas/fumes/vapour/spray.
Avoid skin and eye contact.
Wear respiratory protection.
Wear protective equipment. Keep unprotected persons away.
Ensure adequate ventilation.

6.2 Environmental precautions

Prevent any spillage from entering the sewage system, the surface water and the ground water.
If the product enters into the sewage system or aquatic environment, notify the appropriate authorities.

6.3 Methods and material for containment and cleaning up

Clean up with absorbent material such as sawdust, diatomaceous earth or universal absorbents.
Do not attempt to neutralize spilled liquid with acid!
For large amounts: Pump off product
Ventilate room thoroughly and clean contaminated objects and floors.
Dispose contaminated material as waste according to section 13.

6.4 Reference to other sections

Information on safe handling see section 7.
Information on personal protection equipment see section 8.
Disposal Information see section 13.

6.5 Additional information:

SECTION 7: HANDLING AND STORAGE

7.1 Precautions for safe handling

Protective measures:
Provide good ventilation and/or an exhaust system.
Avoid formation of aerosols.
Check the electrical installation regularly because of increased risk of corrosion.

Safety Data Sheet

according to Regulation (EC) 1907/2006 (REACH)
Product name: Sodium hypochlorite solution, 0,8% Cl
Version: 1.0 / EN

Print date: 17.04.2015
Revision date: 17.04.2015

Information about protection against fires and explosions
No special measures required.

7.2 Conditions for safe storage, including any incompatibilities

Requirements for storage rooms and containers
Unsuitable container/equipment material: Metal
Containers must be labelled clearly and permanently.
Avoid exposure to light.

Note on storage:
Do not store together with acids.

7.3 Specific end uses:

No further relevant information available.

SECTION 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

8.1 Control parameters

Occupational exposure limits:

Sodium hypochlorite, CAS 7681-52-9: No STEL set (Europe)

Released decomposition products:
Chlorine, CAS 7782-50-5
Europe, EU, **STEL**: 0,5 ppm; 1,5 mg/m³
Germany TRGS 900, **AGW**: 0,5 ppm; 1,5 mg/m³
Peak limitation: **1** (I)

DNEL/PNEC-values:

Sodium hypochlorite (CAS 7681-52-9)	
DNEL (Worker)	
acute inhalative (systemic)	3.1 mg/m³
acute inhalative (local)	3.1 mg/m³
long-term dermal (local)	0.5 mg/kg body weight/day
long-term inhalative (systemic)	1.55 mg/m³
long-term inhalative (local)	1.55 mg/m³
DNEL (Consumer)	
acute inhalative (systemic)	3.1 mg/m³
acute inhalative (local)	3.1 mg/m³
long-term oral (systemic)	0.26 mg/kg body weight/day
long-term inhalative (systemic)	1.55 mg/m³
long-term dermal (local)	0.5 % in the mixture
long-term inhalative (local)	1.55 mg/m³
PNEC (Water)	
PNEC aqua (fresh water)	0.00021 mg/l
PNEC aqua (marine water)	0.000042 mg/l
PNEC aqua (intermittent releases, fresh water)	0.00026 mg/l
PNEC (STP)	
PNEC sewage treatment plant	0.03 mg/l

Additional notes:
The lists valid during the creation serve as basis.

Safety Data Sheet

according to Regulation (EC) 1907/2006 (REACH)
Product name: Sodium hypochlorite solution, 0,8% Cl
Version: 1.0 / EN

GRUNDFOS
Print date: 17.04.2015
Revision date: 17.04.2015

8.2 Exposure controls

Personal protective equipment
Protective clothing needs to be selected specifically for the workplace, depending on concentrations and quantities of the hazardous substances handled. The chemical resistance of the protective equipment should be enquired at the respective supplier.

General protective and hygienic measures:
Do not eat, drink, smoke or sniff while working.
Keep away from foodstuffs, beverages and feed.
Immediately remove all soiled and contaminated clothing.
Wash hands before breaks and at the end of work.
Avoid contact with the eyes and skin.

Eye / Face protection:
Tightly sealed goggles

Skin protection:
The glove material has to be impermeable and resistant to the product/ the substance/ the preparation.
Selection of the glove material on consideration of the penetration times, rates of diffusion and the degradation
Suitable gloves made of the following materials (Penetration time >= 8 hours):
Natural rubber - NR (0,5 mm)
Chloroprene rubber - CR (0,5 mm)
Nitrile rubber - NBR (0,35 mm)
Butyl rubber - Butyl (0,5 mm)
Fluor rubber - FKM (0,4 mm)
Polyvinylchloride - PVC (0,5 mm)

Body protection
Alkaline resistant protective clothing

Respiratory protection:
Required when vapours/aerosols are generated. Filter B (–P3).
In case of brief exposure or low pollution use respiratory filter device. In case of intensive or longer exposure use self-contained respiratory protective device.

Environmental exposure controls
See sections 6 and 7.

SECTION 9: PHYSICAL AND CHEMICAL PROPERTIES

9.1 Information on basic physical and chemical properties

a) Appearance:	Physical state: liquid Colour: pale yellowish
b) Odour	like chlorine
c) Odour threshold	no data available
d) pH value at 20°C	9,4
e) Melting point/freezing point	no data available
f) Initial boiling point/boiling range	not applicable
g) Flashpoint	no data available
h) Evaporation rate	no data available
i) Flammability (solid, gas)	not applicable
j) Upper/lower explosion limits	not applicable
k) Vapour pressure	20 mBar at 20 °C
l) Vapour density	no data available
m) Relative density	1,014 g/cm³

Page 5 of 10

Safety Data Sheet

according to Regulation (EC) 1907/2006 (REACH)
Product name: Sodium hypochlorite solution, 0,8% Cl
Version: 1.0 / EN

GRUNDFOS
Print date: 17.04.2015
Revision date: 17.04.2015

n) Solubility in water	Completely miscible with water
o) Partition coefficient:	
n-octanol/water	no data available
p) Auto-ignition temperature	The product is not self-igniting.
q) Decomposition temperature	no data available
r) Viscosity	no data available
s) Explosive properties	The product is not explosive.
t) Oxidising properties	no data available

9.2 Other information

No further relevant information available.

SECTION 10: STABILITY AND REACTIVITY

10.1 Reactivity

Has a corrosive effect

10.2 Chemical stability

Decomposition at heat.
Light sensitive

10.3 Possibility of hazardous reactions

Contact with acids releases toxic gas.

10.4 Conditions to avoid

Warmth/heat

10.5 Incompatible materials

Aluminium
Zinc

10.6 Hazardous decomposition products

Chlorine; hydrochloric acid, oxygen

SECTION 11: TOXIKOLOGICAL INFORMATION

11.1 Information on toxicological effects

Acute toxicity
LD50 (oral): 5800 mg/kg (mouse)
LD50 (oral): 8,91 g/kg (rat)
Source: Toxnet

Skin corrosion/irritation
Irritant to skin and mucous membranes
Eye damage/irritation
Burns, risk of blindness
Sensitisation to the respiratory tract/skin
No sensitizing effects known.

CMR effects:
Germ cell mutagenicity
No information available.
Carcinogenicity
No information available.
Reproductive toxicity
No information available.

Safety Data Sheet

according to Regulation (EC) 1907/2006 (REACH)
Product name: Sodium hypochlorite solution, 0,8% Cl
Version: 1.0 / EN

GRUNDFOS
Print date: 17.04.2015
Revision date: 17.04.2015

Specific target organ toxicity (single exposure)
The substance or mixture is not classified as specific target organ toxicity (single exposure)
Specific target organ toxicity (repeated exposure)
The substance or mixture is not classified as specific target organ toxicity (repeated exposure)
Aspiration hazard
No aspiration toxicity classification.

Other information
The product should be handled with the care usual when dealing with chemicals.

SECTION 12: ECOLOGICAL INFORMATION

12.1 Toxicity:

Aquatic toxicity	Effect dose	Result/ Evaluation	Test duration	Species	Source
Acute (short-term) fish toxicity	LC50	0,08 mg/l	96 h	Pimephales promelas	ECOTOX
Acute (short-term) toxicity to crustacea	EC50	0,04 mg/l	48 h	Daphnia magna	ECOTOX

12.2 Persistence and degradability

Biologic degradation: Methods for the determination of biodegradability are not applicable to inorganic substances.

12.3 Bio accumulative potential

No further relevant information available.

12.4 Mobility in soil

No further relevant information available.

Ecotoxical effects:
Remark:
Harmful effect on aquatic organisms due to pH shift.
Do not allow to enter waters, wastewater, or soil!
Very toxic to aquatic organisms.
Also poisonous for fish and plankton in water bodies.

12.5 Results of PBT and vPvB assessment

This substance does not meet the PBT/vPvB criteria of REACH, annex XIII.

12.6 Other adverse effects:

No further relevant information available.

12.7 Additional ecotoxicological information

No further relevant information available.

SECTION 13: DISPOSAL CONSIDERATIONS

13.1 Waste treatment methods

Recommendation:
Observe section 7.1 when handling product or containers.
Smaller quantities can be reduced with sodium sulphate, sodium bisulphite or sodium thiosulfate
The disposal is regionally differently regulated, therefore the kind of disposal is to be inquired at the responsible authorities.

Page 7 of 10

Contaminated packing:
Handle as the product itself. Not contaminated and residue-free packing can be recycled.

13.2 Additional information

SECTION 14: TRANSPORT INFORMATION

14.1 UN-No

ADR, ADN, IMDG, IATA — not applicable

14.2 UN Proper shipping name

ADR, ADN, IMDG, IATA — not applicable

14.3 Transport hazard class(es)

ADR, ADN, IMDG, IATA — not applicable

14.4 Packing group

ADR, IMDG, IATA — not applicable

14.5 Environmental hazards

Marine pollutant: no

14.6 Special precautions for user

not applicable.

14.7 Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code

not applicable.

Additional information
All transport carriers

Land transport (ADR/RID)
Note: Not subject to transport regulations.
UN "Model Regulation": -

SECTION 15: REGULATORY INFORMATION

15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture

National regulations (Germany):

Statutory order on hazardous incidents:
Annex I, No 9b
Water hazard class:
WGK 1 (self-assessment): light water hazard
Technical Instruction for protection of the air:
Substance: Chlorine, CAS 7782-50-5
Section 5.2.4. Kl. II: In the exhaust stream, the following values must not be exceeded for chlorine:
In mass flow: 15 g/h
Mass concentration: 3 mg/m³
TRGS 510: Storage of hazardous substances in portable tanks:
Storage class: 10 – 13

EU regulations:

Regulation 1272/2008/EG (CLP/GHS) and supplements
Regulation 1907/2006/EG (REACH) and supplements

Safety Data Sheet

according to Regulation (EC) 1907/2006 (REACH)
Product name: Sodium hypochlorite solution, 0,8% Cl
Version: 1.0 / EN

GRUNDFOS
Print date: 17.04.2015
Revision date: 17.04.2015

Other relevant regulations:

Ordinance on Hazardous Substances
TRGS 401: Hazard by skin contact Determination – Evaluation – Measures
TRGS 500: Safety measures
TRGS 510: Storage of hazardous substances in portable tanks
TRGS 555: Operating instructions and information for workers
TRGS 900: Occupational Exposure Limits
Employment restrictions concerning pregnant and lactating women must be observed.
Employment restrictions concerning juveniles must be observed.
EWC – European Waste Catalogue

15.2 Chemical Safety Assessment

For this substance, a chemical safety assessment is not required.

SECTION 16: OTHER INFORMATION

16.1 Indication of changes

First issue

16.2 Abbreviations and acronyms

AGW: Arbeitsplatzgrenzwert
DNEL: Derived No Effect Level
LC50: Letal concentration, 50 percent
PBT: persistent, bio accumulative, toxic
PNEC: Predicted No Effect Concentration
STEL: Short Term Exposure Limit
vPvB: very persistent, very bio accumulative
WKG: Wassergefährdungsklasse
RID: Règlement international concernant le transport des marchandises dangereuses par chemin de fer (Regulations Concerning the International Transport of Dangerous Goods by Rail)
IATA-DGR: Dangerous Goods Regulations by the "International Air Transport Association" (IATA)
ICAO: International Civil Aviation Organization
ICAO-TI: Technical Instructions by the "International Civil Aviation Organization" (ICAO)
ADR: Accord européen sur le transport des marchandises dangereuses par Route (European Agreement concerning the International Carriage of Dangerous Goods by Road)
IMDG: International Maritime Code for Dangerous Goods
IATA: International Air Transport Association
GHS: Globally Harmonized System of Classification and Labelling of Chemicals

16.3 Key literature references and sources for data

ECOTOX
Gestis Stoffdatenbank
Merkblätter gefährlicher Arbeitsstoffe, Loseblattwerk und Software, ecomed Verlagsgesellschaft, Landsberg

16.4 Classification for mixtures and used evaluation method according to regulation (EC)

Classification according to Regulation (EC) Nr. 1207/2009	Classification procedure
Skin Irrit. 2, H315	On basis of expert data
Aquatic acute 1, H400	Calculation method

16.5 Relevant R-, H- and EUH-phrases (number and full text)

R34: Causes burns.
R50: Very toxic to aquatic organisms.
R31: Contact with acids liberates toxic gas.

Page 9 of 10

Safety Data Sheet

according to Regulation (EC) 1907/2006 (REACH)
Product name: Sodium hypochlorite solution, 0,8% Cl
Version: 1.0 / EN

Print date: 17.04.2015
Revision date: 17.04.2015

H290	May be corrosive to metals.
H314	Causes severe skin burns and eye damage.
H315	Causes skin irritation.
H400	Very toxic to aquatic life.

16.6 Training advice:

Training according national regulations of hazardous substances. Use the information in this safety data sheet.

16.7 Further information:

The information given in this Safety Data Sheet only apply to the described product in connection with its appropriate utilization. This information is based on the latest state of our knowledge. In particular, it serve the purpose of describing our product under the aspect of hazards caused by such product and pertaining safety actions. It do not constitute any guarantee of product qualities and/or quality features.
The information given in this Safety Data Sheet is not required in accordance with article 31 and Annex II of the Regulation EC No 1907/2006. They merely serve the purpose of providing sufficient information on the voluntary basis with a view to ensure the safe use of this mixture.

Page 10 of 10

17 APPENDIX B: COMMISSIONING PLAN ISSUES LIST

Commissioning Plan Information
A 24-hour hydrostatic leak test shall be conducted on a bund prior to the filling of its associated storage tank(s) with chemical.

Commissioning Plan Information
Prior to delivery to site, all tanks shall be hydrostatically tested using clean water filled to the overflow level. The full static head is to be held for a minimum of 12 hours. Once installed, the tanks shall be hydrostatically tested to the full static head again to check for any damage which may have occurred during transportation or installation[22]. All tanks shall be transported with capped/covered nozzles to prevent dust and vermin entering.

Commissioning Plan Information
Prior to commissioning the electrolyser(s), the filling line shall be hydrostatically pressure tested in accordance with AS 4041 to 1.5 times the operating pressure of the brine pump and held for a minimum of 30 minutes. Note: The tank shall not be subject to the test pressure as it is only rated for static head up to the overflow level.

Commissioning Plan Information
Safety relief valves shall be fitted with carseals to protect against unauthorised adjustment. The pressure setting of safety relief valves shall be recorded on a red traffolyte tag (labelled PSV82***) attached to either the valve body or the carseal.

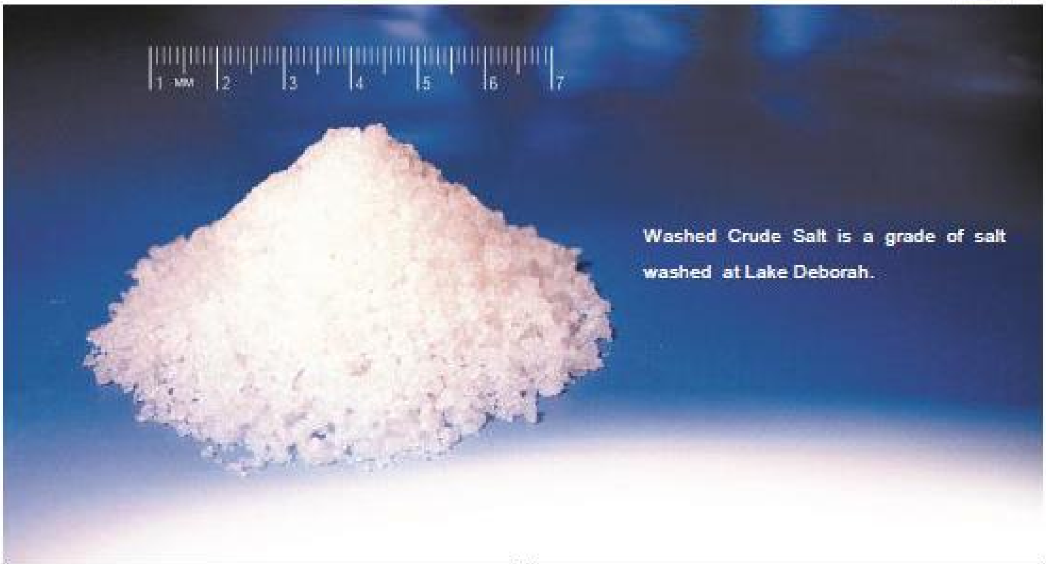
Commissioning Plan Information
All signs and placards shall comply with the requirements of DS 79 - 04 Safety Signage, Labels and Markers.

[22] Water used for testing tanks at site can then be discharged through the scour valve to test the bund as well.

18 APPENDIX C: WASHED CRUDE SALT - SPECIFICATION SHEET

Specification Sheet

Washed Crude Salt



CHEMICAL ANALYSIS	
Salt (NaCl)	97.1 %
Calcium (Ca)	931 ppm
Magnesium (Mg)	194 ppm
Sulphates (SO_4)	2363 ppm
Insoluble Matter in H_2O	100 ppm
Moisture (when packed)	2 %

Note: The above chemical analysis should be taken as a guide only, as some slight variations may occur from season to season.

QUALITY STANDARDS

ISO 9001: 2015 NASAA

INGREDIENTS

Salt [Sodium Chloride (NaCl)]

SIEVING ANALYSIS	
Mesh size (mm)	2.80
Typical % retained	75 %

ORIGIN

Western Australia

PACKAGING

Bulk deliveries.

STORAGE

Store in dry storage area below 75% relative humidity to prolong shelf life.

WA Salt Supply, 187 Cockburn Road, NORTH COOGEE, WA 6163. Tel: +61 (8) 9431 9431 Fax: +61 (8) 9335 3220
Email: quality@wasalt.com.au Web: www.wasalt.com.au www.lakedeborah.com.au

Version 4 Updated 29/07/2022

END OF DOCUMENT