Assets Planning and Delivery Group
Engineering

DESIGN STANDARD DS 35-01

Surge Vessels

VERSION 1
REVISION 6
MAY 2023

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 the 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 Mechanical Engineer, Engineering. Any future Design Standard changes 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.

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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. Inconsistencies or clarifications between standards should be referred to the Senior Principal Mechanical Engineer, Engineering, for guidance and determination.

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	30.08.11	All	New Version	SE	AK
1.1	1/2	23.05.13	9	Fixed hyperlink.		
1.2.3	1/1	18.06.12	9	New Section.		
1.2.4	1/2	23.05.13	9-10	Updated coating specifications.		
1.2.4	1/4	20.02.17	10	DS36 removed and replaced with Strategic Products Register	SS	SE
1.2.7	1/5	24.03.20	13	New Section.	BC	SE
2	1/0	30.08.11	All	New Version	SE	AK
2	1/1	18.06.12	15	Updated flange standard requirements.		
2	1/5	01.10.20	16	Updated Table 2.1 bolting and gasket references	GD	SE
3	1/0	30.08.11	All	New Version	SE	AK
4	1/0	30.08.11	All	New Version	SE	AK
4.10	1/1	18.06.12	23	Updated flange standard requirements.		
4.2	1/5	29.01.21	21	Updated allowable vessel standards and concession requirements	MB	SE
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5.7.2	1/1	18.06.12	29	Update pipe Class requirements.		
5.7.1 5.8	1/4	20.02.17	28,29	DS36 removed and replaced with Strategic products Register	SS	SE
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5.9	1/5	03.07.20	31	Added coatings reference	MB	SE
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6.3	1/2	23.05.13	29	Updated Manufacturer's details	SE	AK
6.4	1/2	23.05.13	30	Added standard sizes.	SE	AK
6.5	1/2	23.05.13	30	Updated text.	SE	AK
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9.2	1/5	24.03.20	42	Updated custodian of Equipment Register	MB	SE
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10.3.1	1/3	25.06.14	39	Added heading to identify section which is air vessel specific for control.	MB	SE
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All	**1/6**	**25.05.23**	**n/a**	**Scheduled review, no change to content required**	**SE**	**SE**

DESIGN STANDARD DS 35-01
Surge Vessels

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1 SCOPE AND GENERAL

1.1 Scope

This standard has been developed to provide both mandatory requirements and informative guidance on the design, construction and integration of hydro-pneumatic pressure vessels used in piping systems for surge mitigation (commonly referred to as surge vessels) and for pressure storage on pumped systems (hydro-accumulators). It is not intended to cover pressure vessels which are intended for the sole purpose of storing compressed air or other gases, or for surge tanks which are open to atmosphere. The general principles may be applied to air cushions (infrequently used) which are pressurised by the protected fluid system but topped up by atmospheric air during regular cyclic down-surge events.

The standard aims to: provide guidance to address recurrent issues which routinely arise during surge vessel selection; ensure that vessels are safe and compliant with relevant standards and regulations; and to provide a level of standardisation aimed at reducing design and construction re-work and associated costs.

Two types of surge vessels are commonly used by the corporation are covered by this standard:

> ***Air Vessels*** - Vessels which have an air/water interface. As some air is constantly dissolved in solution, a supply of compressed air is required to keep the air mass constant. Air vessels are predominantly used for surge mitigation, for larger sizes (=> 1 Cu.m) and where higher hazard levels are required.
>
> ***Bladder Vessels*** – Vessels which contain an impermeable flexible membrane which separates the air and water contents. Bladder vessels require an initial pressurisation (pre-charge) and occasional checking of the pre-charge pressure. They are used for smaller low hazard level applications.

The guidance and content of the standard with regards to general information, manufacture, marking & documentation, instrumentation & control and the functional description are relevant to both *'air vessels'* and '*bladder vessels'*. Any specific requirements for these vessels are identified in their independent Sections.

For comprehensive guidance on maintenance of surge vessels the reader should refer to the Water Corporation' Engineering Assets Maintenance Standard – Pressure Vessels (S427 - Maintenance Standard - Pressure Vessels).

1.2 Governing Standards and Authorities

1.2.1 Australian Standards

AS 1110.1	ISO metric hexagon bolts and screws
AS 1112.1	ISO metric hexagon nuts – Style 1 – Product grades A and B
AS/NZS 1170	Structural Design Actions – General Principals
AS/NZS 1170.2	Structural Design Actions – Wind Actions
AS 1170.4	Structural Design Actions – Seismic Actions
AS/NZS 1200	Pressure Equipment
AS 1210	Pressure Vessels

	NOTE: This version of this standard is consistent with AS1210-2010.
AS 1214	Hot-dip galvanized coatings on threaded fasteners (ISO metric coarse thread series)
AS 1271	Safety Valves, Other Valves, Liquid Level Gauges and Other Fittings for Boilers and Unfired Pressure Vessels
AS 1548	Fine Grained, Weldable Steel Plates for Pressure Equipment
AS 1554	Structural Steel Welding
AS 1657	Fixed Platforms, Walkways, Stairways and Ladders – Design and Installation
AS 1796	Certification of Welders and Welding Supervisors
AS 2700S (N14)	Colour Standard for General Purpose - White
AS 2971	Serially produced pressure vessels
AS 3595	Fire Prevention
AS/NZS 3788	Pressure Equipment – In Service Inspection
AS 3873	Pressure Equipment – Operation and Maintenance
AS 3894.1	Site Testing of Protective Coatings – Non-conductive Coatings – Continuity Testing – High Voltage (‘Brush’) Method
AS 3902.1	Pressure Equipment Manufacture – Assurance of Product Quality
AS/NZS 3992	Pressure Equipment – Welding and Brazing Qualification
AS/NZS 4020	Testing of Products for Use in Contact with Drinking Water
AS 4041	Pressure Piping
AS 4087	Metallic Flanges for Waterworks Purposes
AS 4100	Steel Structures
AS 4343	Pressure Equipment - Hazard Levels
AS 4458	Pressure Equipment - Manufacture

1.2.2 American Standards

ASTM A106	Seamless Pipe
ANSI SA 516-70	Pressure Vessel Plate
ASME BPVC VIII	ASME Boiler and Pressure Vessel Code – Rules for construction of Pressure Vessels
ANSI/WSC PST 2000/2016	Standard Pressurized Water Storage Tank

1.2.3 European Standards

EN1092	Flanges and their joints – Circular flanges for pipes, valves, fittings and accessories, PN Designated – Part 1: Steel Flanges
BS EN 13831:2007(E)	Closed expansion vessels with built in diaphragm for installation in water

1.2.4 Water Corporation Standards & Technical Specifications

A1	Surface Preparation for the Application of Protective Coatings on Steel or Cast Iron
C2	Zinc Rich Epoxy, Epoxy Mastic Coat, Polyurethane Top Coat on Steel or Cast Iron
D1	High Build Epoxy Coating on Steel or Cast Iron
DS 22	Ancillary Plant and Small Pump Stations - Electrical
DS 30-02	General Design Criteria - Mechanical
DS 31-01	Pipework - Mechanical
DS 32	Pump Stations - Mechanical
DS 35	Ancillary Plant - Mechanical
DS 38-02	Flanged Connections
DS 62	Standard Security Treatments
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)
FRP	FRP Structural Material
J1	Anti-Graffiti Coating on New and Old Steel Structures
SPS 261	Butterfly Valves for Water Works Purposes
S151	Prevention of Falls
S197	Site Security, Public Security and OSH Signage Standard
S427	Maintenance Standard - Pressure Vessels
Strategic Products Register	
WS1	Metal Arc Welding

1.2.5 Water Corporation Drawings

AY58-5-2	Tapping Button (Threadolet)
AY58-16-1	Lifting Lug

FS00-2-8.1	Standard Logic Diagram: Surge Vessel Module - Part 1
FS00-2-8.2	Standard Logic Diagram: Surge Vessel Module - Part 2
GX54-6-1	1.8m Chainwire Fence with Buried Selvedge, Barbed Extension & Razor Wire at Top
JZ39-91-10	Flange Isolation Joints
JZ39-91-11	Surge Vessel: General Arrangement
JZ39-91-12	Surge Vessel: Internal Details, Size = $50m^3$
JZ39-91-13	Surge Vessel: Internal Details, Size = $40m^3$
JZ39-91-14	Surge Vessel: Internal Details, Size = $30m^3$
JZ39-91-15	Surge Vessel: Internal Details, Size = $20m^3$
JZ39-91-16	Surge Vessel: Internal Details, Size = $10m^3$
JZ39-91-17	Surge Vessel: Standard Transmitter Panel
JZ39-91-18	Surge Vessel: Anode Details
JZ39-91-19	Surge Vessel: Weld Details
JZ39-91-20	Surge Vessel: Name Plate
JZ39-91-21	Surge Vessel: External Access – Single Vessel*
	* Note: Drawing subject to revision at time of publication. Landing width shown not compliant to AS1657

1.2.6 Other Standards

Use of other standards is permitted where Australian Standards do not cover design. Such standards include:

API 520	Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries
BS PD5500	Specification for Unfired Fusion Welded Pressure Vessels
EN 13445	Unfired Pressure Vessels

1.2.7 Governing Authority

Government of Western Australia Department of Mines, Industry Regulation and Safety

OSH Regulations 1996

1.3 Application

1.3.1 Bulk Water Transfer and Water Distribution Systems

The most frequently used application for surge vessels within the Corporation is for the mitigation of pressure transients within bulk water transfer and distribution systems.

Larger size vessels are often installed immediately upstream and/or downstream of a pump station to protect the supply or delivery main. Where surge vessels are mounted downstream only, careful non-return valve selection is required due to increased water column deceleration rates.

Where surge mitigation is required upstream of the pump-station, primarily to protect the pump station and its supply main from sub-atmospheric pressures, alternate and more simple mitigation devices, (e.g. down-surge tanks) should be considered and selected where practical.

1.3.2 Seawater Bulk Transfer

The Corporation has bladder type surge vessels installed in seawater bulk transfer systems, including seawater intake systems to desalination plants.

1.3.3 Sewerage Systems

Surge vessels are not typically used in sewerage applications due to the aggressive nature of internal gases, the potential for breakdown of internal coatings and the risk associated with corrosion of pressure vessel walls. Wastewater mains are also not required to be maintained under positive pressure in normal operation, as required for potable water conveyance water quality reasons. An alternate means of surge mitigation should be considered or, where considered essential, dispensation sought from the Senior Principal Engineer-Mechanical. If a bladder type vessel is required for sewerage, chemical or similar applications; the designer must verify that the vessel, bladder and fittings are suitable for the intended application and undertake appropriate operational risk assessment.

1.3.4 Treated Effluent Systems

Surge vessels are acceptable for use in treated effluent applications, however for negative pressure mitigation, air valves should initially be considered as the principal method of protection of the associated pressure main.

1.4 Terminology, Process, Acronyms and Abbreviations

1.4.1 Terminology and Design Process

The design process for a surge vessel shall be in accordance with the Engineering Design Manual, DS30 and the guidelines in **Appendix B** of this standard.

The following terminology is used within this document.

Design Manager: The person assigned responsibility for defined design process outcomes, including endorsement of Design Briefs, acceptance of related reports and management of associated issues. In accordance with a customer service agreement is the arbiter for all design issues.

Designer: The person providing engineering design expertise and services as part of a design only, design and construct (D&C), construct only or Panel Agreement Design Job. This could for example be an engineering consultancy company, an individual design engineer (including Engineering staff), a project management company, or a construction company or alliance that Contracts to provide engineering definition and design services.

Vessel Designer: The engineer that is responsible for the detailed design of the pressure vessel component of the overall surge vessel. The *Vessel Designer* shall satisfy the competency requirements of AS1210 Appendix P (Table P2).

Third Party Verifier: The engineering entity responsible for the review of the pressure vessel detailed design drawings submitted by the *Vessel Designer*. The Third Party Verifier shall satisfy the competency requirements of AS1210 Appendix P (Table P2), and shall be not associated with the *Vessel Designer* in any respect.

1.4.2 Acronyms

COIP	Computer Operator Interface Panel
EBU	Engineering Business Unit (of the Water Corporation)
MDR	Manufacturer’s Data Report
MSCL	Mild steel cement lined (refers to pipe material and its lining)
NDT	Non-destructive testing
OC	Water Corporation Operating Centre

2 MATERIALS

All materials and coatings in contact with potable water shall be approved in accordance with AS/NZS 4020.

The vessel shall be constructed from the materials specified in Table 2.1. Alternate materials of a higher grade may be substituted subject to approval by the *Design Manager*.

Table 2.1 Material Selection

Item	Material	Standard	Grade
Shell and Heads	Steel	AS 1548 SA 516	PT 430,460 or 490 Grades equivalent to the above.
Nozzles	Steel	ASTM A106 AS 1548	A or B (seamless) Schedule 160 minimum. PT 430,460 or 490 or equivalent grade (rolled if pipe unavailable).
Compensating Plates	Steel	AS 1548 SA 516	PT 430,460 or 490 Grades equivalent to the above.
Flanges	Steel	EN1092	*Vessel Designer* Select
Gaskets (flanges)	Compressed Fibre or Elastomeric	DS38-02	Novus 30 (orange), Klinger C4430 or equivalent; EPDM (potable water)
Gaskets (manway)	Compressed Fibre	DS38-02	Novus 30 (orange), or Klinger C6327 or equivalent
Gaskets (isolation joint)	Compressed Fibre	DS38-02	Klinger C4430, Novus HDS-1, or equivalent
Flange nuts and bolts	Hot dipped galvanised steel	DS38-02	Grade 8.8, PC8
Internal fitting bolts	Stainless steel	ASTM A312M	Grade 316
External ladder and platforms	Hot dipped galvanised steel	AS 3678 AS 3679	Grade 250, 350
Internal ladder and platforms	FRP (vinyl ester)	TS-FRP	
Anchor points	Steel	AS 3678	Grade 250, 350
Lifting Lugs	Steel	AS 3678	Grade 250, 350
Air inlet line	Stainless steel	ASTM A312M	Grade 316L, Schedule 80S, Class 2A (welded only)

3 DESIGN REQUIREMENTS

3.1 Design Manager Responsibilities

The *Design Manager* is responsible for managing the design process for the Corporation, and therefore provides the design interface between the Corporation and *Designer*. The design of a surge vessel and its associated system for surge mitigation is a multidisciplinary task and as such multiple *Designers* may be required throughout the process. Supply of information and documentation to the *Designer* as stated in Appendix E of AS1210

Where the *Design Manager* is required to make an assessment and determination related to a Concession Request from an external consultant, the *Design Manager* shall refer the matter to the appropriate Engineering discipline lead (e.g. *Senior Principal Engineer – Mechanical* or - *Electrical*).

3.2 Designer Responsibilities

The *Designer* shall be responsible for the design of the surge vessel and its appurtenances, including the design of the pressure vessel component and supply of information and documentation to the *Design Manager* as stated in Appendix F of AS1210.

Unless specifically stated otherwise by the *Design Manager*, the *Designer* shall undertake design of the following:

- Hydraulic modelling.
- General surge vessel sizing, arrangement, configuration and layout.
- Access platforms and walkways.
- Air supply, venting, scour and drainage piping systems.
- Instrumentation and wiring.
- Air compressors.
- Controls and SCADA.

The hydraulic design shall be validated by the *Designer* during *Detailed Design Phase* to enable development of a *Design Specification* for the surge vessel. The *Design Specification* shall be based on AS1210. Dispensation shall be sought where any alternate standard is proposed.

The *Designer* shall take into consideration surge vessel maintenance requirements and the impact this may have to the connecting system when determining the number and layout of the surge vessels and site.

The *Designer* shall engage and manage a specialist *Vessel Designer* to complete the pressure vessel detailed design component of work.

3.3 Vessel Designer Responsibilities

The *Vessel Designer* shall design the pressure vessel component of the surge vessel assembly in accordance with AS1210. Where a Vessel design based on alternate standards (ASME, etc) is proposed, the *Vessel Designer* shall provide justification and receive dispensation from the *Senior Principal Engineer – Mechanical*, prior to proceeding.

The *Vessel Designer* shall provide the *Designer* with the necessary design information for the *Designer* to complete the design of the overall arrangement of the vessel, access and associated equipment.

Detailed design of the vessel and supports are required to be undertaken by the *Vessel Designer* based upon external loadings, pressure cycling and other site specific parameters.

3.4 Hydraulic Design Outputs

Where a surge vessel is necessary for surge mitigation, the following design information shall be determined and recorded in the hydraulics section of the *Engineering Summary Report*:

(a) Design Pressure (P), taking into account maximum transient pressures reached in the pipeline.

(b) The total required volume of each surge vessel group.

NOTE: The *Designer* shall determine the nominal size of each surge vessel, and the number of duty and redundant (if any) surge vessels of each group accordingly.

(c) Design volume (V) of each vessel.

(d) Operating Cycles (e.g. full pressure, pump station start, pump station stop, pump station trip).

(e) The maximum outflow and inflow rates to the vessel.

(f) The configuration of the inlet pipework, including:

- Vessel inlet pipe size.
- The need for an inlet non-return valve, the valve type, size, and its orientation.
- The inlet non-return valve bypass pipe size, and need for a throttling valve.

3.5 Hydraulic Design Process

Hydraulic modelling shall be carried out in accordance with the requirements of DS 32 and DS 60.

Particular note shall be taken of the following regarding minimum allowable pipe pressures:

(1) Water bulk transfer and distribution systems: the minimum pressure at any point in the system, produced during a transient event, shall not be less than atmospheric pressure.

If this is demonstrated to be impracticable, a concession request shall be submitted and accepted by the *Design Manager*.

Air valves shall not be relied upon as the primary or principal method of protection for water mains.

(2) For treated effluent and raw water systems: it is acceptable for transient pressures to fall below atmospheric pressure during a transient event, provided that the pipe is suitably rated. It is acceptable for air valves to be the primary or principal method of protection for non-potable water and treated effluent mains.

When determining the vessel *design volume*, the minimum volume of water in the vessel (each vessel if more than one in the group) shall be 30% of the maximum air volume reached in the critical scenario (maximum down surge in the transient hydraulic modelling). This is to allow for uncertainty in modelling and provide a safety margin to prevent the vessel from emptying and air entry into the main.

$$V = V_{A\,(max)} + V_{W\,(min)} = 1.3 \cdot V_{A\,(\mathrm{max})}$$

where:

V	=	*Design volume* of the vessel (refer Sections 4.3, 4.4)
$V_{A\ (max)}$	=	Modelled maximum air volume in the vessel when it discharges during a transient event
$V_{W\ (min)}$	=	Minimum volume of water remaining in the vessel when it discharges during a transient event

3.5.1 Modelling Existing Piping Systems

The modelling software selected shall be appropriate for the complexity of the system to be analysed. Where a vessel is required to provide surge mitigation for an existing piping system, pressure and transient tests shall be conducted on the associated piping. The test results shall be used to calibrate the hydraulic model to meet characteristics of the existing system (eg. celerity, roughness, max/min pressure envelope).

NOTE: Pressure testing may be conducted by the Corporation, or the *Designer* as agreed. The testing shall include monitoring using high speed data loggers strategically located at air valves and high points in the piping system.

3.6 Design Specification Requirements

A *Design Specification* is required to be developed during the *Detailed Design Phase* to enable *Detailed Design* and procurement of a surge vessel which should include the information and documentation as stated in Appendix E of AS 1210.

The Specification shall include details as per AS 1210 and the following:

(a) The design pressure.

(b) The design temperature.

(c) The operating pressure and operating temperature, and if the vessel is to operate below 20^0C, the design minimum temperature and coincident temperature.

(d) The number of operating cycles expected from the intended service of the vessel.

NOTE: Details of the range of pressures (minimum and maximum) for the various operating cycles, including start-up, shut-down, and transients, and the number of cycles shall be provided for each range over the service life of the vessel.

(e) The materials to be used and corrosion allowance(s).

(f) Classification of the vessel (refer to AS 1210 sections 1.6 & 1.7, or the alternate nominated vessel design standard).

(g) Hazard level as defined in AS 4343.

(h) Nature of the water in the pipeline (particular note shall be made of corrosive fluids).

(i) Significant loads to be applied to nozzles and other parts of the vessel.

(j) Relevant environmental data to allow wind and seismic loadings to be determined.

(k) Foundations (the *Designer* may require input from the *Detailed Design* of the pressure vessel in order to finalise the foundation design.)

(l) Maintenance access requirements (including platforms, ladders, approach clearances and hardstand areas).

(m) Corrosion protection requirements

(n) Earthing Requirements

(o) Air supply and venting requirements.

(p) Scour and drainage requirements.

The *Designer* shall submit Surge Vessel Arrangement Drawings and Specification to the *Design Manager* for stakeholder review and comment and revise as instructed by the *Design Manager*.

3.7 Regulatory Authorities and Approval

The *Vessel Designer* shall submit Vessel Fabrication Drawings to the *Design Manager* for stakeholder review and comment and revise the drawings as instructed by the *Design Manager*.

Upon acceptance from the *Design Manager*, the *Vessel Designer* shall:

(a) Submit the accepted design drawings for verification by an independent *Third Party Verifier*, in accordance with the requirements of the Occupational Safety and Health (OSH) Regulations 1996. The Third Party Verifier shall issue a certificate verifying that the design is in compliance with the requirements of AS1210, AS 3920, or the approved design standard.

(b) For hazard level A, B, C or D vessels, register the design with an Australian regulatory body (refer Regulation 4.2, and section 8 of AS 3920).

(c) Supply all necessary documentation (as stated in the approved design standard or section 7 of AS 1210) and certification to the *Design Manager* for all vessels. The documentation provided shall enable the Water Corporation to register hazard level A, B or C vessels as a Plant item with WorkSafe Western Australia prior to installation and use.

(d) The *Design Manager* shall forward a copy of the MDR and 'as-constructed' drawings to be added to the Water Corporation's Pressure Equipment Register.

(e) *The Designer* shall be responsible for ensuring that all structures, including the vessel access platforms, are in accordance with the Commission of Occupational Safety and Health Code of Practice: Safe Design of Buildings and Structures.

Drawing JZ39-91-19 'Nameplate' shall be completed for all vessel designs, to identify all vessel specific input and design data and shall include the items as listed in section 7.1 of AS 1210. A separate drawing shall additionally be compiled to give a schematic of the vessel which clearly identifies the installed and minimum allowable thickness of each component of the vessel.

4 DESIGN PARAMETERS

4.1 Design Life

The vessel shall have a design life of 50 years based on the cyclic loading criteria, unless approved otherwise by the *Senior Principal Engineer - Mechanical* . The vessel drawings shall clearly indicate the year that fatigue assessment is required.

4.2 Class of Construction

The vessels shall be to AS 1210 Class 2A or 2B. Other classes of construction as listed in section 1.6 of AS 1210 may be used subsequent to agreement of all parties. Concession may be granted by the *Senior Principal Engineer - Mechanical* to permit the use of 1H vessels where the design parameters cause the vessel design to become impractical for manufacture.

Other pressure vessel construction standards listed in section 1.2 may be used for diaphragm vessels as further defined in sections 6 and 7. The design shall be acceptable for registration by an Australian regulatory body if the vessel is hazard level A, B, C or D.

The *Designer* shall perform preliminary vessel sizing to specify the required class of construction of the vessel such that the overall cost of design, material and NDT inspection is optimised. The *Vessel Designer* shall validate the class of construction during detailed vessel design.

4.3 Vessel, Orientation and Configuration

Unless otherwise accepted by the *Design Manager*, surge vessels shall be orientated vertically and of standardised configuration. The standard configurations are intended to capture accepted configuration features such as access, fall prevention requirements, coatings and maintainability.

*Standard total volume*s (*V*) that may be selected for the air vessels shall be one of the following standardised volumes:

Standard Size / Cu.m	Reference Drawing No.
10	JZ39-91-16
20	JZ39-91-15
30	JZ39-91-14
40	JZ39-91-13
50	JZ39-91-12

Where vertical vessels are precluded by site specific constraints, vessels may be orientated horizontally.

Horizontal air vessels have a greater air/water interface surface area, and as such will result in greater absorption of the air and longer compressor run times. The potential for discharge vortexing and air entrapment during downsurge shall be considered by the *Designer* when designing horizontal vessels.

NOTE: Horizontal vessels have historically not been preferred due to the complexity in calculating the air volume in the control logic (refer DS22), however with current technologies this is no longer a constraint. Horizontal vessels have not been used extensively throughout the Corporation and shall therefore be used with caution and with due consideration of the lack of standard designs.

4.4 Design Volume (*V*)

Refer Section 4.3.

Under particular circumstances the *Design Manager* may accept a *design volume.*

The *design volume* may be other than one of those stated in Section 4.3, adapted to achieve intermediate capacities. A non-standard size may be used if agreed and approved by the *Senior Principal Engineer - Mechanical* , after consideration of the cost of re-design and the feasibility of maintaining the OH&S attributes incorporated in the standard designs.

4.5 Design Pressure (*P*)

The *design pressure* is defined in AS1210, Clause 1.8.7.

The *Designer* shall conduct hydraulic modelling to determine the maximum transient pressure in the piping system based on ultimate pumps and flows, and shall then nominate a *Design Pressure* rating for the vessel.

The *design pressure* for the vessel shall match the rated pressure of the pipeline, which shall be at least 10% greater than the maximum transient pressure determined during hydraulic modelling.

The *design pressure* of the vessel and pipeline shall be selected from one of the following:

- PN16
- PN21
- PN25
- PN35
- PN40

NOTE: PN25 and PN40 *design pressures* are not standard pressure classes used by *the Corporation* and require the specific acceptance of the *Senior Principal Engineer - Mechanical* .

Notwithstanding the above, the *design pressure* of the vessel shall not be less than the rated pressure of the pipeline.

4.6 Design Temperature ($T_{amb(max)}$ $T_{amb(min)}$ T_{max} and T_{min})

The ambient temperature range shall be determined by the *Designer*.

The metal *design temperature* for the pressure vessel is defined in AS1210, Clause 1.8.9. The *design temperature* range shall be determined by the *Designer*. In instances that temperature data is not available for the installation site, the following shall apply:

$T_{amb(min)}$	=	- 0°C
$T_{amb(max)}$	=	50°C
T_{min}	=	0°C
T_{max}	=	55°C

NOTE: Temperature information may be sourced from water temperature monitoring data held by the Corporation's Operations Centre, or from the Bureau of Meteorology website. The dam and reservoir temperatures are logged by the Operations Centre.

4.7 Operating Cycles

4.7.1 Pressure Cycles

The *Designer* shall indicate the range of expected pressure *operating cycles,* taking into account transient pressures occurring in the lifetime of the vessel.

If not otherwise stated by the *Designer*, the range of the pressure *operating cycles* shall be assumed to be *full pressure cycles* (i.e. 0 to *P*).

The *Designer* shall determine the number of pressure *operating cycles* expected per year, which shall include estimates of:

- Normal transient events (e.g. pump station controlled start / stop cycles, changes in suction pressure for boosting pump stations). The frequency of events shall be determined from analysis of the expected number of cycles per day over the life of the vessel.

- Abnormal transient events (e.g. power failure, variable speed drive trip). The frequency shall be based on two events per month unless a more reliable number can be determined from historical data.

Table 4.1 provides an example of how the transient events for a design may be tabulated.

Table 4.1 Estimated Lifetime Pressure Cycles (Example)

Event	**Pressure (MPa)**			**Number of Cycles per year**
	Operating Steady State	**Max. Transient**	**Min. Transient**	
Power Failure				
1 Pump Start/Stop				
2 Pump Start/Stop				
3 Pumps Start/Stop				
2nd Pump Cycling				
3rd Pump Cycling				

4.7.2 Fatigue Analysis

Notwithstanding the requirements of AS 1210, a detailed fatigue analysis shall be carried out on all surge vessels where:

- Class 1 and Class 2: the lifetime total number of pressure *operating cycles* exceeds 1000.

- Class 1H: the lifetime total number of pressure *operating cycles* exceeds 500 (i.e. not *full pressure cycles* as stated in Table 1.7A of AS 1210)

4.8 Corrosion Allowance

The pressure vessel shall have a corrosion allowance of not less than 1.0mm. Vessels nozzles shall be a minimum of Schedule 160, to allow an additional corrosion allowance in excess of 1.0mm. Vessels constructed of stainless steel may have reduced or no corrosion allowance but this must be agreed by all parties. Vessels constructed of other materials may be acceptable as agreed by all parties and these may be exempt from corrosion allowance.

Adjoining piping used for the air inlet and air pressure sensing shall be a minimum of Schedule 80S.

4.9 External Loading

The *Designer* shall assess/ determine the relevant external loads acting upon the pressure vessel and advise the *Vessel Designer* accordingly. These shall include:

- Maximum nozzle loads (static and dynamic).
- Wind actions (refer AS/NZS 1170.2).
- Seismic actions (refer AS/NZS 1170.4).
- Lifting/ handling devices (refer Clause 4.11).

These parameters shall be determined independently for each vessel due to the variability of locations and exposures.

4.10 Flanged Connections

Flanges integral with the pressure vessel component of the surge vessel, and flanges which mate with the vessel, shall comply with EN1092 and AS 1210.

A protective coating of silicone based water repellent shall be applied to the flange faces after welding and machining. This coating shall be removed prior to flange installation.

All structural and flange fasteners shall be hot-dip galvanized in accordance with AS1214. Structural fasteners shall comply with the ‘Fasteners for Structural Applications’ requirements of DS30-02.

Where the associated water main has, or may in the future have, Cathodic Protection impressed current applied, the flange connection between the vessel and nearest isolation valve shall be an isolation joint providing electrical isolation of the vessel from the main. A de-coupler is required to connect across the isolation flange and to the bypass line to prevent galvanic corrosion and the potential for electrocution whilst conducting work on the pipeline. (Refer to Figure 2 below).

4.11 Lifting/Handling Devices

The pressure vessel shall be fitted with permanently fixed lifting and handling appurtenances including trunnions and/or lugs to facilitate in-transit lifting, transportation, handling and installation. These appurtenances shall be located in positions sufficiently braced to prevent distortion during lifting. Bracing requirements for support legs, to prevent distortion during installation, shall also be identified.

To facilitate the lifting of inlet pipework from a vertical vessel, lifting lugs rated to not less than two (2) tonnes shall be fixed on the lower dished end of the vessel, and flanged inlet elbow (refer to drawing AY58-16-1 for dimensions of the standard lifting lug). The lugs shall be used for the installation and lowering of the inlet elbow only. The *Vessel Designer* shall confirm with the *Designer* that the 2 tonne capacity is adequate for the pipework. The resulting stresses on the vessel dished end during lifting operations shall be analysed as part of the *Detailed Design* of the pressure vessel. Refer to Figure 1 below for the recommended lifting lug configuration.

A 316 stainless steel earthing stud shall be fitted to the vessel support base plate.

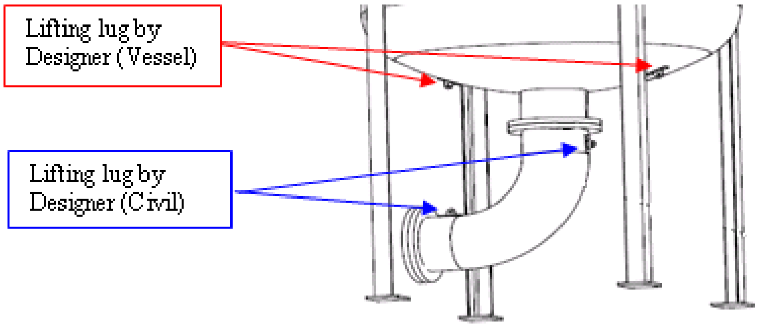

Figure 1 - Inlet pipe elbow lifting arrangement

4.12 Connection of Surge Vessel to Water Main

Where practical, off-take pipework from the water main to the vessel shall rise above ground level and run horizontally such that all valves are mounted above ground level. Valve hand-wheels shall be located at a height of between 850mm and 1250mm from the operating floor level.

Pipe supports shall be designed and located by the *Designer*.

Two isolation valves shall be provided on the off-take from the water main. Isolation valves shall be 'seal-on-body' butterfly valves complying with SPS 261, where a suitable selection can be made for the pressure rating and velocity required. Alternatively 'seal-on-disc' butterfly valves complying with SPS 262 shall be used.

Scour valves shall be installed to enable emptying of the vessel and immediate piping; and for monitoring of the sealing integrity of each valve during isolation (refer Figure 2 below). Scour valves shall be resilient seated gate valves complying with SPS 272 where available for the pressure rating, alternatively metal seated gate valves complying with SPS 271 shall be used. Appropriate scour valve drainage shall determined by the *Designer*.

The inlet elbow which bolts to the vessel is required to be removed during maintenance of internal coatings. The elbow shall be of short radius type, flanged at both ends (refer clause 4.10), and fitted with lifting lugs to facilitate removal.

4.13 Restricted Vessel Recharge Arrangement

The *Designer* shall carry out hydraulic modelling to determine the need for a non-return valve with bypass. This may be required to provide a restricted vessel re-charge rate, and so reduce oscillation of the greater hydraulic system after a transient event. Non-return valves shall be dual-plate type complying with SPS 226 unless deceleration values from the surge analysis require use of a 'Rapid Response' valve complying with SPS 230.

Where a non-return valve and bypass are required, the *Designer* shall specify the nominal bypass size and the required pressure differential across the non-return valve - during the first transient cycle.

The material for the recharge line (to bypass the non-return valve) on a one-way surge vessel shall be MSCL. The piping and valve shall be sized to limit the velocity through the pipe to 4.5 m/s.

The control valve shall be a single butterfly valve conforming to SPS 261. This valve shall be set during commissioning to provide the appropriate differential pressure (during recharge) as predetermined during hydraulic modelling. The valve shall have position indication, and lockable position or a removable handle to enable setting during commissioning. The final position set-point of the valve shall be marked on the notch plate or a plate on the valve, and recorded on a mechanical summary design drawing for the system.

Two tapping points shall be located either side of the bypass tie-in points to enable measurement of the differential pressure during commissioning. These shall be comprised of a DN25 ‘Threadolet’ weld on button connected to a DN25-DN15 reducer and DN15 valve, constructed in accordance with the standard drawing AY58-5-2.

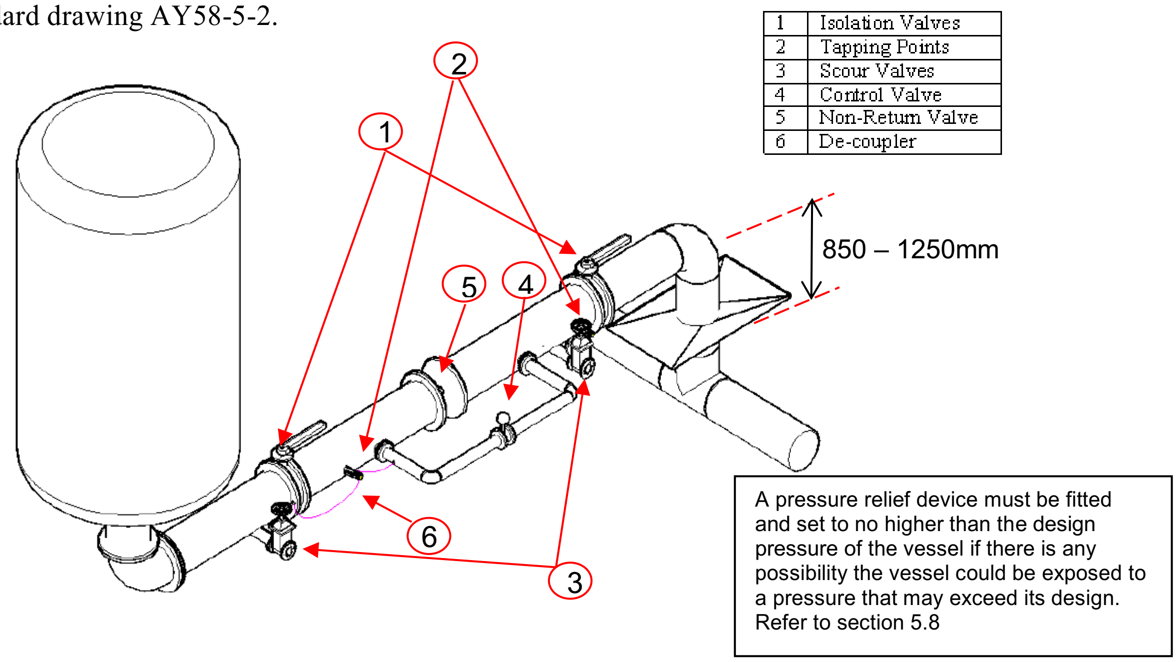

Figure 2 Re-charge Bypass Line Arrangement

4.14 Associated Fittings and piping

All valves and fittings shall be selected by the *Designer* to match the pressure class of the piping system. All associated pipe work shall comply with DS 31-01 and this standard.

Earthing is required across all flanged joints along the connecting pipework from the water main to the vessel.

4.15 Security Lighting and Fire Considerations

Vessels shall be assessed by the *Designer*, in accordance with Corporation Standard Security Treatments DS62 and associated protocols, to identify their security category A, B, C, D or E. Typically the vessel will match the site category; however may be identified as a lower or higher risk component. Vessels assessed as category A and B must have a specific security report for the asset, whilst categories C, D and E shall be subject to an informal review. For information regarding category classifications, security and lighting contact the Corporation’s Security Program Manager.

The design of security components of the vessel shall consider:

- Malicious intent with the possible use of hand tools
- Vehicle accidental damage (roadside location)
- Vehicle deliberate damage.
- Public liability – e.g. unauthorised access fall from height.

The design shall minimise climbing aids for illegal activity on both the main structure and adjacent structures. Standalone vessels shall be placed within a 2.4m high fenced compound, with a nominal distance of 3m between the vessel and appurtenances achieved on all sides. The final selection of fencing shall be made following a situational and operational risk assessment, and consideration of localised environmental aesthetic requirements. For single isolated vessels, the use of a removable section of fencing for maintenance activities requiring infrequent access may be considered.

Refer to Section 5.4 for requirement for security of working platforms to access air vessels.

All signage used to deter access shall be in accordance with the Corporations S197 Security and Safety standard.

All locks shall be selected in accordance with Water Corporation's locking standard, installed to minimise unauthorised manipulation and attack, and be environmentally robust.

The requirement for lighting, for operation and maintenance shall be assessed, by the *Designer*, based on the level of service requirements (as advised by the *Design Manager*) for the vessel. Where response times are such that night-time work may be required, suitable lighting should be installed. For vessels located in the high security categories A and B, lighting should be considered as a means to deter unauthorized access.

The vessel site shall be assessed for fire risk and fire prevention/protection in accordance with the requirements of the approved design standard AS1210 clause 8.12. The ground and asset surface areas shall be selected and treated to minimize situational and seasonal fire risk/fuel loads.

5 AIR VESSELS

5.1 Introduction

This section covers specific requirements for *Air Vessels* - the most common type of surge vessel used by *the Corporation*, where the inside of the vessel is a wetted surface and an air/water interface exists. *Air Vessels* utilise air compressors to maintain a constant stored energy (pressure x volume) within the vessel, and are used for the mitigation of extreme high and low pressures resulting from transient events on water pipelines.

In addition to the general surge vessel design requirements and parameters, covered in previous sections, the following shall be incorporated in the design of an *Air Vessel*.

5.2 Upper Dished End Nozzles

Three nozzles shall be provided and located on the upper dished end of the vessel as follows:

- Air inlet / air purge
- Air pressure sensing
- Spare

The nozzles shall protrude externally from the vessel a vertical height of 180mm from the external surface of the dished end to flange face. They shall be situated at the outer perimeter to enable ease of access for inspection. Each nozzle shall be size DN100 to ensure sufficient access for coatings application and selected in accordance with section 4.8.

Two grade 316L stainless steel nozzle mating flanges, each with 25mm" threaded socket connection shall be supplied with the vessel. The nozzle flanged joints shall be insulated in accordance with the 'Isolated Flange Joints' requirements of DS30-03 and standard drawing JZ39-91-10.

The spare nozzle shall be fitted with a grade 316L stainless steel blank flange.

5.3 Access and Platforms - Manhole

A DN600 manhole shall be provided in the shell near to the circumferential joint between the shell and the bottom dished end. The manhole shall be sealed by a bolted flange connection, using a full face, high elastomeric content, compressed fibre gasket. A davit arm shall be fitted to the vessel to facilitate lifting of the manhole blank plate. A grab rail shall be located both internally and externally a distance of 300mm vertically above the manhole.

5.4 Access and Platforms - External

Refer to standard drawing JZ39-91-21 for typical single access platform general arrangement.

A single working platform of maximum 3m height shall be located 500mm below the invert of the manhole. This working platform shall be free standing with no attachment to the vessel. Where multiple vessels are adjacent, a common platform may be used. The platform shall be fitted with a guardrail inclusive of toe-board. The entry to the platform shall be fitted with a self-closing gate, also with toe-board. The gates shall be a proprietary item.

The design of access to the working platform shall provide safe and secure access as follows:

For Security Category A and B complexes:

- Access to the platform shall be via a stairway.

- The self-closing gate to each platform shall be lockable.

For Security Category C and D complexes and stand-alone sites:

- Access to the platform shall be via a 3m (maximum vertical height) inclined ladder fitted with a double-sided full length lockable hinged cover.

Provision shall be made for the manoeuvring of mobile elevated work platform (EWP) into position adjacent to the side of the vessel where the three upper dished end nozzles are located, to enable external inspection of the vessel. An access-way and a minimum of 5m of level hardstand ground are required

The *Designer* shall provide construction drawings for all platforms, ladders and guardrails and ensure their compliance with AS 1657, DS30-02 'General Design Criteria – Mechanical', DS100 'Suspended Flooring (Grid Mesh and Chequer Plate)' and S151 'Prevention of Falls'.

5.5 Access and Platforms - Internal

An internal, removable FRP floor shall cover the entire cross-section of the surge vessel. The top of the grating shall be located 500mm vertically below the invert of the manhole. Grab handles shall be provided to aid movements into and out of the vessel.

All FRP platforms shall have a vinyl ester resin base with a load bar centre-centre spacing of 38mm.

The floor bracing/support shall be designed for uniformly distributed live loading of not less than 2.5MPa. The resulting stresses at the intersection of the shell to support ring and cleats shall be analysed; areas of overstress shall be identified and rectified. Where practical, the support beams for the lower platform shall avoid the high velocity zone across the centre of the vessel. Each section of FRP flooring shall be bolted securely in place using stainless steel bolts (grade 316) and nuts (grade 320).

Access to the top of the vessel for visual inspections shall be achieved via camera inspection, with no climbing aids provided internal to the vessel.

5.6 Cathodic Protection

Each surge vessel shall be internally fitted with equally spaced magnesium anodes. The recommended anode type is MA12C 600 x 90 x 90mm with a 38 x 6mm core. Refer to the table below for the quantity of anodes required.

Volume (m^3)	***Quantity Required***
50	4
40	4
30	3
20	3
10	2

Standard 75 x 10mm flat bar brackets shall be welded to the vessel shell to enable mounting of the anodes. The lower bracket shall be positioned 1m vertically above the top surface of the lower platform. All mounting nuts and bolts shall be hot dipped galvanised. After assembly the mounting brackets and core shall be coated as required (above) for the internal walls. No other part of the anode shall be coated.

Refer to standard drawing JZ39-91-18 for anode requirements and mounting details.

5.7 Air Charge and Vent System

5.7.1 Air Compressors

All air compressors shall be compliant with Section 4 of DS35 – *Ancillary Plant – Mechanical,* and selected from products listed in the Strategic Products Register.

Each surge vessel group (or single stand-alone vessel) shall incorporate at least two air compressors (one duty and one standby). The control system will incorporate alternate duty operation and call for a standby unit on detection of a compressor fault.

5.7.2 Pipework and Valves

The air supply line runs from the air compressors to a common manifold, and then to the air inlet nozzle at the top of each surge vessel. Where multiple vessels form a group, each vessel shall have the ability of being filled independently. The air supply lines shall be not less than DN25 Class 2A, Schedule 80S stainless steel seamless pressure pipe. The pipe shall be welded only. Pipe supports shall be evenly spaced along the length of the vessel for both of the air lines. The attachment of the pipes shall be via insulated pipe brackets to avoid galvanic corrosion.

NOTE: The pipe rating greatly exceeds the maximum required pressure rating to ensure a robust system in the absence of access platform provision.

5.8 Vessel Safety Pressure Relief Valve

Each vessel shall be provided with a spring safety pressure relief valve (PRV) in accordance with section 8.2 of AS 1210 unless the pressure is under such positive control that the vessel cannot exceed its nominated design pressure. For vessels pressurised from an air compressor a pressure relief valve shsll be supplied on the air inlet line located in the Valve and Instrument Panel. The PRV shall be DN25 or larger. Relief piping shall discharge to waste at a point below the cabinet.

The valve and relief pipe shall be sized in accordance with the requirements of AS 1271 and API 520 to relieve the maximum capacity of all upstream compressors that could, under any circumstance, operate simultaneously to pressurise the vessel. No other valves shall be installed between the PRV and the vessel. The make/model of the valve shall be selected from products listed in the Strategic Products Register.

The PRV shall be installed in the correct orientation as specified by the valve manufacturer (typically vertical) and be set to discharge at the vessel *Design Pressure*.

5.9 Coatings

Internal and external coating of the vessel surface shall be in accordance with Section 8.5 of this standard.

6 DIAPHRAGM TANKS – AS 1210 Compliant

This section covers the bladder type pressure vessels used by the Water Corporation, primarily for surge mitigation, which are designed and manufactured to AS 1210. Guidance on Diaphragm Pressure Tanks classed as "serially produced" is provided in Section 7.

6.1 General

AS1210 Diaphragm Tanks incorporate a water filled internal butyl rubber bladder designed to provide water/gas separation, surrounded by a pre-charged cushion of gas (usually Nitrogen) which maintains pressure. Surge pressures in the connected system are mitigated by the charging or discharging of pressure in the vessel.

Bladder type surge vessels have been used by the Corporation for surge protection on seawater applications and in remote locations where the provision of power for compressors is prohibitively expensive. AS1210 compliant diaphragm tanks that have Design Registration in Australia are listed in the Strategic Product Register in capacities of 1, 2 and 3 Cu.m with P16 pressure rating. In addition to the general requirements in Section 3 of this standard, the following shall be addressed in the selection and design of AS1210 Diaphragm Tanks.

6.2 Considerations in Selection

Whilst bladder type pressure vessels are available either vertically or horizontally mounted, the latter shall be used for vessel sizes in excess of $10m^3$ unless the foot-print for the site is insufficient.

The following considerations should be made prior to choosing a bladder type vessel over a conventional air vessel:

(a) Bladder Replacement – Bladders are warranted for 3 years and have a design life of 10 years. Bladders may exceed their design life, and do not require replacing until a leak has been detected. Whole-of-life cost analysis including multiple bladder replacements shall be undertaken.

(b) Operational impact on both the hydraulic system and maintenance resources when bladder replacement is required.

(c) If no SCADA monitoring is available, the vessels must be inspected and recharged regularly.

(d) The risks associated with there being currently a single 'sole supplier' of the vessels, including possible obsolescence and the long term availability of replacement bladders.

(e) The safety and practicality of replacing the bladder, Safety in Design and operator acceptance is required.

(f) The lead time for replacement bladders, likely to be several weeks or months for larger vessels (refer Clause 6.3) as they are custom engineered products, currently manufactured in Europe, and not held as a stock items in Australia.

6.3 Availability

The current sole distributer to Australia is SafeSurge Pty Ltd (NSW). The vessels are not an 'off the shelf' item, however are available from the Manufacturer in volumes from 100L to 3000L, with a design life of 20-25 years. Larger vessels are available as a custom design. The pressure rating, coating, access and monitoring requirements must be individually specified for all vessels.

6.4 Sizing

Bladder vessels shall be sized in accordance with section 3.5. The *Designer* shall also calculate the required pre-charge pressure for the vessel for record on relevant design documentation.

The Corporation has adopted a *standard design pressure (P)* rating of PN16.

*Standard total volume*s (*V*) that may be selected for the bladder vessels shall be one of the following standardised volumes:

- $1m^3$
- $2m^3$
- $3m^3$

Larger sizes and design pressures are not permitted unless approved by the *Design Manager* in consultation with the *Senior Principal Mechanical Engineer (Engineering)*.

The vessels shall be of vertical orientation for Corporation Standard sizes.

6.5 Access

Where horizontally mounted vessels are used, they shall be fitted with two DN600 manholes, one in each dished end, provided with sufficient clearance for bladder replacement. The manholes shall be located with the centre at a height no greater than 1m from ground/platform level. The two points of entry/exit are required to enable safe extraction and insertion of the bladder. Davit arm(s) shall be fitted to the vessel to facilitate lifting of the manhole blank flange(s). An external grab handle shall be fitted above the manhole to aid entry into the vessel. No internal grab handles shall be fitted, to avoid damaging the internal bladder.

6.6 Coatings

Internal and external coating of the vessel surface shall be in accordance with Section 8.5 of this standard.

Note: Whilst the majority of the surface is in contact with Nitrogen and not subject to corrosion, the lower reducer will be in contact with the water and requires the standard protective coating.

6.7 Burst Disc

The vessel shall be fitted with a burst disc sized to protect the vessel during the pre-charging process. The disc shall be rated at the design pressure of the vessel.

For larger vessels (above $3m^3$) a relief valve may be used in lieu of a burst disc.

6.8 Control and Monitoring

Bladder vessels shall be pre-charged with nitrogen, rather than dried compressed air, in order to minimise corrosion potential. The pre-charge connection point (shraeder valve) shall be located at a height range between 850mm and 1250mm from the operating floor level.

The vessels shall be fitted with a differential pressure transmitter for monitoring apparent water level in the vessel to detect a bladder failure and reduce inspection intervals. This shall be connected to the SCADA system for remote monitoring. The following alarm settings are required:

High water level: Indicating loss of Nitrogen in the vessel. This may be thru the associated gas side piping and appurtenances, or possible bladder failure (absorption of gas in the fluid).

Low water level: Indicating loss of water. Immediate inspection is required as damage to the bladder may be caused due to prolonged contact with the inlet/outlet grating. This will typically occur during a shut down or burst pressure main.

Sufficient time delay for the alarm should be allowed to avoid triggering during a typical surge event.

Individual leads to the differential pressure transmitter are preferred over a 3-way bypass on the instrumentation to prevent filling of water into the gas side of the sensing line.

SCADA monitoring is not required where a vessel is used to extend operating cycles of pumps and bladder failure will not have a significant impact to the connecting system. Such failure would be detected during routine maintenance and/or in increase in pump starts.

6.9 Procurement & Specification

The corporation has produced a *Strategic Product Specification – SPS 249 – Bladder Vessels.* This specification shall be used in the procurement of all bladder type vessels with all information required in *Appendix A - Project Specific Requirements* being completed by the *Designer*.

7 Diaphragm Pressure Tanks (American & European Standards)

A diaphragm pressure tank falls under the definition of an unfired pressure vessel and may also be classed as a Serially Produced Pressure Vessel to which AS 2971 applies. Approved design standards for these type of vessels also include ANSI/WSC PST 2000/2016, EN 13831:2007(E) or ASME BPVC VIII Div 1. Hazard level B or C vessels stated as serially produced vessels that do not comply with AS 2971 are not acceptable as being exempt from plant registration (ref: Schedule 4.2 OS&H Regs), Diaphragm pressure tanks are commonly used on small booster pump systems to store and maintain fluid pressure and to prevent rapid cycling of pumps. They may also be used for surge mitigation for small pump station and similar applications.

Diaphragm tanks that have received Design Registration by an Australian regulatory authority are available for use and listed in Section C of the Strategic Product Register Unlisted and **unregistered diaphragm tanks shall not be used.**

7.1 Standards and Regulations

The Australian Standards which cover diaphragm pressure tanks include AS/NZS 1200, AS 1210, AS 3920 and in the case of serially produced vessels AS 2971 must apply. These standards cover a wide range of vessels (refrigeration vessels, ductile plastic vessels, etc).

There are no known suppliers of diaphragm pressure tanks to the Australian market, that have provided evidence of compliance and appropriate marking, to demonstrate that their tanks fulfil the requirements of "serially produced" as defined by AS 2971.

The European Standard which covers diaphragm pressure tanks is EN 13445 'Unfired Pressure Vessels and EN 13831:2007(E). The American Standards covering diaphragm tanks are ANSI/WSC PST 2000/2016, or ASME BPVC VIII Div 1. These standards may also align with the Simple Pressure Vessels Directive 87/404/EEC and Pressure Vessel Directive 97/23/EC which is legally binding throughout the European Economic Area. Compliance with the Pressure Vessel Directive appears to have been more widely adopted by manufacturers supplying diaphragm pressure tanks to the Australian market.

The Manufacturer or Supplier of a hazard level A, B, C or D vessel is required to register their design with an Australian regulatory authority. Vessels for which this has occurred are listed in Appendix C of the Strategic Product Register. Classified Plant Registration with Worksafe WA is required for hazard level A, B and C vessels.

7.2 Design Limitations

The following size and pressure limitations apply to the classification of serially produced and simple pressure vessels:

Standard	**AS 2971**	**EN 13445**
Title	Serially produced pressure vessels	Unfired pressure vessels
Pressurised Fluid Types	Non-harmful, harmful and very harmful.	Air or nitrogen only.
Maximum Volume	500L	-
Minimum Design Pressure	0.05MPa	0.05MPa
Maximum Design Pressure	-	3MPa
Allowable P.V *(P – Pressure*	1MPa.L – 3000MPa.L (non-harmful contents)	<u>*Categories:*</u> A1: PV > 300MPa.L

V – Net Volume)	1500MPa.L (harmful or very harmful contents)	A2: 20MPa.L < PV < 300MPa.L A3: 5MPa.L < PV < 20MPa.L B: PV< 5MPa.L
Minimum Temperature	-30ºC	50ºC
Maximum Temperature	150ºC	300ºC – steel 150ºC – aluminium

7.3 Availability

Diaphragm pressure tanks are typically vertically mounted, however are also available horizontal. The standard maximum operating pressure is 10 bar (1MPa), 16 bar models are available for industrial high pressure purposes. The actual capacity of the vessel can range from 2L to 3000L, whilst the nominal draw-off is approximately a 30% of the actual capacity.

7.4 Requirements/Limitations

Diaphragm pressure tanks for use within the Water Corporation shall be designed, manufactured and tested in accordance with AS 1210, AS 2971, EN 13831:2007(E), ANSI/WSC PST 2000/2016, EN 13831:2007(E) or ASME pressure vessel codes; or shall have EC certification as proof of design, manufacture and testing in accordance with a suitable design standard and directive 97/23/EC.

Diaphragm pressure tanks shall be supplied with a name plate in accordance with the approved design standard. In the case of serially produced vessels the design shall be compliant with AS 2971 and the nameplate details as stated in section 4.1 of this standard. The nameplate shall include but is not limited to; vessel model and type, standard and class of construction, place of manufacture, design or maximum working pressure, design temperature, volume, serial number, test pressure, year of manufacture and design registration number.

Diaphragm pressure tanks supplied to the Water Corporation shall not exceed the following parameters unless approved by the *Design Manager* in consultation with the *Senior Principal Engineer - Mechanical (Engineering)*:

Volume - 500 L

Pressure - 1 MPa

Pressure x Volume (PV) - 200 MPa.L

Note: Vessels with P.V below 200 MPa.L have reduced ongoing inspection requirements which are consistent with The Corporation's operating practises for this type of asset (refer section 7.8)

7.5 Sizing and Selection

Vessel capacity sizing shall be based upon the worst case number of pump starts which will usually occur when the system demand flow rate is half of a single pump duty flow rate.

Where used for the storage of pressure in booster pump stations, pressure tanks shall be sized subject to the constraints in the previous section. For fixed speed booster pumps the following equation may be used to size the diaphragm tank. Where the Volume or PV limits in the previous section are exceeded, multiple pressure tanks may be selected to achieve the required volume.

$$V = \frac{Q \times 1000 \times (1 + (\text{cut-in}) + \Delta P)}{4 \times n_{max} \times \Delta P \times k} \times 1$$

Where:

V = Tank Volume (L)

Q = Mean flow rate (m3/h)

ΔP = Difference between cut-in and cut-out pressure (bar)

Cut-in = Cut-in pressure (lowest) (bar)

N_{max} = Max. number of starts/stops per hour

k = Constant for tank pre-charge pressure: k=0.9

7.6 Number of Vessels

Where vessels form part of a Booster Pump Station, consideration shall be given to the system availability required and the downtime associated with the renewal of a failed vessel diaphragm.

For systems supplying directly to customers where ‘n’ is the number of vessels required to achieve the capacity for an acceptable number of pump starts (refer Sizing and Selection), n+1 vessels shall be provided.

7.7 Provision for In Service Testing

The design of the system to which the vessels are connected shall permit monitoring and testing of the integrity of the bladder in the vessel. This is normally achieved by isolation of the vessel under pressure, bleeding a small flow rate from the vessel, monitoring the rate of change of pressure in the vessel. Provision for testing shall be made as follows:

- A pressure gauge on the vessel
- A valve for isolation of the vessel from the system
- A small (usually 15mm) bleed valve piped to a suitable discharge location.

7.8 Installation

The procedures regarding the installation of vessels shall be strictly in accordance with the manufacturer’s Installation and Operations Manual, in addition to the following;

(a) Vessels shall be firmly secured to the floor.

(b) When possible, the vessel shall be pre-charged with dry nitrogen, as this can effectively eliminate the source of internal corrosion.

(c) Pressure relief valves and pressure indicating devices shall be installed where necessary and in accordance with DS 38-01.

(d) The vessel pipework shall be properly supported in accordance with DS 38-01.

(e) Vessels shall be stored in a fully enclosed or undercover dry environment such that they are not exposed to direct sunlight, extreme weather or corrosive conditions.

(f) Vessels shall be installed such that the vessels can be easily accessed for inspection and maintenance procedures.

7.9 Maintenance and Inspection

The pre-charge pressure should be set according to the manufacturer's Installation and Operations Manual and must be checked twice a year.

All vessels with must have an internal and external inspection conducted by a competent person as per the manufacturer's instructions and AS 3788, at least every two years. If an internal visual inspection is not possible, non-intrusive methods of inspecting the internal condition of the vessel should be used.

An issue with these vessels (bladder failure) will typically be observed by increased pump cycling.

8 MANUFACTURE

8.1 General

This section sets out the requirements for both air and bladder vessels. It is not intended to cover serially produced vessels.

8.2 Structural Fabrication Accuracy

The *Vessel Designer* shall take into account rolling and fabrication tolerances, and clearly specify these on the vessel fabrication drawings.

Structural steelwork shall be fabricated in compliance with AS 4100. Due allowances shall be made during fabrication for distortions due to welding and precautions shall be taken to minimise these defects.

8.3 Vessel Supports and Foundations

The vessel shall be supported to withstand the maximum imposed loadings without causing instability or excessive localised stresses and deformations in the vessel wall.

Supports for vertical vessels with a diameter greater than 2m shall be of skirt design. The skirt shall have provision for access and egress via an opening for the water inlet/outlet pipe extending from ground level to a minimum height of 1400mm. A second access/egress opening shall be provided diametrically opposite, extending from 300mm to 1500mm above ground level. Both openings shall have a minimum width of 750mm and provided with appropriately curved corners.

Vessels with diameter less than 2m, shall have leg supports.

All supports shall be designed as per AS 1210 and allow for:

- movement of the vessel wall due to thermal and pressure changes
- seismic events and wind actions
- the possibility that highest stress may occur when the vessel is empty, operating, or under hydrostatic test pressure.

The supporting concrete slab foundation design shall be undertaken by the *Designer*, and take into account slab drainage, including inside the skirt. The *Vessel Designer* shall provide all information required for the slab design including maximum loads at each base plate (including during on-site hydrostatic test) and the required bolting arrangement.

Skirts or Legs shall be raised to a height of at least 30mm above slab level and seated on a suitable grout layer to avoid corrosion.

8.4 Manufacture and Welding

All vessel welding shall be carried out under supervision of a person who has relevant training and experience in the form of construction and the process of welding used on the vessels. The welding supervisor shall hold a supervisor’s certificate in accordance with AS 1796 or have other qualifications or experience acceptable to the Superintendent and the Inspection Authority.

Vessel welding shall be conducted in accordance with AS 4458 and Water Corporation Specification WS1. Qualification of the welding procedure shall be in accordance with AS/NZS 3992.

The following shall comply with the relevant sections of AS 1210:

(a) all materials which are to be welded

(b) procedures for preparation of surfaces for welding

(c) assembly of plates and components for welding

(d) arrangement of welding joints

(e) all other applicable welding techniques during manufacture of pressure parts of the vessel

Vessels utilising a plate thickness of 32mm or greater may require post weld heat-treatment. All welding of attachments to the vessel shall be carried out prior to post weld heat-treatment and coating. All pressure water pipe welding shall be conducted in accordance with AS 4041 Class 2P and Water Corporation Specification WS1. (Note: all pipe which is a component of the vessel shall be welded in accordance with AS 4458).

All structural steel welding shall be conducted in accordance with AS 1554.1 and Water Corporation Specification WS1.

Where dissimilar materials are used, they shall be isolated from each other.

8.5 Protective Coating

All protective treatments shall be in accordance with Water Corporation Design Standard DS95.

The vessel internal surfaces shall be prepared to Water Corporation technical specification A1; followed by coating to minimum 500µm thickness with high build epoxy in accordance with Water Corporation technical specification D1. The anode shall not be coated, however the tabs and bolts should be coated. The coating used shall have AS/NZS 4020 certification for suitability for use with potable water. The final colour shall be white.

The internal coating shall be continuous and extend on to the flat face of the flange face by max 12mm.

Zinc rich epoxy shall be applied to the flange face extending to past the faces of all flanges, allowing overlap by the vessel internal coating. The coating thickness over flange faces shall fall in the range 60-80µm. (Refer to drawing JZ39-91-19.)

The vessel exterior shall be prepared to Water Corporation technical specification A1; followed by coating with zinc rich epoxy, epoxy mastic coat and polyurethane top coat in accordance with Water Corporation technical specification C2. The final colour shall be advised on a project specific basis by the *Design Manager*, and selected to minimise visual impact.

A compatible final graffiti resistant external surface/coating shall be applied to vessels where a situational graffiti risk is assessed. The graffiti resistant paint shall be in accordance with Water Corporation technical specification J1, and as outlined on the Government website http://www.goodbyegraffiti.wa.gov.au/.

8.6 Testing

8.6.1 Impact Testing

Certain materials require impact testing when operating at low temperatures. Refer to curve A in Figure 2.6.2(A) of AS 1210 for the material design minimum temperature of as welded AS 1548 plate.

Note: AS1548 plate is provided with batch impact test results regardless of the operating temperature. Where alternative materials are used, the need for impact testing must be considered.

8.6.2 Non-Destructive Testing

Examination shall be conducted in accordance with AS4037.

Plate that is ≥32mm thick shall be subject to UT examination for laminations.

Butt welds utilised in the joining plates for the purpose of forming dished ends shall be tested in accordance with AS 4037, Type A welds. In addition butt welds shall be 100% ultrasonic or radiographic and magnetic particle tested in the knuckle area post forming and normalising.

8.6.3 Hydrotest

The hydrotest shall be in accordance with the approved design standard. For vessels constructed to AS 1210 exemption from hydrotest shall not be granted as per Clause 5.10.7 of AS1210.

For all Classes of vessels, the following increased hydrostatic test pressure shall be used for vessel design and testing:

$$P_h \geq 1.5 \cdot P$$

Where: P_h = hydrostatic test pressure

P = design pressure of vessel

8.6.4 Holiday Testing

Holiday testing of the vessel coatings shall be conducted using the high voltage test method in accordance with AS 3894.1. All detected defects shall be repaired.

9 MARKING AND DOCUMENTATION

9.1 Markings

All vessel materials including flanges shall be clearly stamped with the material heat number. Individual components shall be clearly marked to aid identification during erection.

The vessel shall have a name plate installed in a prominent and accessible position. The markings shall be in accordance with approved design standard, section 7 of AS1210 or in the case of those classed as "serially produced" section 4.1 of AS2971 and should include the information as per the standard name plate drawing JZ39-91-19.

Signage shall be fitted to the piping to enable identification between the air and water lines.

9.2 Documentation

A *Design Specification* shall be prepared by the *Designer* for each surge vessel or group of vessels.

Design calculations and *detailed design drawings* shall be prepared by *Vessel Designer*. A copy of these shall be forwarded to the *Design Manager* to be stored in the Corporation's Pressure Equipment Register held in Engineering.

An *MDR* shall be submitted by the *Vessel Manufacture* to the *Corporation's Welding Inspector* upon physical completion of manufacture and testing of the vessel(s). This shall then be stored in the Corporation's Pressure Equipment Register held in Engineering.

10 INSTRUMENTATION AND CONTROL

This design standard shall be read in conjunction with Section 13 of DS22 – *Ancillary Plant and Small Pump Stations – Electrical* and Standard Electrical Drawings FS00-2-8.1 and FS00-2-8.2.

10.1 Instrumentation & control devices

Each surge vessel shall, be provided with the following instruments for control and monitoring purposes:

- An (absolute) pressure transmitter (PT), with pipework connecting it to air space. This pressure transmitter is utilized to monitor the air pressure in the surge vessel for filling and venting purposes (*Air Vessels only*)

- A level transmitter (LT) in the form of a differential pressure transmitter, with pipework connecting it to both the water space and the air (or nitrogen) space. This level transmitter is utilized to determine the water level in the surge vessel.

- A solenoid actuated valve utilised for the control of air for charging purposes (*Air Vessels only*).

- A solenoid actuated valve, complete with silencer, utilised to vent air from the vessel (*Air Vessels only*) if pressure exceeds setpoint.

- A condensate trap, of the electrically operated type, installed on the instrumentation air line. (*Air Vessels only*)

NOTES:

1. The list shall be regarded as a minimum requirement, additional instrumentation may be specified

2. Compressed air type mechanical condensate traps shall not be used due to reported operational experience of this style of valve ‘popping’ at frequent intervals. All instruments shall comply with DS 40-09 – Field Instrumentation.

The readings (4-20mA signals) from each pair of LT and PT are input to the PLC for calculation of:

- The ‘normalised air-mass volume’ of the respective vessel.

- An average normalised air mass volume of the surge vessel group for display on SCADA.

The signals from the above instruments are monitored for out-of-range readings, which represent a fault condition for the respective vessel. Any out-of-range faults will:

- Inhibit the opening of the fill valve, so preventing filling or venting of that particular vessel.

- Initiate “surge vessel system failure” alarm and indication on SCADA and at the COIP for that particular vessel.

- Initiate a surge vessel permissive interlock and activate an alarm at the OC and the COIP. Refer to section 10.2 for application of the interlock.

10.2 Valve and Instrument Panel

The Valve and Instrument Panel shall be:

- A fully enclosed cabinet housing: the pressure transmitter, the level transmitter, the charging and venting valves and the condensate trap listed in Section 10.1. Refer to standard drawing JZ39-91-17 for the general equipment layout within the Valve and Instrument Panel.

- Located adjacent to each surge vessel. Where two surge vessels within the same surge vessel group are located adjacent to each other, a common cubicle may be used for mounting of the equipment. Where two surge vessels are located opposite each other across a main, separate cubicles are required.

- Fitted with hinged lockable covers.

10.3 Instrument Piping

Three (3) separate pipes (lines) shall extend from ground level to the top of each surge vessel, viz:

(a) The air charge/ vent line from the air charge/ vent manifold to a nozzle on the top of the vessel (Air Vessels only, refer Section 5.7.2).

(b) From the (absolute) pressure transmitter (PT) located in the Valve and Instrument Panel to a second nozzle on the top of the vessel.

(c) From the differential pressure transmitter (LT) located in the Valve and Instrument Panel to the same nozzle used for the (absolute) pressure transmitter (PT).

NOTE: Separate lines are required to the top of the vessel for monitoring and air fill, as combining the two could lead to erroneous pressure readings, caused by pressure fluctuations when either the compressors or air purge valve are operating.

An additional line shall connect the differential pressure transmitter (LT) to either a flanged spigot on the bottom of the vessel, or to the water inlet/ outlet pipe.

Instrument tubing shall connect to the steel air line piping once it has entered the transmitter cabinet.

Provision shall be made to enable the bleeding of all instrument lines, via drain valves. Tapping points on the air and water line shall be provided to enable calibration of the pressure transmitters.

Where the vessel is not located in a secure compound, small pipe lines between the vessel, compressors and the control panel shall be buried or suitably caged to a height that deters access.

Flexible couplings of suitable rating and material may be used within the instrument cabinet for ease of connection of the pressure transmitters to the stainless steel tubing.

11 FUNCTIONAL DESCRIPTION

11.1 General

The functional control of a surge vessel group (SVG) treats each surge vessel as a stand-alone unit. In this way, a measure of redundancy is provided.

Where a vessel forms part of a surge vessel group, that vessel:

- Shall be independently monitored, controlled and isolated (hydraulically and electrically) without impacting other vessels in the surge vessel group.

- A fault signal from that vessel shall not cause the surge vessel group to become faulted, but may be used to restrict capacity of the pump station to a level, determined by modelling, at which the remaining vessel(s) provide adequate surge mitigation.

11.2 Surge Vessel Permissive Interlock

An out-of-range "Surge Vessel Permissive Interlock" signal is required to be output from the controlling PLC to the SCADA. The basis for determining the interlock will depend on the level of redundancy for a surge vessel group.

As the levels of redundancy differ between various surge vessel groups, the interlock is implemented differently for each SVG, and may require the imposition of flow constraint(s) on the connected water main. For fixed speed pumps a controlled stop will occur, but re-start will not be possible. For VSD driven pumps, a possible reduction is flow is acceptable.

The flow constraint shall be Local Operator adjustable via the COIP, as will the nominal maximum main capacity.

11.3 Surge Vessel Calculations

The air in the sealed space above the water acts as a pneumatic spring and hence damps sudden pressure changes in the pipeline.

The volume of water in the vessel must be sufficient to supply the required volume into the pipeline in the event of a down-surge event and to maintain the minimum reserve required in clause 3.5. The volume of air must be sufficient to mitigate high or low pressures during a surge event. These relative volumes are determined through hydraulic modelling.

Generally, it is sufficient to assume that the temperature of the air within the vessel remains constant, and no temperature compensation is required to be provided in the air measurement system subject to the check of operating levels discussed below.

The water level in the vessel is determined by the differential pressure transmitter. As the overall volume of the vessel is known, the air volume is determined by subtraction.

NOTE: The notation of the offset height of the level transmitter from the base of the cylindrical section is +ve if above the base, -ve if below the base.

11.3.1 Air vessel Specific

The air pressure in the vessel is measured by the (absolute) pressure transmitter (PT). As both the volume and the pressure are known, the pressure-volume multiple PV (air mass volume) can be calculated. The air mass volume remains constant assuming no change in temperature (Boyle's Law). Excursions from the steady-state water level for a given pipeline pressure, and modelled transient events, can be predicted and appropriate set-points assigned for air pressure to achieve a required water level.

This means that the allowable variation in and the subsequent selection of the air mass volume must be such that the normal diurnal variation in temperature does not initiate control or alarm functions. Seasonal temperature variations are catered for by the normal air make-up or release operations over time.

For control operation and logic refer Design Standard DS22 Section 13 and Standard Electrical Drawings FS00-2-8.1 and FS00-2-8.2.

12 APPENDIX A Project Specific Requirements (Normative)

12.1 General

Project specific information and requirements, not included elsewhere in this Design Standard, shall apply as specified in the following clauses.

12.2 Technical Requirements

The following table details project specific requirements for the surge vessels to be procured.

Table 5.1: Purchasing Schedule – Project Technical Requirements

Surge Vessel Details	
Quantity:	
Vessel Location:	
Standard Size - 10, 20, 30, 40, or 50m^3 (Clause 4.3):	
Design Pressure - PN16, 21, or 35 (Clause 4.5):	
Maximum Operating Temperature (Clause 4.6):	
Minimum Operating Temperature (Clause 4.6):	
Pre-charge Pressure – Bladder Vessels (Clause 6.4):	

Operating Cycles (Clause 2.6.2)				
Pressure Changing Event	Operating Steady State Pressure (kPa)	Max Transient Pressure (kPa)	Min Transient Pressure (kPa)	No. Operating Cycles per Year

13 APPENDIX B Surge Vessel Design Process

The following table summarises the documentation used in the design process for Vessels and is intended as a guide. Actual responsibilities will be defined in the design brief, specifications and procurement documents.

ID	Task	Stage	Input Document(s)	Responsible for Preparing Document(s)	Output or Output Document	Responsible for Output	Review Hold Points
1	Preliminary Hydraulic Analysis	*Planning*	Various	*Planning*	Planning Report (1)	IPB	
2	Hydraulic Analysis (Engineering Design- pre final pump/valve selections)	*Scoping – Engineering Design*	*Design Brief, Planning Report. Field Test Results*	*Design Manager*	Hydraulic Analysis as part of *Engineering Summary Report*	Designer (2)	Engineering - M&E
3	Hydraulic Analysis (Detail Design – Post Final pump / valve selections	*Scoping/Deliver - Detailed Design*	*Design Brief, ESR, Final equipment data*	*Design Manager*	*Final Hydraulic Analysis Report (Detailed Design)*	Designer (2)	Engineering - M&E
4	Prepare Surge Vessel Arrangement Drawings and Specification	*Scoping/Delivery- Detailed Design*	*Design Brief, ESR, Final Hydraulic Analysis Report*	*Design Manager*	Arrangement Drawings and Specification for: vessel, appurtenances, accessories, landings etc.	Designer (2)	Engineering - M&E Stakeholders
5	Detailed Design of Vessel	*Delivery*	Arrangement Drawings & Specification	*Designer*	Vessel Fabrication Drawings	Vessel Designer (3)	Engineering - M&E, Stakeholders
6	Third Party Verification	*Delivery*	Vessel Fabrication Drawings	*Vessel Designer*	Verification Certificate	Third Party Verifier (4)	Third Party Review
7	Detailed Design of Landings	*Delivery*	Arrangement Drawings and Specification for: vessel, landings etc. Vessel Fabrication Drawings	*Designer* *Vessel Designer*	Detailed construction drawings of landings etc. Comments on any interfaces between landings and vessel	Designer (5)	

NOTES

1. 'Preliminary' Hydraulic Analysis may be undertaken by IPB but shall be verified and revised by the Designer Hydraulic
2. Designer - may be the same entity or several independent entities.
3. Vessel Designer - will normally be engaged by the Vessel Fabricator.
4. Third Party Verifier will normally be engaged by the Vessel Designer
5. Will normally be engaged by the Vessel Fabricator

END OF DOCUMENT