



Assets Planning and Delivery Group  
Engineering

# **DESIGN STANDARD DS 70-20/30**

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## **Small Chlorination Systems – Basis of Design**

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VERSION 1  
REVISION 2

JANUARY 2024

## 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.

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## Head of Engineering

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## 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	6.06.18	All	New Version/Revision	NH	DH
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	1/2	01.24	14	S3.2.1 Reference to motorised valves removed	NH	BM
	1/2	01.24	16	S3.4.1 Hardwiring mandated	NH	BM

# DESIGN STANDARD DS 70-20/30

## Small Chlorination Systems - Basis of Design

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# 1 SCOPE

This design standard provides an overview of the design of the Water Corporation’s standard chlorine module and an explanation for the features that it incorporates. It also acts as a roadmap to the design standards for small chlorination systems for Water (DS70-20) and Wastewater (DS70-30).

## 1.1 Related Documents

The documents related to this design standard are as follows:

- DS70-20 Small Chlorination Systems (Water) Control Function Description
- DS70-20 Small Chlorination Systems (Water) Functional Description Overview
- DS70-30 Small Chlorination Systems (Wastewater) Control Function Description
- DS70-30 Small Chlorination Systems (Wastewater) Functional Description Overview
- DS70-02 Chlorine Leak Detectors
- DS70-03 Emergency Shutoff Devices for Use on Chlorine Containers
- DS70-05 Chlorine Container Floor Scales
- DS70-25 Drum Sequenced Vacuum System Control Function Description
- DS79 Design of Chemical Systems – Legislative Requirements and General Principles
- DS79-02 Emergency Safety Showers and Eyewash Stations
- DS29 Arc Flash Hazard Assessment of Switchgear Assemblies
- EO28 (planset) - Drawings for chlorine modules:
  - EO28-60-78-01
  - EO28-60-80-01
  - EO28-60-80-03
  - EO28-60-80-14
  - EO28-60-80-15
  - EO28-60-80-31
  - EO28-60-81-02
  - EO28-60-81-03
  - EO28-60-81-04
  - EO28-91-20
  - EO28-91-21
  - EO28-91-22
  - EO28-91-23
  - EO28-91-24
  - EO28-91-30
  - EO28-91-31
  - EO28-91-90

[F70-01 Procurement Data Sheet for Chlorine Module](#)

Operational Technology (SCADA) Approved Equipment List (Nexus# [58653590](#))

## 1.2 External Standards

This design standard makes reference to the following external standards

AS2927 The storage and handling of liquefied chlorine gas

## 1.3 Definitions

Container A chlorine drum or cylinder

DG Dangerous Goods

## 2 BACKGROUND

The standard chlorine module was first developed in 2002 and has undergone a number of improvements in order to improve operability and maintainability. Significant changes have also occurred to the SCADA elements of the design, which has allowed more data to be transmitted offsite.

The design of the standard chlorine module shall comply with the requirements of AS2927 “The storage and handling of liquefied chlorine gas” and the deviations recorded in the site’s Dangerous Goods Risk Assessment, which is based on the generic [Dangerous Goods Risk Assessment \(DGRA\) template](#).

### 2.1 Building Configuration

The standard chlorine module consists of a transportable building with integral pre-stressed concrete foundation that incorporates three rooms:

- (a) A Chlorine Store room in which the chlorine containers (cylinders or drums) are housed;
- (b) A Chlorinator room in which the chlorinators and “wet” equipment such as ejectors and analysers are housed; and
- (c) A Control Room in which control, SCADA and electrical distribution gear/cabinets are housed.

The room functions have been specifically chosen so that:

- (a) The highest source of OSH risk (i.e. chlorine gas) is limited to one room;
- (b) All “wet” activities are confined to one room and are separated from electrical and SCADA equipment.

Note:

For many chlorination modules, plant operators or asset managers often request a workstation to be provided. A workstation is only permitted in the vicinity of a switchboard where the Arc Flash PPE Category is Cat 0 as per the DS20 general design requirements for Switchboards for Modular Package Plants. For switchboards with a higher PPE category than Cat 0 a **fourth** room shall be provided with the workstation and switchboard(s) in separate rooms.

Water Corporation “[Prefabricated Treatment Module](#)” [Specification PTM](#) defines the physical requirements of the module in detail.

The chlorine module has a number of optional features that need to be specified in the [F70-01 Procurement Data Sheet](#) that forms part of the contract specification. F70-01 shall be completed by the Water Corporation Design Manager or Engineering Panel Consultant during Engineering Design.



## 2.2 Key Design Changes Since 2010

The standard chlorine module has undergone a number of changes since it was developed in 2002, but, the key changes that have occurred in recent times are as follows:

- 1) A pressure transmitter has been introduced to replace the low and high vacuum switches on the chlorinators. This change arose because of the perceived greater reliability of transmitters over switches and the fact that a fault in a switch is more likely to go un-noticed than a fault in an analog transmitter.

Action: This change is only being retrofitted to existing sites when the existing switches reach the end of their life.

- 2) Emergency shutoff devices (ESDs) have been introduced to close chlorine container valves in the event of 5ppm chlorine gas concentration being detected. This change arose because of the reduction in the cost of ESD devices and the need to demonstrate ALARP risk mitigation, particularly for those sites in close proximity to the public and where emergency response actions cannot be implemented quickly.
- 3) Emergency shutoff devices (ESDs) were initially installed as either electrically or pneumatically driven. All new ESDs shall be electric in accordance with DS70-03.

Action: This change is being retrofitted to existing pneumatic sites as part of the ESD Stage 3 project in 2024.

- 4) Carbon canisters have been introduced to the end of the vacuum regulator vent lines in order to minimise nuisance 5ppm chlorine leak alarms. This change arose because of extensive nuisance alarms experienced due to the frequent starting and stopping of chlorinators at country sites in particular. The starting and stopping of chlorinators causes a chlorine gas surge to occur in the vacuum lines (similar to water hammer) which causes the vacuum regulator relief valve to activate (when it detects close to positive pressure) and vent a small puff of chlorine gas. The carbon canisters that are now included in the design absorb this small puff of chlorine, significantly reducing the number of nuisance leak alarms.
- 5) Carbon filters have been introduced to the chlorine analyser sample water piping to allow quick maintenance calibration (zeroing) of the chlorine residual analyser. During normal operation the carbon filter is normally isolated with the sample flow bypassing the filter. The operator directs the sample flow through the carbon filter when performing a calibration zero. This change arose because of difficulty experienced by maintenance personnel in undertaking the zero calibration and affected analyser accuracy if not undertaken.

Action: The retrofitting of this change is being undertaken as part of the Regional Chlorination Modifications project in 2024.

- 6) pH and temperature sensors have been introduced to the sample water system in order to improve chlorine analyser performance under variable water pH conditions and to provide more water quality information. The additional information is also useful in diagnosing other issues that might arise.

Action: This retrofitting of this change is to be assessed on a site by site needs basis.

- 7) A high range chlorine leak sensor (5-100ppm) has been included in the container store room in order to provide greater information concerning the severity of a chlorine leak so as to assist emergency response decision making. The data from the high range sensor is included on SCADA to allow trending of data remotely.

Action: The retrofitting of this change is to be assessed by Assets Planning.

## 2.3 Chlorine Module Overview

(Refer drawings EO28-91-20 to 91-30)

### 2.3.1 Control Room

The control room contains the following equipment:

- Control cubicle
- Electrical switchboard (see section 2.1 for discussion on the possible requirement for a separate switchroom)
- Air-conditioner (optional)
- Emergency shutoff device control panel/board
- Alarm panel (where required)

### 2.3.2 Chlorine Store

The chlorine store contains the following equipment;

- Chlorine containers (up to eight cylinders or two drums)
- Fixed scales (for cylinders) or rail mounted trolleys equipped with scales (for drums)
- Emergency shutoff device actuators
- Chlorine leak sensors (fitted in accordance with DS70-02)
- Chlorine vacuum regulators and yoke connectors
- Ventilation fan(s)
- Carbon canisters (installed on vacuum regulator relief vent lines)

### 2.3.3 Chlorination Room

The chlorination room contains the following equipment:

- Chlorinator(s)
- Ejector booster pumps and ejectors
- Analysers (including sample pump where necessary)
- Ventilation fan(s)
- Chlorine leak sensor (fitted in accordance with DS70-02)
- Analyser water recovery tank & return pump

### 2.3.4 Switchroom (where required to be separate from Control Room)

See section 2.1 for discussion on the possible requirement for a separate switchroom.

The switchroom contains the following equipment:

- Electrical switchboard

### 2.3.5 Building External

The following equipment is mounted on the exterior of the building:

- Safety Shower
- Warning strobes

## 3 CHLORINE SYSTEM – BASIS OF DESIGN

The following section discusses the chlorine system components in detail.

### 3.1 Chlorine Container Room Components and Operation

(Refer P&IDs EO28-60-80.1 and -60-80.3)

#### 3.1.1 Chlorine Cylinder Systems

Housed in the chlorine store are up to 8 chlorine cylinders. The maximum number of cylinders normally permitted for connection in a duty/standby arrangement, is four; in a two duty - two standby configuration. Four further “spare” cylinders (i.e. unconnected) may be stored, two either side of the doors.

The connection of 6 cylinders (in a three duty – three standby configuration) is not recommended because of the likelihood that the cylinders will run out of chlorine at different times, resulting in one cylinder having to provide the entire required supply rate once two have become exhausted. This arises because the vacuum regulators draw at different rates due to slightly differing spring tensions within each vacuum regulator assembly.

If three duty cylinders are required to provide the design chlorine supply rate, then a sequenced vacuum system should be employed – refer DS70-25.

Air-conditioners should not be provided in the chlorine store due to O&M cost reasons - the high risk of corrosion will likely result in premature asset failure and the small room volume combined with the high natural ventilation provisions of AS2927 result in air-conditioners running continuously when the ambient temperature is below that required to sustain chlorine supply. Approval shall be sought from the Principal Engineer Water Treatment Engineering for the inclusion of chlorine store air-conditioning.

Each cylinder that is connected to the chlorine manifold shall have an emergency shutoff device mounted on it in accordance with DS70-03 so that supply from the container can be terminated in the event of a leak being detected – see section 2.20 pt 2).

Scales for chlorine cylinders shall comply with DS70-05. Weight measurement is only used for monitoring purposes and is not used as part of the cylinder changeover system. The reason for this is historical and relates to the poor accuracy and reliability of scales in the past.

#### 3.1.2 Chlorine Drum Rail Systems

Housed in the chlorine store are up to 2 chlorine drums operating in a duty - standby configuration. No spare drums are provided for.

If two drums are required to provide the required chlorine supply rate, then an alternative system design shall be provided – e.g. a chlorine building (sized for four drums) with a crane, or two drum rail modules (i.e. a duty chlorine store and a standby chlorine store in separate buildings) if the available chlorine buffer permits it.

Each drum that is connected to the manifold shall have an emergency shutoff device mounted onto it in accordance with DS70-03 so that supply from the container can be terminated in the event of a leak being detected.

#### 3.1.3 Chlorine Container-Vacuum Regulator Connections

The online chlorine containers are each connected to a vacuum regulator using a yoke connection that is tensioned against the container valve outlet. A lead washer sits in-between the valve outlet and yoke connection to provide a seal – when the yoke is tightened against the container valve outlet the washer gets “squashed”/compressed to seal off any potential leak paths.

In the eastern states, some chlorine users do not use a yoke connection and instead use a special fitting that can be screwed onto the chlorine cylinder valve and vacuum regulator. Like the yoke system, a lead washer is also used as a seal between the screwed fitting and cylinder valve outlet. The screwed system is reliant on the integrity of the threaded connections to hold the container pressure. The Corporation requires the use of the yoke connection for all of its chlorine gas facilities.

### 3.1.4 Vacuum Regulators and Ancillaries

The vacuum regulators reduce the pressurised gas supplied from the chlorine container to vacuum (the vacuum being created by the ejectors - see below). Vacuum regulators have three states: “standby”, “online” and “exhausted”. When a vacuum regulator in standby experiences a high vacuum on its suction side, it gets “sucked” into its “online” state. When the chlorine container is empty of chlorine, a second high vacuum state occurs that “sucks” an “online” vacuum regulator diaphragm into its “exhausted” state.

The vacuum regulator incorporates a relief valve that vents if the pressure on the downstream side of the vacuum regulator nears positive pressure. The relief valve outlet shall be piped through a flexible hose to a carbon canister that is included to absorb minor “puffs” of chlorine that can be released if the hydraulic conditions in the vacuum line change suddenly – see section 2.2 pt 4). The carbon canisters shall each be located in close proximity to a chlorine leak sensor so that if they become saturated with chlorine (~600g), any chlorine release will be detected and alarmed.

The vacuum (outlet) line from the vacuum regulator is connected to the chlorinator which controls the flow rate of chlorine.

## 3.2 Chlorination System Components and Operation

(Refer P&IDs EO28-60-81.1, -60-81.3 and -60-81.4)

### 3.2.1 Chlorinators

The flexible tubing between the vacuum regulator and chlorinator shall include the following:

- An isolation downstream of each vacuum regulator
- An isolation on the inlet to each chlorinator
- A pressure transmitter to detect loss of vacuum (see section 2.2 pt 1))

The chlorinators can be designed as manual fixed rate units (typical for wastewater applications) or as automatic control variable dose rate units. Potable water applications shall always have duty-standby chlorinators whilst some recycled water applications may only require a single chlorinator. Control functionality is detailed in DS70-20 and DS70-30 Control Function Descriptions and shall be specified in the [F70-01 Procurement Data Sheet](#) that forms part of the project specification.

Located on the line between each chlorinator and ejector is a manual valve and non-return valve.

### 3.2.2 Ejector Water System

The ejectors can each be supplied water by ejector booster pumps or by motorised valves that supply water from a high pressure source (the latter are normally only used at dam or pump station sites). The ejector water circuit shall include the following:

- Duty-standby ejector water booster pumps or motorised control valves
- A flow switch downstream of each pump or valve to detect insufficient flow rate. For sites with ejector booster pumps the low flow switch shall be interlocked to protect the pump from potential dry running.

- A pressure indicator downstream of each pump or valve to allow fault diagnosis in the event of a chlorinator faulting due to low vacuum
- An isolation valve located on the water feed side of each ejector
- A non-return valve located on the discharge side of each ejector
- An isolation valve located on the discharge side of each ejector
- A pressure indicator downstream of each ejector isolation valve to allow fault diagnosis in the event of a chlorinator faulting due to high or low vacuum
- An isolation valve located at the dose point

### 3.3 Sampling and Analysis

(Refer P&ID EO28-60-81.2)

Water applications shall include a sampling and analysis system in accordance with DS70-20 Control Function Description. Wastewater applications may require a sampling and analysis system as a project requirement, in accordance with DS70-30 Control Function Description and the [F70-01 Procurement Data Sheet](#) that forms part of the project specification.

Where required, the system shall include the following:

- An isolation valve located on the feed side of the sample water circuit
- A high point vent valve that discharges upwards to allow the release of air (normally only used during commissioning of the system if it has been drained of water).
- A carbon filter and associated isolation and bypass valving – refer section 0 pt 5).
- A flow meter and low flow switch to indicate the sample water flow and detect insufficient flow of water to the analyser(s)
- For systems employing free chlorine disinfection, a Free Chlorine Residual Analyser. Only analysers on the SCADA [Approved Equipment List \(AEL\)](#) shall be used.
- For systems employing chloramination disinfection, both a Multi-Parameter Chloramination Analyser and a Total Chlorine Residual Analyser are to be provided. The Multi-Parameter Chloramination Analyser shall measure; total ammonia, free ammonia, mono-chloramine and total chlorine. When the dosing system is operating in normal chloramination mode, dose rate control shall be based on the free ammonia and mono-chloramine outputs from the Multi-Parameter Chloramination Analyser. The Total Chlorine Residual Analyser is to provide a backup in the event of failure of the Multi-Parameter Chloramination Analyser.

The Total Chlorine Residual Analyser also serves as the primary analyser when a chloramination facility is operating in “Breakpoint Chlorination Mode”. In this control mode, the operator will calibrate the Total Chlorine Analyser to indicate the approximate free chlorine residual, including disabling any potassium iodide (total chlorine residual reagent) dosing to the analyser.

Only analysers on the SCADA [Approved Equipment List \(AEL\)](#) shall be used.

- A Water Recycling Tank in which analyser water is collected so that it can be pumped back into the supply main. The tank shall include high and low level switches that operate the water return pump. The tank shall be sealed to prevent the release of chlorine gas into the chlorination room and shall instead vent externally to the building, with a midge screen located on the vent termination point to prevent the entry of insects into the tank.
- Isolation valves on the suction and discharge sides of the water return pump.
- A non-return valve on the discharge side of the water return pump.

Note: At some sites, there may be a requirement in the [F70-01 Procurement Data Sheet](#) that forms part of the project specification, to include a sample pump, sample pressure reducing valve, turbidity analyser and/or pH analyser.

## 3.4 Risk Management

### 3.4.1 Safety

The standard chlorine module incorporates a number of safety features to prevent or mitigate a possible chlorine release, as follows:

- Remote vacuum regulators are connected directly onto the valves of containers (via yokes) in order to minimise the extent of pressurised pipework and fittings.
- Two chlorine leak sensors are located in the chlorine store room, where pressurised gas leaks are most likely to happen. The operation of the sensors is detailed in DS70-02 Chlorine Leak Detectors.
- One chlorine leak sensor is located in the chlorination room, primarily for OSH exposure reasons, in order to detect any gas leak due to pressurisation of the vacuum piping, or because of a chlorine solution leak.
- The chlorine leak detector controller is connected to an ESD controller with a hard-wired link to provide greater certainty of ESD activation. The leak detector activation of ESDs is periodically tested in accordance with AS2927 to confirm functionality. As noted earlier, all online containers are fitted with ESDs in accordance with DS70-03.
- At sites in very close proximity to the community, chlorine gas scrubbers may be employed to absorb all gas released during a chlorine emergency.

### 3.4.2 Water Quality

The standard chlorine module incorporates interlocking to initiate shutdown of supply water in the event of chlorination failure or unacceptable water quality (including excessive high or low chlorine residual) being detected.

### 3.4.3 Reliability

The standard chlorine module incorporates battery backup and redundant communications in order to ensure that all control and safety equipment can continue to operate in the event of power failure or primary communications failure.

### 3.4.4 Failure Scenarios Envisaged

The following failure scenarios have been identified and are mitigated by administrative controls and engineering controls in some cases:

#### 1) Chlorine container gland packing leak

This issue normally arises during transport, but, has occurred in at least one storage location. The rate of release of chlorine gas is restricted but closing of the container valve will not stem it. Tightening of the gland nut or capping of the container are the only means of stemming such a leak.

This type of leak is limited to the container store.

#### 2) Vacuum regulator failure

This is potentially a major release event if the cartridge inside the regulator fails fully open. Inadequate maintenance or the accumulation of iron deposits are the main reasons anticipated for the cartridge to

operate incorrectly. This type of event can result in leaks occurring in the container store and/or the chlorination room. This event can be mitigated by an ESD.

3) Vacuum Regulator Yoke becomes loose or disconnected

This is potentially a major release event if the yoke becomes significantly disconnected. This event can occur if the yoke has not been sufficiently tightened and is subjected to sudden movement. This type of leak is limited to the container store. It can be mitigated by an ESD as long as the yoke provides sufficient support for the actuator (more likely for electric ESDs as they exert less force on the yoke during operation).

4) Cylinder or drum is punctured during movement operation

This is potentially a major release event, but, is mitigated by the use of:

- Cylinder trolleys that allow the lifting of cylinders by use of crane hooks rather than having to use slings. The trolleys also allow easy movement of cylinders by personnel and minimise the amount of cylinder manhandling which decreases the risk of a cylinder being dropped,
- Drum lifting beams and cranes that avoid the need to use forklifts whose tines present a penetration risk, and
- Drum trolleys mounted on rails that allow drums to be pushed by hand into storage, thereby eliminating the risk of drums coming into falling contact with structures that might penetrate them.

## 3.5 Control Functionality

The control functionality for water and wastewater chlorine modules is documented in the following standards:

DS70-20 Small Chlorination Systems (Water) Control Function Description

DS70-20 Small Chlorination Systems (Water) Functional Description Overview

DS70-30 Small Chlorination Systems (Wastewater) Control Function Description

DS70-30 Small Chlorination Systems (Wastewater) Functional Description Overview

As has been mentioned in earlier sections, there are a number of optional control features included in the above documents, in addition to the mandatory requirements. The need for the optional control features is determined on a project by project basis and recorded in the [F70-01 Procurement Data Sheet](#) that forms part of the contract specification.



**END OF DOCUMENT**