Specification

Fibreglass Reinforced Plastic (FRP) Chemical Storage Tanks Technical Specification

NOTES:

1. This Specification is to be used by Designers for all FRP Chemical Storage Tank projects.
2. The content of this Specification must not be changed or altered without authorisation.
3. This Specification is not intended to be a stand-alone document. Project specific documents and additional technical clauses must be added to the contract document.

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Revision details

Version No.	Clause	Description of revision
2	Various	Update format, Clause 3.1 Additional notes under Table related to temperature, Clauses 4.2 and 4.3 designer and 3rd party verifier experience to comply with D0000833, Clause 5.1 Tanks >6m diameter can use metallic clips rather than HDLs and HDL relocation requirement amendments, Clause 5.2 Lifting lug design requirements amended and allowance of 4 lugs included, Clause 5.3.2 Nozzle design amended, Clause 5.3.3 Manway design requirements amended to improve safety, Clause 5.4 clarification of resin requirements, reinforcement requirements added, Clause 5.11 Standpipes requirement relaxed, Appendix 2 – Media and Design density amendments, resin selection/curing requirements relaxed, addition of design matrix for ferric tanks.
1	All	First issue

Introduction

This Specification is for the design, supply and construction Fibreglass Reinforced Plastic (FRP) Chemical Storage Tanks for Sydney Water assets.

Sydney Water makes no warranties, express or implied, that compliance with the contents of this Specification shall be sufficient to ensure safe systems or work or operation.

It is the user's sole responsibility to ensure that the copy of the Specification is the current version as in use by Sydney Water.

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Acronyms

Acronym	Definition
ASME	American Society of Mechanical Engineers
BS	British Standard
CSM	Chlorosulfonated Synthetic Rubber
gsm	Grams per metre square
HDL	Hold Down Lugs
ITP	Inspection Test Plan
kPa	Kilopascal
mm	millimetres
MPa	Megapascals
PVC	Polyvinyl Chloride
QA	Quality Assurance
QC	Quality Check
RTP	Reinforced Thermoset Plastic

1. General

1.1 Scope

This Specification covers the design, supply, installation, testing and commissioning requirements for FRP Chemical Tanks at Sydney Water facilities.

The specification is to provide uniformity in the tank construction and design methodology and clarifying the requirements of the specification outside of the fabrication processes.

1.2 Exclusions

This specification excludes the following equipment:

- FRP ACF & BTF units
- FRP lined vessels
- FRP vessels subject to over-pressure or vacuum that exceeds those from wind loads or filling/draining operations
- FRP buried tanks, manholes or similar below ground structures
- FRP ducts, stacks and miscellaneous equipment
- Vortex structures
- Bespoke fabrications
- Safety harness restraint points
- Platforms, handrail, ladders & staircases.

2. Referenced Documents

Title	Document Reference (Section, clause)
Sydney Water Technical Specification Part 1	Civil Works
Sydney Water Technical Specification Part 2	Mechanical Works
Sydney Water Technical Specification Part 3	Electrical Works
All relevant Australian Standards including all those referenced in the above Specifications and Codes	
AS1170.0 – Structural Design Actions	General Principals
AS1170.1 – Structural Design Actions	Permanent Imposed and other actions
AS1170.2 – Structural Design Actions	Wind Loading
AS1170.4 – Structural Design Actions	Earthquake Actions
AS4586 – Slip Resistance	
AS1657 – Fixed Platforms walkways stairways and ladders	
ASME RTP-1 Reinforced Thermoset Plastic Corrosion Resistance Equipment	
BS4994 Design and construction of vessels and tanks in reinforced plastics	
BSEN13121:2016 GRP Tanks and Vessels for use above ground	

Unless noted specifically, any reference to standards is at the current revision, or last revision for discontinued standards.

3. Chemical Storage Applicability

3.1 Chemicals covered within this specification

The following chemicals are covered by this specification with the following concentrations within the temperature limit specified.

Where no specified resin is nominated by Sydney Water or where new chemicals or concentrations outside of the values given are to be considered, the specification can be used on the provision that the corrosion barrier design and resin system can be demonstrated as compatible with the chemical. This compatibility shall be supported by historical use and by confirmation of compatibility shall be obtained from the resin supplier. The resin suppliers support shall as a minimum specify the resin, the catalysation and promotion requirements with any post cure requirements as well as veil and backing layer construction. The confirmation must also confirm the resin's use under the maximum long-term design strain of the vessel.

Unless agreed otherwise by Sydney Water the pre-approved resin system shall be used, no "grey" imported resin systems may be used, and only those from the resin manufacturer's approved agents.

Chemical Name	Concentration	Maximum Temperature
Ferrous Chloride	20-30%	65°C
Ferric Chloride	30-60%	65°C
Ferric Sulphate	40-50%	65°C
Aluminium Sulphate	47%	65°C
Sodium Hydroxide	50%	65°C
Sodium Hypochlorite	10-30%	65°C
Sodium Bisulphite	25-40%	65°C
Hydrofluosilicic Acid	20%	65°C
Hydrochloric Acid	TBC	65°C
Sulphuric Acid	TBC	TBC
Acetic Acid	TBC	65°C
Citric Acid	TBC	65°C
Ammonium Hydroxide	TBC	65°C
Biocides	TBC	65°C
Anti-scalants	TBC	65°C
Liquid Polyelectrolytes	TBC	65°C
Magnesium Hydroxide	60%	65°C
Calcium Nitrate	50%	65°C

Chemical Name	Concentration	Maximum Temperature
Liquid Chlorine	TBC	65°C
Potassium Permanganate	TBC	65°C

Notes:

- For all strong acids and alkali chemicals the fabricator shall demonstrate that the selected resin system, cure system and manufacturing method does not excessively discolour the corrosion barrier nor discolour the stored chemical.
- All areas noted TBC shall be agreed between the project and the tank supplier.
- The design temperature for the tank may be lower the maximum temperature where it can be confirmed that the chemical is delivered, stored (temperature controlled or ambient) or processed in such that the maximum temperature is not exceeded. The design temperature shall maintain a suitable temperature buffer no less than 10degC between maximum expected temperature and the design temperature.

4. Chemical Tank Design

4.1 Design Standard

The design standard for Sydney Water chemical tanks subject to the requirements and permitted deviations within this specification shall be BS4994 1987 Amd1.

The specification of load cases and force/bending moments etc. from wind and seismic events shall be to the appropriate Australian standards.

A 50 year design life for wind and seismic loads shall be used.

The expected service life for the tanks design to this standard is expected to be a minimum of 20 years.

4.1.1 General Requirements

The design requirements of each tank are tabulated in the applicable design matrix. Each tank is defined by its contents and size, from which the design parameters that need to be met are given.

The matrix defines minimum requirements for each vessel based on size and chemical.

Where a chemical service is not covered within this specification Sydney Water will advise accordingly.

This specification interprets BS4994 requirement of “special consideration” within the design approach to mean a design supported by a full and competent Finite Element Analysis or testing of a prototype or the use of an alternative published design method or standard. The same structural design limits shall be maintained.

4.1.2 Project Specific Requirements

Sydney Water may apply additional requirements on any aspect of the design as it deems necessary. Those requirements shall wherever practical follow the design intent of the vessel in question. These requirements may take preference over some or all of this specification.

4.1.3 Design Factors

The design factors shall be as per BS4994. For short term loadings i.e. wind and seismic the overall design factor may be reduced to 4 for external tank attachments other than those which are safety critical i.e. platform supports. For main structural laminates the ultimate load cases shall be factored as per the appropriate Australian Standard. In the absence of a service factor the inverse of the square root of 1.5 may be used.

For the derivation of total design factor K, the following shall be used as a minimum:

K1=1.5, manual chopper gun application is not permitted
K2= As per chemical design matrix
K3= As per standard
K4=1.2, unless contradicted by the specific project application
K5=1.5, regardless of whether a full tank post cure is undertaken.

If a chemical design matrix is not specified, K2 shall be selected on the basis of the resin supplier’s corrosion guide information.

4.1.4 Load cases

Load cases to be considered are as per BS4994 Table 3.

The primary load cases are:

- Hydrostatic head
- Wind load - (external pressure, shear and bending moment)
- Seismic Load- (sloshing roof load, shear and bending moment)
- External Pressure – i.e. roof loading
- Nozzle loads

Secondary load cases need to be considered depending on site environmental conditions i.e. snow loading.

Maximum wind and seismic do not need to be considered simultaneously. Maximum wind speed or seismic loads and live roof traffic do not need to be considered simultaneously.

The hydrostatic head shall be taken at the specified media design density as per this specification or otherwise directed by Sydney Water. The design media height shall be taken as the invert of the overflow. For seismic analysis the nominal working volume derived height shall be used.

Permanent traffic loads on the roof should not normally be present. If permanent roof access is specified in the project specification as a minimum 2.5kPa shall be used. See Section 5.5 for roof loading.

Scrubbing systems, or extended vent systems should not be connected to the tanks. Designs should ensure vents are sized based on the combined outlet and inlet capacities. Where scrubbers and extended vents are fitted, as confirmed by the fabricator with Sydney Water, the design shall take into account the induced vacuum or overpressure.

Nozzles shall be protected from loading other than low magnitude plumbing loads are required by BS4994. All connecting pipework, valves etc regardless of material shall be supported. Where loads from pipes and or valves etc are present and cannot be avoided, the nozzles, flanges and tank structure shall be assessed and reinforced as necessary.

All design calculations shall incorporate the appropriate load cases.

4.1.5 Corrosion Barrier

This specification is intended primarily for the construction of a tank with a thermoset Vinylester resin based corrosion barrier as opposed to a thermoplastic corrosion barrier i.e. PVC. However, the structural requirements of the standard is still applicable, consideration of the construction of the tanks with a thermoplastic lining needs to be considered as per BS4994. All BS4994 QA requirements relating to the liner and its construction shall apply. Any fabricator constructing a tank using a thermoplastic liner must be able to demonstrate adequate welding capabilities and be able to demonstrate adequate bonding of the liner to the FRP structural laminate.

The minimum backing layers for the thermoset resin based corrosion barrier is 1200gsm of powder bound CSM. The veil type and quantity shall be as per the tank service matrix or in the absence of any specific requirement it shall be based on the recommendations of the resin supplier. The backing layer may be required to have a higher weight per square metre based on the resin supplier’s recommendations.

The strength and stiffness contributions from the corrosion barrier shall be removed from the calculations of tank strength and stiffness, so that only the structural laminate is considered to support stresses and resist buckling from operating loads. The weight of the corrosion barrier shall be accounted for.

The corrosion barrier shall be essentially free from entrapped air. The corrosion barrier (subject to veil type) shall be essentially clear and “glass like” in appearance. The phenomenon where the resin is affected by “foaming” i.e. the inclusion of microscopic air bubbles at a level where the clarity of the corrosion barrier is affected is not permitted. Tanks and or their components affected by foaming shall be rejected and not used. Where the corrosion barrier is obscured by the veil, it shall be demonstrated by the fabricator that the corrosion barrier is not subject to foaming and/or inclusions of large quantities of air bubbles even where they are below the maximum size permitted by the standard.

4.2 Design Competency

The fabricator may elect any person within their organisation or from an outside entity to provide the required engineering calculations. Any designer must comply with the relevant state codes and federal codes for the supply of engineering services.

The designer shall be suitably experienced as per Sydney Water’s Engineering Competency Standard (D0000833) and covered by Professional Indemnity insurance. Any insurance shall specify the designer by name. This insurance maybe the designer’s own insurance or as part of the fabricator’s insurance. Where tanks are supplied in-direct of the fabricator the insurance shall be in the name of the designer or the designer’s company. The designer nor the fabricator shall rely on the 3rd Party verification to re-engineer the design on-behalf of the fabricator or supplier.

All tank designs shall be supported by formal calculations covering all structural items/features of the tank. Where no formal calculations are required as designated by this specification, an in-house design record shall be kept. This record shall be a competent design assessment and be clear and readily understood if the design needs to be reviewed by Sydney Water or nominated representative. A design verification statement shall be supplied where specified.

4.3 3rd Party Verification

3rd party verification of vessel designs shall be undertaken by qualified (refer D0000833) and insured engineers with coverage in Australia and be registered with an organisation such as Engineers Australia or similar recognised body which shall be part of the Washington Accord.

Third party verification bodies or individuals shall have extensive experience in the design of FRP tanks and associated equipment and be familiar with the design, testing, installation, commissioning and operation of FRP vessels and equipment. In addition, the 3rd party verifier shall have experience across a wide range of standards, materials and manufacturing methods.

The 3rd party verifier shall if necessary during the verification, have the authority to set aside any design or formal calculation they deem insufficient or inappropriate. It will be the tank suppliers’ responsibility to improve or replace the design calculation to the satisfaction of the verifier.

All 3rd party verifiers shall be independent from any designer and from all fabricators or suppliers both financially and organisationally to ensure impartiality. Sydney Water shall wherever practical engage the verifier directly. A verifier or a designer (not both) from an organisation which has no relationship with any fabricator, maintainer, repairer of FRP equipment or supplier of same or similar equipment may be used at the discretion of Sydney Water.

4.4 3rd Party Inspection

The standard number of inspections for any single standby/emergency tanks of less than 2500 litres is one. For larger tanks the minimum requirement shall be two or three as per the tank specification matrix. Where multiple tanks are fabricated by the same fabricator within an appropriate timescale, vessels shall be co-ordinated to economically undertake the inspections.

Where hydrotesting has not been specifically requested by Sydney Water to be undertaken prior to delivery, the final inspection shall be of the completed tank prior to flow coating.

Any third-party inspector shall have sufficient experience and competency not to rely on the guidance of others to be able to undertake the inspection to a sufficiently diligent level.

The inspector shall not be considered as being in replace of the fabricator's QC personnel and shall be able to interpret any aspect of the tank to ensure that the technical requirements of the specification are being met. The onus is on the fabricator to manage their own work and as such the fabricator shall complete all repairs prior to the final inspection. Where advice is sort from the inspector the fabricator shall indicate all areas of the tank in question prior to the inspector's arrival.

The inspector's role is not to undertake the inspections that are part of the fabricator's QA/QC responsibilities.

Inspection & Test Plans shall be approved prior to the beginning of fabrication by the nominated inspector. A review of the MDR shall be made by the inspector to ensure compliance with the record and reporting requirements of the ITP and BS4994. The review and acceptance of an ITP cannot be excluded from the inspector's scope by any contractor/supplier/fabricator without the approval of Sydney Water.

The engagement of an inspector does not absolve the purchaser (i.e. contractor supplying the tank on behalf of Sydney Water) from undertaking their own inspections or audits when determining the tank supplier/fabricator is fit to fabricate the tank to the specification and the contractual requirements. Consideration of past performance of a supplier across the Sydney Water business shall be made.

5. Tank Construction

The specified BS4994 design standard shall be implemented however particular features of the tanks shall meet the following additional requirements.

The use of stainless steel or other metallic components (other than fasteners) whose durability maybe affected in the case of a spillage, i.e. in locations where contamination may not be readily seen, shall not be used, and alternative materials used in replacement of the metallic components.

5.1 Hold Down Lugs

Hold Down Lugs (HDLs) may be either of the types listed below.

- FRP U Shape
- Metallic Lug

For large diameter tanks >6m the use of metallic clips to resist the overturning moment and shear loads may be used with the agreement of Sydney Water.

All FRP HDLs shall be designed such that they have sufficient inherent strength that they do not rely on external backing plates (regardless of material) or similar to carry or transmit the required loads from the anchor bolts to the HDLs with the minimum level of safety.

All HDLs shall be designed in accordance with ASME RTP-1 to ensure the attachment of the bracket and its effect on the tank is considered adequately. The size and construction of the HDL is by the vendor.

BS4994 minimum lug spacing, or quantities need not apply provided the design method of ASME RTP-1 is adhered to.

Secondary bonded FRP U shaped HDLs are Sydney Water preferred.

HDLs are to be located away from nozzles and manways are as far as practicable. Where a clash between a HDL and a nozzle is unavoidable then the HDL may be moved to the minimum possible distance but must maintain a sufficient clearance that any nozzle compensations/attachment laminates are not overlaid by HDL lugs, or the HDL attachment laminates or pads. Where a relocation of a HDL is necessary after the tank process designers have concluded under practical examination of the requirements for the satisfactory installation of the tank that the clash cannot be avoided, the tank designer shall confirm the adequacy of the design of the HDL in the new location. HDLs must not be modified, i.e. cut short or profiled in any way unless specific design analysis demonstrates that the HDL is sufficiently adequate.

FRP HDLs shall be laminated such that the internal and external laminate plies are continuous. The assessment of the HDL foot under maximum anchor loads shall be as a wide beam supported at two ends with a centrally located concentrated load. The assessment shall take into account the loss of material from the bolt hole.

The top of the lug shall be a minimum of 75mm wide. The bottom of the lug shall have a minimum clearance of 10mm to the tank base elevation. The top face of the HDL plate shall be no higher than the tangent point between the knuckle radius and the shell.

Where HDLs extend above the knuckle of the vessel, or where the basic knuckle thickness is insufficient, local pads may be used to give the required thickness for the lug design. These pads shall comprise of CSM and WR layers only and shall be to the ASME RTP-1 Type 2 designation. The pads shall extend past the attachment laminate by a minimum of 75mm (excluding a 1:6 Taper) and above the lugs by 75mm (excluding a 1:6 Taper).

Metallic HDLs shall be 316 stainless steel of an L shape and comprise lock bars to facilitate the mechanical connection with the attachment laminate. The design of the metallic anchors may include a hole for the anchor bolt or for highly loaded anchor points, cleats shall be provided.

The designer shall consider the metallic components design and limit the induced stress to less than 0.8x yield strength of the metal lug or weld details under ultimate load conditions.

All welded components shall be accompanied by the necessary level of QA/QC documentation. This will include as a minimum:

Material property certification i.e. Mill Cert.

Welding records, including welder certification

Weld inspection record

Where the storage of the chemical may have deleterious effect on metallic lugs if spilled, FRP lugs shall be used.

Anchor bolt loads shall be reported on the drawings submitted for approval to Sydney Water and/or its nominated contractor for vessels 2500L or greater working capacity or on request by Sydney Water or their nominated representative.

5.2 Lifting Lugs

Lifting lugs may be one of three types:

- Vertical triangular FRP design
- Metallic trunnion
- Qualified rotating pad eyes

The use of flat plate lugs are not permitted, unless authorised by Sydney Water and these may only be used on tanks subject to direct vertical lift only and less than 400L in volume.

All lifting lugs shall be attached to the vessel wall below the roof knuckle tangent point or directly under the upper flange if the top is removable.

The location of lifting lugs shall be orientated to prevent lifting strops coming into contact with nozzles/manways/brackets etc during lifting operations.

The design of the lugs must take into potential tank weight error (min 10%), dynamic "snatch" loading (min 1.5) and a minimum slinging factor of 0.75 to generate a WLL for the lugs. The slinging factor will vary depending on the proposed lift plan. This must be painted on the vessels immediately adjacent to each lug. .

All lug designs shall be backed up by a suitable and independently verified test demonstrating that for a particular type of lifting lug design the fabrication method is appropriate, where required by site specific or contractor specific requirements.

The number of lifting lugs per vessel size is given in the appropriate vessel specification matrix, where the number of lugs are not given, the preference is for 3 lugs for any vessel over 500kg. 4 Lugs may be fitted for larger tanks, any lift plan using 4 lugs must include the use of equalising sheaves and spreader bars, the lifting plan must be agreed with the fabricator/designer and the installer.

5.3 Sumps, Nozzles, Manways & Bracketry

5.3.1 Sumps

No vessel shall be designed with a sump. Should full drainage be required a false floor shall be designed and fitted. A raised floor shall not form the primary envelope of the tank and shall be fitted internally. Due care in the design of the floor and its edge overlays to account for the deflection of the vessel under load. Any infill material shall have a suitable parallel to the load compressive strength 4 times greater than the maximum design hydrostatic head. The false floor shall comprise of a corrosion barrier and be backed by a minimum of 3mm of laminate with a minimum glass content of 1350gsm CSM. The design of the false floor shall use the same design strain and Factors of Safety as the vessel.

5.3.2 Nozzle Design

All nozzles (excluding Manways) must be designed to the maximum hydrostatic pressure of the vessel or 200kPa, whichever is greater, subject to the minimum thickness requirement of BS4994. Roof nozzles must be designed to a minimum of 100kPa.

Process nozzles must not be less than 50mm internal diameter. Flanges shall have a minimum structural flange thickness (i.e. not including the corrosion barrier) of 12.5mm. Non process nozzles, i.e. instrumentation or tank gauges, must not be less than 25mm internal diameter.

Nozzles may be filament wound or hand laminated and shall be fabricated with the same resin as the corrosion barrier.

All nozzles in the shell less than 150NB and all nozzles in the roof with the exception of the roof vent shall be of the penetration type.

All nozzles shall be of a one piece construction and must not have extensions attached to create the necessary required length.

The gusset requirements of BS4994 must be adhered to, plate gussets or conical gussets (preferred) are to be fitted as per the standard or where nozzle loads are present and may terminate at the hub radius.

The flange design must be suited to the type of connection intended for the installation of the tank. Therefore the default flange type for process nozzles must be stub flange with a stainless steel backing ring. Full face flanges are to be used where the intended connection is also full face. If in doubt the tank specifier must specify stub and backing ring. Stub and backing ring design must follow the BSEN13121 method using the BS4994 allowable material stress.

Alternative design methods based on satisfactory historical use may be used providing the allowable stresses in the FRP and backing ring are not exceeded. The stub flange is to be laminated integral to the nozzle for nozzles of 150NB of less. Nozzles greater than 150NB may have non-integral flanges. The use of adhesively bonded stub or filament wound stub flanges is prohibited. The minimum backing ring thickness is 10mm, all backing rings must make uniform contact across the back of the stub flange, must be free to rotate and shall not bind on the hub or hub radius. Restraining lugs must be installed on the nozzles to prevent excessive movement of the backing ring from sliding and damaging the nozzle coating. A maximum serviceability design stress of 138MPa must be used in the design of the backing ring. For full face flanges, the design maybe to either BS4994 or RTP-1. Regardless of design method or the type of flange the minimum external laminate of 1200gsm of CSM must be continuous from the flange edge to the top of the hub. A minimum of 50% of the flange structural thickness must be continuous across the flange and up the hub. The maximum design stress for RTP-1 full face flange design will be based on the BS4994 conditions

and shall have the same factor of safety as the rest of the tank. Flange bolt stress shall be limited to a maximum of 138MPa.

For full face flanges, all washer seating shall be sufficiently flat to allow the washer to be in full contact with the flange and the bolt to remain perpendicular to the flange face. When spot facing is required, minimum material removal shall be achieved. The nozzle faces shall not be machined in any way other than localised spot facing.

Design and maximum bolt torques shall be noted on the drawings.

5.3.3 Manways

To improve the safety of fabrication, inspection and repairs all tanks greater than 1800ID shall have a 600mm manway fitted. The manway shall be located at a suitable height to allow for ease of access and to ensure its installation complies with this specification. For tanks between 1350ID and 1799ID a 450mm manway shall be fitted. For tanks below 1350ID the roof of the tank shall be flanged to permit removal and have a top inspection port of between 300mm and 450mm depending on the amount of room available in the roof.

All manways shall be located such that they are at a suitable height for entry and shall be flush with the inside of the vessel. The manway nozzle shall be a minimum of 5mm thick excluding the corrosion barrier and shall be fabricated from the same resin as the corrosion barrier. The design of the manway nozzles shall be in accordance with the design standard. The closing plate shall be designed either as a flat plate or as a domed cover. The minimum design pressure for flat closing plates is 100kPa or the tank hydrostatic design pressure whichever is greater. Domed closing plates may be designed to BS EN13121:2016 but retain the same strain and Factors of Safety as the vessel according to BS4994.

All manway closing plates shall be fitted with two number lifting handles and where requested provision for a davit to support the plate during removal and installation.

All manway covers shall have the same corrosion barrier as the vessel.

Where davits are required, special consideration for its attachment shall be undertaken and as a minimum take into account the applied loads on both the davit attachment laminate and the vessel. As a minimum this will include secondary bond shear stress, cross laminate shear stress, peel and tensile loads.

The design of the Davit shall be to the appropriate Sydney Water Specifications and Australian standards where applicable.

5.3.4 Bracketry

All external bracketry shall be suitably and detailed for the intended purpose and suitably designed where significant loads are applied. Any assessment of the loads and the laminate shall include as a minimum overlay bond strength, peel strength tensile and compressive strength and buckling.

For internal brackets, all surfaces subject to the media shall have a corrosion barrier. Any internal components shall be constructed from the same resin as the corrosion barrier. Buoyancy and hold up loads shall be considered.

5.3.5 Internal Overlays

All internal overlays relating to the joints between sections of the tank and nozzles and internals shall be subject to the following requirements:

Maximum deviation between the shell and the base/roof for butt joints shall be 6mm in both the horizontal and vertical directions.

The hole provided in the shell to accept a penetration i.e. nozzle shall a maximum annulus of 6mm.

All internal overlays shall have an additional CSM sealing laminate applied in addition to the required minimum internal overlay (see section 5.4).

All overlays for each aspect of the tank fabrication i.e. joint or nozzle etc shall be separate overlay laminates and shall not be combined.

Any deviation between the shell and base and/or roof profile shall be filled with CSM layers to bring the edges within 6mm. This shall be suitably profiled to generate a smooth surface onto which to apply the internal overlay. Any infill shall be tapered at 1:6. The use of putty or filler shall be minimal to fill fabrication assembly holes or to remedy minor deviations.

The grinding area for internal overlays shall be kept to a practical minimum. All grinding marks shall be covered by the specified overlay. The most extreme edge of the ground area no more than 5mm wide may be coated with just a top resin coat. All other grinding marks less than 0.5mm deep shall be covered with the specified veil. Grinding deeper than 0.5mm shall be covered with the internal overlay laminate.

Care shall be taken beneath nozzles to ensure the overlay does not sag and generate voids.

All internal overlays shall have a suitably paraffinated and catalysed “hot coat” that is compatible with the tank service conditions.

5.3.6 Compensation

Any compensation required by the design shall be between two and three times the diameter of the nozzle ID as per BS4994. The compensation shall be applied to the required laminate construction thickness to the extent of the design compensation diameter before tapering.

The use of compensation plies to form the nozzle attachment may be permitted as per BS4994.

All non-circular penetrations shall conform to the limits of the standard. Rectangular openings are not permitted unless special consideration is applied.

Where the shear strength of the compensation pad is exceeded the preference is for interleaving the additional plies to ensure the allowable shear strength is not exceeded.

Other than Sodium Hypochlorite service, Sodium Hydroxide or Sulphuric acid service, the compensation may, if required by the design shear limit, be split internally and externally. The amount applied internally shall be the minimum necessary to meet the shear strength requirements but not exceed one third of the total compensation requirement. Where this cannot be achieved the shell must be redesigned to increase the shell’s inherent strength. The corrosion barrier between the structural laminate and the internal compensation shall not be considered part of the compensation. The internal compensation shall be the same diameter as the external compensation. The internal compensation shall use the same resin as the corrosion barrier and comprise only of CSM layers.

Compensation laminates may only be completed after all other structural joints, i.e. knuckle of shell joints, in its vicinity have been completed. Secondary bonding of brackets, HDLs etc must be performed after the compensations and attachments are completed. The use of other external laminates, i.e. knuckle laminates, joint laminates etc, to form compensation pads either in full or in part is prohibited.

Design calculations shall demonstrate the adequacy of any internal compensation.

5.3.7 Nozzle Attachment Laminates

All nozzle attachment laminates must be the same thickness as the total thickness of the nozzle or greater if required by the design. Attachment laminates must be dimensioned as per the standard and must be the same diameter as the compensation.

Attachment laminates may only be completed after all other structural joints have been completed in its vicinity.

The use of other external laminates i.e. knuckle laminates, joint laminates etc to attach nozzles and/or gussets either in full or in part is prohibited.

5.3.8 Heaters, Agitators and Ancillary Equipment

Where agitators are specified, the weight and torque of the agitator shall be taken into account. Baffle design shall have the same factors of safety as the tank. The natural frequency of the tank and the agitator shall be checked and the tank redesigned if the agitator causes the tank to resonate.

Where heaters are fitted localised thermal affects and the weight of the heater shall be taken into consideration. Where the heater thermal control allows the heater to exceed the design temperature of the tank, the nozzle shall be designed for the higher temperature.

Adequate clearance shall be maintained around the heater including the penetration nozzle. The minimum annular clearance shall be 25mm unless advised otherwise by Sydney Water or confirmed by the heater supplier. The heater shall be supported to minimise loads on the vessel.

Miscellaneous equipment and their affects shall be taken into account in the vessel design, additional reinforcement through compensation pads, gussets etc shall be employed as appropriate.

5.4 Laminate Construction

Only Vinylester and Isophthalic resin systems may be used. Unless the proposed resin by the resin supplier has been specifically developed for the tank contents. Orthophthalic polyester resins are not to be used for any tanks designed and supplied under this specification. Any resin must have an elongation at failure of greater than 2.0%.

All laminates shall have a glass content within the range specified in the standard.

Corrosion barrier backing layers shall use ECR glass only. CSM used for the corrosion barrier shall be powder bound only. The corrosion barrier must use a suitable vinylester resin.

For CSM only 450gsm material weight may be used. For woven rovings only 800gsm material weight may be used.

Combination mats that are supplied pre-stitched may be used providing that they comprise 450gsm CSM and 800gsm Woven rovings and do not exceed 1350gsm in total glass weight. Any combination mat ply or woven roving ply must be laminated onto a wet CSM layer and must finish on a CSM layer, laminating onto a pre-gelled or cured Woven layer is not permitted.

Stitched (non-crimp) biaxials of any weight can be used providing they are accounted for in the design and may have different warp and weft weights. Woven biaxials of unequal warp and weft weights are not permitted. Woven biaxials of equal warp and weft shall be treated as woven roving for design purposes.

Tank designs that require filament winding or biaxial laminates shall incorporate a random mat layer to prevent bridging behind the corrosion barrier. This may be accomplished using a 450gsm CSM layer which may be counted as structural in nature. A chopper gun based layer that is machined controlled and gives uniform coverage may be used. Manual chopper gun application may be used but must be excluded from the structural analysis of the tank. However, the weight of the layer must be included as appropriate by the designer.

All nozzles shall be laminated into the shell by a reinforcement layup inside (additional to the corrosion barrier) as per below to insure against leakage.

Minimum reinforcement:

< 150NB	t_3 = 2 x 450 g/m^2 CSM
150NB - 400NB	$t_3 \geq$ 3 x 450 g/m^2 CSM
> 400NB	$t_3 \geq$ 4 x 450 g/m^2 CSM

All reinforcing shapes and members shall be laminated as primary bond. Secondary bonding will not be accepted.

5.5 Tank Roof Design

The tank roof may be pitched (min 15deg) or domed as required by the project. Flat roofs are not permitted unless specifically authorised or requested by Sydney Water.

Tank roofs are by default non-trafficable. However, the roof shall be checked for strength and buckling for a 1.5kN point load (over an area 300mm diameter at the worst case location) and a 1.5kPa UDL for access purposes.

Roofs shall be indicated as non-trafficable in an appropriate number of conspicuous places in a contrasting colour to the flowcoat. The lettering shall be of sufficient size to be easily readable from ground level.

Where requested for permanent roof access is requested by Sydney Water the minimum design shall be 1.5kN concentrated load (over an area of 300mm diameter) and a minimum of 2.5kPa UDL unless a higher value is stated by the specification.

Where the roof is accessible suitable provision for handrail/guardrail and ladders shall be made. Non-slip coatings shall be employed as appropriate. Trip hazards shall be kept to a practical minimum.

Internal support for flat roofs for tanks may not be used..

5.6 Tank Base Design

The minimum total thickness of a flat based tank shall be as follows:

- <2m Internal Diameter = 6mm
- >2m<3.5m Internal Diameter =7mm
- >3.5m Internal Diameter =11mm

All bases shall comprise CSM and a minimum of one layer of woven roving for every 5mm of total design thickness.

All tank bases shall be uniform and flat and free from high spots or an undulating edge. The flatness of the tank shall ensure that the knuckle is continuously supported. Oil canning of the base is permitted up to the thickness of the base laminate.

Where raised tanks are specified or flat-bottomed tanks on a distributed support, the tank base/bottom shall be designed as per BS4994.

Plywood is not permitted as a core for any laminate that is of a sandwich construction or infill.

Any tank that is supported on a skirt shall be designed such that the skirt is located vertically in line with the tank wall. Any cut-outs in the skirt shall be considered for axial strength and stability as per BS4994 and any compensations designed and installed as necessary. Special consideration methods maybe applied as appropriate.

5.7 Knuckle

The knuckle shall be constructed as per the standard. The base knuckle shall incorporate a vertical straight section not less than 75mm. The base wall to shell transition shall be uniform and shall be free from localised bulges or sudden changes in thickness and shall be vertical. Any assembly tabbing shall either be uniform and tapered at 1:6 or longer or removed and replaced with the structural laminate. Tapered or flared bases or shells are not permitted other than a small angular draft to facilitate removal from the tool. Any residual taper after completion of all structural laminates shall be mostly indiscernible by eye.

5.8 Roundness

The tank shall meet the requirements of BS4994 with respect to roundness.

Roundness tests shall be conducted on the mandrel (where used) or on the corrosion Barrier “gelsheet” (where used).

The roundness check shall be conducted to ensure that no vertical crease lines are present within the tank. The definition for this specification is a localised deviation from a cylindrical profile that may not exceed the permitted roundness limits.

This check shall be part of the ITP and shall be considered a HOLD point for the fabricator and a review point for the inspector. Where a crease is discovered in the corrosion Barrier, a local build up using CSM either side of the crease line shall be undertaken to “re-round” the vessel, so as to make the deviation visually indistinguishable. Any build up action shall be recorded. The vessel profile after re-working must still meet the stated tolerance in BS4994.

The presence of a vertical crease line in the structural laminate of a tank shall give cause for the tank shell to rejected, regardless of the tank intended content or the completion status of the vessel.

If the tank is horizontal the presence of a crease in either the hoop or axial direction shall be cause for rejection of the vessel shell.

5.9 Flowcoating

Flowcoating shall be undertaken on all vessels to the agreed colour once approval from the inspector (as per the specification matrix) has been granted in writing or from Sydney Water.

Flowcoating shall be applied in as many layers as necessary to ensure an even coating when viewed from the inside (unless prevented in doing so by the presence of an opaque corrosion barrier.

The coating shall prevent as far as practical the passage of light into the vessel and provide adequate weathering and UV protection. Externally the coating shall be uniform and free from major drips, runs and foreign matter. Flowcoat shall cover all external faces of the vessels including flange edges. The flowcoat shall be system specifically formulated to provide the required protection i.e. Iso-NPG. A standard pigmented resin is not to be used.

Flange faces shall be clear of any flowcoat. Layers of excess flowcoat shall be avoided around penetrations, lugs etc.

Washer seating areas shall be uniform and free of localised build ups, similarly all nozzle bolt holes shall be free of excess flowcoat. Hold down lugs holes and FRP lifting lug holes shall be adequately covered.

5.10 Post Curing

All vessels shall be post cured in accordance with the resin suppliers' instructions and shall be for a minimum of 4hrs at 80DegC. Where post curing temperature or duration differs from that specified, the recommendation of the resin supplier shall be followed. Lower (but not less than 65DegC) post cure temperature maybe used with significantly extended duration. Any variation in post cure temperature and duration must be supported by a recommendation from the resin supplier. If the recommendation does not permit a change in the temperature and or duration and alternative means of post curing shall be employed.

The post cure duration shall be started from the point the full thickness of the corrosion barrier has reached the required temperature and as such the temperature measuring point shall be specifically located to represent that the condition has been met.

The tanks shall be cured upon completion. Staged post curing maybe used. Vessels if assembled on site shall use the minimum number of joints, all internal overlays shall be post cured with a suitable system that assures that the temperature and time of the post cure can be achieved i.e. heat lamps.

When post curing due consideration for the rate of heating, size and thickness of vessel laminates and surrounding air temperatures.

A record of the post curing shall be made.

5.11 Factory Hydrotesting

Hydrotesting the tank upon completion is not required, unless specifically requested by Sydney Water. Where requested the hydrotest shall be undertaken with water up to the overflow level for a period no less than 1hr. When the hydrotest is performed by the fabricator it shall be witnessed by the 3rd Party Inspector or nominated Sydney Water representative. The use of standpipes, etc, to increase the water pressure to simulate higher density media is only permitted when the tank has been specifically designed and fabricated to withstand the additional loads on the roof, shell, HDLs and any affected components or details. The adequacy of the design must be detailed in the full design calculations. The loads must be assessed with the calculated factors of safety. Wind and seismic loading need not be considered for hydrotesting.

The fabricator shall ensure that when Sydney Water undertakes the commissioning of the vessel which may include a water based hydrotest, suitable resources of personnel and appropriate materials are available to undertake any unforeseen repairs within 48hrs (or as agreed by Sydney Water) of the vessel being made available for those repairs.

5.12 Horizontal Tanks

Horizontal tanks shall be designed to BS4994, however aspects of the nature of horizontal tanks not covered in BS4994 shall use the method from BS EN 13121. The laminate design shall be to the BS4994 standard.

All vessels shall have two,120deg saddle supports which shall be FRP.

5.13 Tank Marking

The tanks shall bear any required warning, marking etc as required by Sydney Water or state, or federal regulations. These markings shall include, but limited to:

- Lifting Lug WLL
- Confined Space Entry
- Roof Access Limitations

Every tank shall have a durable 316 stainless steel etched nameplate as per BS4994.This name plate shall include, but not limited to:

- Equipment/ Tank No.
- Tare Weight
- Working Volume
- Tank Content by name and concentration
- Design Density
- Design temperature
- Design pressure(s)
- Corrosion Barrier resin & curing system or type if thermoplastic material is used.
- Structural resin & curing system
- Tank Design Code
- Wind Code & revision
- Seismic Code & revision
- Manufacturer
- Build Date (Month & Year)
- Inspection Authority
- Warranty Expiration date (Month & Year)

Additional provision on the tank plate shall be marked “Inspection Date” to allow for the engraving of future inspection dates on the plate. The area shall permit the engraving of day, month and year in the format “XX/XX/XX” in 12mm high letters. The area shall permit a minimum of 5 records to be entered.

The plate shall be affixed to a raised bracket or thickened pad laminated to the shell of vessel above the manway or other conspicuous location.

6. Installation

6.1 Tank Bedding Requirements

All tanks shall be placed onto a suitable foundation free from uneven settlement and shall provide uniform support under the tank knuckle and base. Suitable foundations may be by concrete plinth with a maximum deviation of 1.5mm/m. Alternatively a concrete plinth with a grout or suitable incompressible medium to support the tank. Compressible felt material may not be used. DHL's shall be anchored.

Field assembly of tanks is not permitted.

6.2 Lifting & Handling

A lifting and handling plan shall be provided by the fabricator to aid the moving of the vessel. The fabricator shall be responsible for ensuring transport tie-down advice is available to the transport company and Sydney Water.

The fabricator shall keep a photographic record of the tank(s) on dispatch. This shall include both side and end views after completion of the tank tie down onto the vehicle.

The fabricator shall provide all reasonable remote assistance to Sydney Water and/or the contractor during the lifting/moving of the vessels.

6.3 Commissioning

Commissioning of the tanks shall be by Sydney Water or nominated contractor. The fabricator shall provide all reasonable assistance to Sydney Water and/or the contractor during the commissioning.

Commissioning of the vessel will include hydrotesting. The fabricator shall ensure that suitable resources of personnel and appropriate materials are available to undertake any unforeseen repairs with 48hrs (or as agreed by Sydney Water) of the vessel being made available for those repairs to take place.

The hydrotest shall be undertaken with water up to the overflow level for a period no less than 1hr.

The use of standpipes etc to increase the water pressure to simulate higher density media is not permitted.

6.4 Pipe Loads and Connections

Tank nozzles shall be free of any significant loads, unless specified and due consideration must be undertaken See Section 4.1.

Full face FRP flanges shall not be connected to raised face flanges. All gaskets must be full face. The use of gaskets promoted as being specifically for FRP full face to raised face flanges shall not be used. Where connections must be made to equipment with raised face flanges a metallic adaptor plate maybe used of suitable material and stiffness. The preferred remedy is to fit tank nozzles a stub flange and 316 stainless steel backing ring. The flange and ring shall be designed accordingly.

7. Quality Requirements

The QA/QC requirements are stated in BS4994 Table 4. The requirements of this table shall be met unless indicated otherwise within this specification.

7.1 Inspection & Test Plan

The fabricator shall generate and submit for approval an ITP for every tank. The ITP shall consider each structural component and assembly tasks in sufficient detail to facilitate the QA/QC process.

An example ITP extract is given in Appendix A.

The fabricators' ITP shall have the same level of detail, or greater, as the example subject to specific tank requirements.

7.2 Manufacturing Data Record

On completion of the vessel the MDR (Manufacturing Data Record) shall be submitted to Sydney Water and/or nominated contractor upon delivery or a maximum of two weeks after completion of the vessel whichever is earlier.

All MDR's shall contain but not limited to the following:

- Fabricators Statement Of Compliance
- Design Verification Statement
- Design Calculations
- Drawings Issued For Construction
- As-Built Drawings (as Appropriate)
- Raw Material Conformity Certificates
- Purchased Items Conformity Certificates (including FRP components manufactured by the same company at a different site)
- Material delivery dockets
- Laminating Records
- Inspection Records
- NCR's
- Material Test Certificates
- Burn-off Construction Analysis Record
- Calibration records for testing equipment i.e. Barcol Hardness Tester.

All MDR's shall be marked "Commercial-In-Confidence".

7.3 Material Testing

All laminates used in any part of the tank shall be supported by test reports showing compliance with Table 5 of BS4994. These tests shall be undertaken at the ply level, i.e. CSM, Woven Roving etc and not on complete tank laminates.

Testing is required for the specific combination of glass reinforcement (and type if appropriate, i.e. Powder bound 450gsm CSM) and resin (by name i.e. Hetron 922). All test results shall be no older than 12mths, and the tests undertaken by an independent NATA approved test laboratory accredited to undertake the specific tests, or other independent accredited test house approved by Sydney Water.

The tests shall include as per BS4994 Table 4

- Tensile Strength
- Tensile Modulus
- Lap Shear Strength

The tests results shall demonstrate compliance with Table 4. Where the properties are not sufficient, the fabricator shall re-evaluate their materials and processes and make appropriate changes and re-test. Compliance shall be based on the lowest tested value from the tensile sample size (usually 5) meeting or exceeding the minimum value stated in Table 4 for the material under test.

If a fabricator is unable to meet the requirements of Table 4, the fabricator cannot begin the fabrication and shall be considered not competent to undertake the manufacture of the tanks to this specification.

Test values above the requirements of Table 4 are not permitted to be used in the design. Minimum property values are to be employed.

Production test samples are not required unless specifically requested by Sydney Water.

Burn-off testing of a sample cut-out to demonstrate the shell laminate has been completed to the design shall be undertaken, the design report shall include a photographic record of the laminate sequence and actual ply weights calculated from the sample.

7.4 Cross Laminar Shear Strength

It shall be assumed for design purposes the ultimate cross laminar shear strength for CSM or WR or combination is 50MPa before the application of the required factor of safety. Cross laminar shear strength parallel to the fibre direction for unidirectional shall be assumed to be zero, and 50MPa before the application of the required factor of safety, perpendicular to the fibre direction.

7.5 Record Keeping

Tank Fabrication records and tank cut-outs shall be retained for a period of 7yrs. These records shall be made available to Sydney Water on request within a reasonable item frame. After 7yrs the fabricator may elect to keep the records indefinitely (min 10yrs) or send to Sydney Water.

8. Extended Warranty

The normal minimum warranty shall be 12mths backed up a contractual retention as agreed between the fabricator/supplier and Sydney Water.

An extended warranty period for all vessels shall be agreed between the fabricator/supplier and Sydney Water from the time of completion of the vessel, in addition to the minimum 12months.

The extended period shall be as follows:

Sodium Hypochlorite service – 3yrs (total 4yrs)

Sodium Hydroxide service – 5yrs (total 6yrs)

Sulphuric Acid service – 5yrs (total 6yrs)

All other service tanks – 6yrs (total 7yrs) Or as agreed.

This warranty shall remain in place regardless of future minor modifications i.e. additional nozzles etc providing that such modification does not initiate or lead to any failure within the tank, unless those modifications are undertaken by the original fabricator or its authorised representative.

All modifications from the original design undertaken after commissioning shall be supported by suitable design calcs and drawings. The modified parts shall be marked after flowcoating by the addition of a pin strip of a contrasting colour painted onto the modified part i.e. around a nozzle. This marking shall be sufficiently conspicuous to aid identification.

The warranty shall also remain in place if the tank if the tank is re-purposed to a new site or location with the same or lower wind/seismic loads or for use with the same media with the same or lower density, the same media with the same or lower operational temperature or same or lower chemical reactivity (i.e. 15% Hypo to 12.5% Hypo) and is within the resin suppliers service recommendations.

Changing media service is subject to agreement between the supplier, Sydney Water and the resin supplier and will be based on suitable chemical neutralisation and decontamination procedures to remove diffused chemical components from the laminates.

Modifications to the warranty duration, starting date or terms may be modified by Sydney Water as required.

All vessels shall be supplied with a maintenance plan and check list relating to items that the fabricator considers critical to being checked to maintain the warranty. Acceptance or rejection of these recommendations is at the sole discretion of Sydney Water.

Ownership

Ownership

Role	Title
Group	Water and Environmental Services
Owner	Engineering Manager
Author	Jason Smith, Senior Mechanical Engineer, Engineering and technical Solutions
BMIS Number	D0000824

Change history

Version No.	Prepared by	Date	Approved by	Issue date
2	Jason Smith	15/05/2026	Norbert Schaeper	15/05/2026
1	Jason Shawpan, Project Engineer Mike Leggett, Oceania Composites Engineering	1/06/2018	Daryl Gilchrist	1/06/2018

Appendices

Attachment	Title
Appendix 1	ITP Example
Appendix 2	Tank Design Matrices

Appendix 1 ITP Example

INSPECTION AND TEST PLAN

Document No. XXXX-XXXX
Issue Date: 01/01/18

R - Review Document
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ITP No.: 001 **Quality Std**: ISO9001 **Revision**: A

Project Name: Sydney Water Replacement Tank **P.O No.**:

Manufacturing Location: Australia **Drawing Number**: **Applicable Standard**: BS4994 (Cat 1)

3rd Party Surveillance: TBA

Inspection Activity Type and Verification

Factory **3rd Party**

No.	Activity	Test and/or Inspection	Standards & Procedures	Verifying Document	Acceptance Criteria	Rev	IP	Sign	Date	IP	Sign	Date	MDR CHECK
1.0	**DOCUMENTATION**												
1.1	Contract Review		Factory Quality Manual				R						
1.2	Specification & Standard Review		Factory Quality Manual				R						
2.0	**PLAN & DESIGN**												
2.1	Inspection and Test Plan	ITP Approval	Client Specification / BS4994	ITP	Client and QA sign-off		H			H			
2.2	Review of Laminator & Operator Experience	Procedures and Training Records	BS4994	Personnel Records	History and Experience in relevant Fabrication techniques		R			R			
2.3	Measurement Equipment Calibration	Verify calibration records	Factory Quality Manual	Doc QA/CALIB/01	All relevant measuring equipment calibration is current		V			R			
2.4	Design/Design Review	Review design outputs against Client Contract and specs.	BS4994-Cat I & Client Specification	Design Calculations and Fabrication Drawing	All requirements covered and 'Approved for Construction' sign-off		R			H			
2.5	Fabrication Drawings/Review	Drawing Approval Review	BS4994-Cat I & Client Specification	3rd Party Review/Client Approval	Client Approved, Signed and dated		H			H			
3.0	**MATERIALS**												
3.1	Materials Receivable	Validate Material Certificates	Client Specification	Batch Certificates / Sunny Doc QA Record	All materials supplied are issued with conforming certificates		S			R			
3.2	Resin Gel Test	Resin Batch Test	Factory Quality Manual	Sunny Doc QA Record	Manufacturer's Data & COA		S			R			
3.3	Parts Receivable	Validate Material Certificates/MDR	Client Specification	Batch Certificates / Sunny Doc QA Record(a)	All parts supplied are issued with conforming certificates		H			R			
4.0	**SHELL**												
4.1	Prepare Mandrel	Free from Defects / Clean	Factory - Quality Plan	QA Record No. AAA	BS4994 (30.1) / SWC Spec Section X		H			R			
4.2	Madrel Roundness Check	Mandrel Is Round with no obvious crease	Factory - Quality Plan	QA Record No. AAA	SWC Specification		H			R			
4.2	Laminate CB	Ensure Laminating has complied procedure QA & BS4994	Factory - Quality Plan	QA Record No. XXX	All laminate layers recorded for traceability.		R			R			
4.3	Check for Crease	Check roundness and presence of crease	Factory - Quality Plan	QA Record No. YYY	Modify profile as required and record details		H			R			
4.4	Laminate Structure	Ensure Laminating has complied procedure QA & BS4994	Factory - Quality Plan	QA Record No. DDD	All laminate layers recorded for traceability.		R			R			
4.5	Inspect Structural Laminate	Structural Layer Visual Inspection	Client Specification / BS4994 / Factory Quality plan / Ultrasonic / QA	QA Record No. ZZZ	BS4994 Table 16		S			S			

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Project Name: Sydney Water Replacement Tank **P.O No.**:

Manufacturing Location: Australia **Drawing Number**: **Applicable Standard**: BS4994 (Cat 1)

3rd Party Surveillance: TBA

Inspection Activity Type and Verification

Factory **3rd Party**

No.	Activity	Test and/or Inspection	Standards & Procedures	Verifying Document	Acceptance Criteria	Rev	IP	Sign	Date	IP	Sign	Date	MDR CHECK
4.5	Check Structural hardness	Barcol Hardness Test (cut-out / outside only)	BS4994 / Factory Quality Plan / Method B.14	QA Record No. BBB	80% of resin according to manufacturer's datasheet		S			R			
4.6	Shell Thickness Check	Check Overall laminate thickness	Factory - Quality Plan	QA Record No. XXX	BS4994 (30.1)		S			S			
4.7	Inspect corrosion barrier	Ensure Laminating has complied procedure QA & BS4994	Client Specification / BS4994 / Factory Quality plan / Ultrasonic / QA	QA Record No. XXX	BS4994 Table 16		S			S			
4.8	Check CB hardness	Barcol Hardness Test	BS4994 / Factory Quality Plan	QA Record No. BBB	80% of resin according to manufacturer's datasheet		S			S			
4.9	Check CB cure	Acetone Test	BS4994 / Factory Quality Plan / Method B.18	QA Record No. CCC	No Tackiness		H			R			
4.9	Check Shell Roundness	Check Roundness	BS4994 / Factory Quality Plan	QA Record No. YYY	BS 4994 & SWC Spec Section X		S			S			
5.0	**BASE**												
5.1	Prepare Tool	Free from Defects / Clean	Factory - Quality Plan	QA Record No. BBB	BS4994 (30.1)		S			R			
5.2	Laminate CB	Ensure Laminating has complied procedure QA & BS4994	Factory - Quality Plan	QA Record No. CCC	All laminate layers recorded for traceability.		R			R			
5.3	Laminate Structural layers	Ensure Laminating has complied procedure QA & BS4994	Factory - Quality Plan	QA Record No. YYY	All laminate layers recorded for traceability.		R			R			
5.4	Check Structural hardness	Barcol Hardness Test (cut-out / outside only)	BS4994 / Factory Quality Plan / Method B.14	QA Record No. BBB	80% of resin according to manufacturer's datasheet		R			R			
5.5	Thickness Check	Check Overall laminate thickness and roundness	Factory - Quality Plan	QA Record No. CCC	BS4994 (30.1)		S			S			
5.6	Inspect corrosion barrier	Ensure Laminating has complied procedure QA & BS4994	Client Specification / BS4994 / Factory Quality plan / Ultrasonic / QA	QA Record No. YYY	BS4994 Table 16		S			S			
5.7	Check CB hardness	Barcol Hardness Test	BS4994 / Factory Quality Plan	QA Record No. YYY	80% of resin according to manufacturer's datasheet		S			S			
5.8	Check CB cure	Acetone Test	BS4994 / Factory Quality Plan / Method B.18	QA Record No. YYY	No Tackiness		S			S			
5.9	Inspect corrosion barrier overlay	Ensure Laminating has complied procedure QA & BS4994	Client Specification / BS4994 / Factory Quality plan / Ultrasonic / QA	QA Record No. YYY	BS4994 Table 16		S			S			
5.10	Check CB hardness	Barcol Hardness Test	BS4994 / Factory Quality Plan	QA Record No. YYY	80% of resin according to manufacturer's datasheet		S			S			
5.11	Check CB cure	Acetone Test	BS4994 / Factory Quality Plan / Method B.18	QA Record No. YYY	No Tackiness		S			R			

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Project Name: Sydney Water Replacement Tank | **P.O No.**:

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6.0	**NOZZLE FABRICATION & INSTALLATION**												
6.1	Laminate Structural layers	Ensure Laminating has complied procedure QA & BS4994	Factory - Quality Plan & BS4994	QA Record No. CCC	All laminate layers recorded for traceability.		S			R			
6.2	Inspect structural layer	Structural Layer Visual Inspection / Thickness	Client Specification / BS4994 / Factory Quality plan / Ultrasonic	QA Record No. CCC	BS4994 Table 16		S			S			
6.3	Inspect corrosion barrier	Ensure Laminating has complied procedure QA & BS4994	Client Specification / BS4994 / Factory Quality plan / QA	QA Record No. CCC	BS4994 Table 16		S			S			
6.4	Check CB hardness	Barcol Hardness Test (Resin Sample or cut off)	BS4994 / Factory Quality Plan	QA Record No. CCC	80% of resin according to manufacturer's datasheet		S			S			
6.5	Check CB cure	Acetone Test	BS4994 / Factory Quality Plan / Method B.18	QA Record No. CCC	No Tackiness		S			R			
6.6	Laminate Comp & overlays	Ensure Laminating has complied procedure QA & BS4994	Client Specification / BS4994 / Factory Quality plan / QA	QA Record No. CCC	All laminate layers recorded for traceability.		R			R			
6.7	Inspect structural layer	Structural Layer Visual Inspection / Thickness	Client Specification / BS4994 / Factory Quality plan	QA Record No. CCC	BS4994 Table 16		S			S			
6.8	Laminate CB Overlays	Ensure Laminating has complied procedure QA & BS4994	Client Specification / BS4994 / Factory Quality plan / QA	QA Record No. CCC	All laminate layers recorded for traceability.		R			S			
6.9	Inspect corrosion barrier	Structural Layer Visual Inspection / Thickness	Client Specification / BS4994 / Factory Quality plan / QA	QA Record No. CCC	BS4994 Table 16		S			S			
6.10	Check laminate hardness	Barcol Hardness Test (Resin Sample or cut off)	BS4994 / Factory Quality Plan	QA Record No. CCC	80% of resin according to manufacturer's datasheet		S			S			
6.11	Check CB cure	Acetone Test	BS4994 / Factory Quality Plan / Method B.18	QA Record No. CCC	No Tackiness		S			R			
7.0	**EXTERNAL FITTINGS & MINOR INTERNAL ATTACHMENTS FABRICATION / INSTALLATION**												
7.1	Fittings Manufacture	Structural Layer Visual Inspection / Thickness / Flatness / Drilling	Design & Dwg Requirements BS4994 / AS2634	QA Record No. CCC	Dimensions meet Design & Dwg Requirements plus BS4994		R			R			
7.2	External Attachment laminate	Applicable for All Fittings (exc nozzles)	Factory - Quality Plan & BS4994)	QA Record No. CCC	All laminate layers recorded for traceability.		R			R			
7.3	Inspect Attachment layers	Structural Layer Visual Inspection / Thickness	Client Specification / BS4994 / Factory Quality plan / QA	QA Record No. CCC	BS4994 Table 16		S			S			
7.4	Internal Attachment laminate	Applicable for All Fittings (exc nozzles)	Factory - Quality Plan & BS4994)	QA Record No. CCC	All dimensions within tolerance. BS4994 (28.4)		R			R			

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Inspection Activity Type and Verification

Factory **3rd Party**

No.	Activity	Test and/or Inspection	Standards & Procedures	Verifying Document	Acceptance Criteria	Rev	IP	Sign	Date	IP	Sign	Date	MDR CHECK
7.5	Inspect Internal Attachment layers	Structural Layer Visual Inspection / Thickness	Client Specification / BS4994 / Factory Quality plan / Ultrasonic / QA	QA Record No. CCC	BS4994 Table 16		S			S			
7.6	Laminate corrosion barrier	Ensure Laminating has complied procedure QA & BS4994	Factory - Quality Plan	QA Record No. CCC	All laminate layers recorded for traceability.		R			R			
7.7	Inspect corrosion barrier	Ensure Laminating has complied procedure QA & BS4994	Client Specification / BS4994 / Factory Quality plan / QA	QA Record No. CCC	BS4994 Table 16		S			S			
7.8	Check CB hardness	Barcol Hardness Test (Resin Sample)	BS4994 / Factory Quality Plan	QA Record No. CCC	80% of resin according to manufacturer's datasheet		S			S			
7.9	Check CB cure	Acetone Test	BS4994 / Factory Quality Plan / Method B.18	QA Record No. CCC	No Tackiness		S			R			
7.10	Fittings Location Check	Check fitting (brackets) location are within tolerance	Design & Dwg Requirements BS4994	QA Record No. CCC	All dimensions within tolerance. BS4994		S			W			
8.0	**FINAL PRODUCTION - INSPECTION AND TESTING**												
8.1	Factory Internal Inspection	Corrosion Barrier Inspection	BS4994, Client specification	QA Record No. CCC	Factory Final Inspection Sheet Conformance in all checks		H			W			
8.2	Factory External Inspection	External Surface Inspection	BS4994, Client specification	QA Record No. CCC	Factory Final Inspection Sheet Conformance in all checks		H			W			
8.3	Mechanical Testing	Ultimate Tensile (laminate samples by type), Lap shear test (CSM)	Approved Test, BS4994	Independent Testing Authority Report	Verifier Reviewed		S			R			
8.4	Physical Testing	Glass Content & Construction Analysis (head, shell)	Approved Test, BS4994	Independent Testing Authority Report	Verifier Reviewed		S			R			
8.5	Lifting lug load test	Prototype test	Client approved testing procedure	Factory - Test Record	Verifier Reviewed		FAT			W			
8.6	Flowcoating	Visual Inspection	Design & Dwg Requirements BS4994 / AS2634	Factory QA Doc, client approved drawings	Uniform thickness and colour		S			R			
8.7	Nameplate Inspection	Nameplate Verification	BS4994, Client specification	Nameplate Drawing Check	Conforms to standard and to approved nameplate drawing		S			R			

INSPECTION AND TEST PLAN

Document No. XXXX-XXXX
Issue Date: 01/01/18

ITP No.: 001	**Quality Std**: ISO9001	**Revision**: A	R - Review Document S - Surveillance Point
Project Name: Sydney Water Replacement Tank		**P.O No.**:	W - Witness Inspection H - Hold
Manufacturing Location: Australia	**Drawing Number**:	**Applicable Standard**: BS4994 (Cat 1)	
3rd Party Surveillance: TBA			

FAT – Factory Acceptance Test

V - Verify

Inspection Activity Type and Verification

	Factory					3rd Party					
No.	**Activity**	**Test and/or Inspection**	**Standards & Procedures**	**Verifying Document**	**Acceptance Criteria**	**Rev**	**IP**	**Sign**	**Date**	**IP**	**Sign**	**Date**	MDR CHECK
9.0	**DISPATCH**												
9.1	Transport protection	Visual Inspection	Client Specification/Factory Quality Manual	Factory Doc QA Record. Photographic record	Vessel secure and protected from contact with hard surfaces		S			R			
9.2	Lifting & Handling	Lifting & Handling procedure has been approved by Client QA & BS4994	Factory Procedures	Factory - O&M Manual	Client Approved Document		S			R			
10.0	**DOCUMENTATION - MDR**												
10.1	Deliver to Customer	Laminate Cut-out (On Request)	Client specification	Factory - Delivery Check Sheet	Delivery Conformance		S			R			
10.2	As-built drawings	Update all changes made during construction to As-Built Drawing	As-built drawing	As-built drawing	All variations made during construction added to 'As-Built' Drawing		R			R			
10.3	MDR	MDR Compilation	MDR Checklist	Factory - MDR Document	All required documents signed and approved		R			R			

No.	Date:	By:	Revision (recent changes in rev B)

Factory Approval
Signature:

Client Approval
Signature:

Appendix 2 Tank Design Matrices

A2.1 ALUMINIUM SULPHATE DESIGN SPECIFICATION MATRIX

TANK DATA			
Tank Type	Emergency	Day	Storage
Tank Size	<2500L	>2500L<7500L	>7500L
Media	47% Aluminium Sulphate		
Media Density	1.34	1.34	1.34
Design Density	1.4	1.5	1.6
Wind – AS1170.2 *	NA	Region A2, TC=2	Region A2, TC=2
Seismic – AS1170.4 #	NA	P=1/500 Soil=Ce, Z=0.1	P=1/500 Soil=Ce, Z=0.1
Design Temperature	-10/+65DegC	-10/+65DegC	-10/+65DegC
Lifting Lugs - Qty	2	3	3
Design factor k2	1.3	1.3	1.3
Hold Down Lug	Min 2	As Required	As Required
CB Thickness	3.5mm	3.5mm	3.5mm
CB Construction (minimum)	Veil + 1200gsm CSM	Veil + 1200gsm CSM	Veil + 1200gsm CSM
CB Resin System	Nominated By Fabricator/Resin Supplier		
CB Cure System	Resin Supplier's Recommendation		
Structure Resin System	Nominated By Fabricator/Resin Supplier		
CB Post Cure	80 Deg C @ 4hrs	80 Deg C @ 4hrs	80 Deg C @ 4hrs
QA/QC Requirements			
Formal Calculations	NR	Yes	Yes
Design Record	Yes	NA	NA
Fabricators CoC	Yes	Yes	Yes
3rd Party DVS	Yes	Yes	Yes
3rd Party Inspection	NR	Min 1 Visit	Min 2 Visits
ITP	NR	Yes	Yes
MDR	Yes	Yes	Yes
Burn-off Construction	NR	Yes	Yes
Material test Records	Yes	Yes	Yes

Notes

Tank type description is a nominal description and does not specifically relate to the intended use.

'* Cfig = 1.2 for wind pressure, 0.85 for external pressure

'# Full sloshing analysis to be performed on roof where insufficient freeboard exists.

A2.2 HYDROFLUOSILICIC ACID DESIGN SPECIFICATION MATRIX

TANK DATA			
Tank Type	Emergency	Day	Storage
Tank Size	<2500L	>2500L<7500L	>7500L
Media	20% Hydrofluorosilicic Acid		
Media Density	1.22	1.22	1.22
Design Density	1.3	1.35	1.4
Wind – AS1170.2 *	NA	Region A2, TC=2	Region A2, TC=2
Seismic – AS1170.4 #	NA	P=1/500 Soil=Ce, Z=0.1	P=1/500 Soil=Ce, Z=0.1
Design Temperature	-10/+65DegC	-10/+65DegC	-10/+65DegC
Lifting Lugs - Qty	2	3	3
Design factor k2	1.4	1.4	1.4
Hold Down Lug	Min 2	As Required	As Required
CB Thickness	3.5mm	3.5mm	3.5mm
CB Construction (minimum)	2xVeil + 1200gsm CSM	2xVeil + 1200gsm CSM	2xVeil + 1200gsm CSM
CB Resin System	Nominated By Fabricator/Resin Supplier		
CB Cure System	Resin Supplier's Recommendation		
Structure Resin System	Nominated By Fabricator/Resin Supplier		
CB Post Cure	80 Deg C @ 4hrs	80 Deg C @ 4hrs	80 Deg C @ 4hrs
QA/QC Requirements			
Formal Calculations	NR	Yes	Yes
Design Record	Yes	NA	NA
Fabricators CoC	Yes	Yes	Yes
3rd Party DVS	Yes	Yes	Yes
3rd Party Inspection	NR	Min 2	Min 3
ITP	NR	Yes	Yes
MDR	Yes	Yes	Yes
Burn-off Construction	NR	Yes	Yes
Material test Records	Yes	Yes	Yes

Notes

Tank type description is a nominal description and does not specifically relate to the intended use.

'* Cfig = 1.2 for wind pressure, 0.85 for external pressure

'# Full sloshing analysis to be performed on roof where insufficient freeboard exists.

A2.3 FERRIC SOLUTION DESIGN SPECIFICATION MATRIX

TANK DATA			
Tank Type	Emergency	Day	Storage
Tank Size	<2500L	>2500L<7500L	>7500L
Media	Ferric Chloride/Sulphate (or similar)		
Media Density	1.7	1.7	1.7
Design Density	1.8	1.87	2.0
Wind – AS1170.2 *	NA	Region A2, TC=2	Region A2, TC=2
Seismic – AS1170.4 #	NA	P=1/500 Soil=Ce, Z=0.1	P=1/500 Soil=Ce, Z=0.1
Design Temperature	-10/+65DegC		
Lifting Lugs - Qty	2	3	3
Design Factor k2	1.6	1.6	1.6
Hold Down Lug	Min 2	As Required	As Required
CB Thickness	Min 3.5mm	Min 3.5mm	Min 3.5mm
CB Construction (minimum)	Min Veil + 1200gsm CSM Subject To Resin Suppliers Recommendation		
CB Resin System	Nominated By Fabricator/Resin Supplier		
CB Cure System	Nominated By Fabricator/Resin Supplier		
Structure Resin System	Nominated By Fabricator/Resin Supplier		
CB Post Cure	Nominated By Resin Supplier		
QA/QC Requirements			
Formal Calculations	NR	Yes	Yes
Design Record	Yes	NA	NA
Fabricators CoC	Yes	Yes	Yes
3rd Party DVS	Yes	Yes	Yes
3rd Party Inspection	NR	Min 2	Min 3
ITP	NR	Yes	Yes
MDR	Yes	Yes	Yes
Burn-off - Construction	NR	Yes	Yes
Material Test Records	Yes	Yes	Yes

Notes

Tank type description is a nominal description and does not specifically relate to the intended use.

‘* Cfig = 1.2 for wind pressure, 0.85 for external pressure

‘# Full sloshing analysis to be performed on roof where insufficient freeboard exists.

A2.4 SODIUM HYDROXIDE DESIGN SPECIFICATION MATRIX

TANK DATA			
Tank Type	Emergency	Day	Storage
Tank Size	<2500L	>2500L<7500L	>7500L
Media	50% Sodium Hydroxide		
Media Density	1.55	1.55	1.55
Design Density	1.6	1.7	1.8
Wind – AS1170.2 *	NA	Region A2, TC=2	Region A2, TC=2
Seismic – AS1170.4 #	NA	P=1/500 Soil=Ce, Z=0.1	P=1/500 Soil=Ce, Z=0.1
Design Temperature	-10/+65DegC		
Lifting Lugs - Qty	2	3	3
Design Factor k2	1.6	1.6	1.6
Hold Down Lug	Min 2	As Required	As Required
CB Thickness	Min 3.5mm	Min 3.5mm	Min 3.5mm
CB Construction	Min Veil + 1200gsm CSM Subject To Resin Suppliers Recommendation		
CB Resin System	Nominated By Fabricator/Resin Supplier		
CB Cure System	Resin Supplier's Recommendation		
Structure Resin System	Nominated By Fabricator/Resin Supplier		
CB Post Cure	80DegC @ 4hrs Unless Temperature or Duration Is Higher based on Resin Suppliers Recommendation		
QA/QC Requirements			
Formal Calculations	NR	Yes	Yes
Design Record	Yes	NA	NA
Fabricators CoC	Yes	Yes	Yes
3rd Party DVS	Yes	Yes	Yes
3rd Party Inspection	NR	Min 2	Min 3
ITP	NR	Yes	Yes
MDR	Yes	Yes	Yes
Burn-off - Construction	NR	Yes	Yes
Material Test Records	Yes	Yes	Yes

Notes

Tank type description is a nominal description and does not specifically relate to the intended use.

'* Cfig = 1.2 for wind pressure, 0.85 for external pressure

'# Full sloshing analysis to be performed on roof.

A2.5 SODIUM HYPOCHLORITE DESIGN SPECIFICATION MATRIX

TANK DATA			
Tank Type	Emergency	Day	Storage
Tank Size	<2500L	>2500L<7500L	>7500L
Media	15% Sodium Hypochlorite		
Media Density	1.2	1.2	1.2
Design Density	1.26	1.32	1.4
Wind – AS1170.2 *	NA	Region A2, TC=2	Region A2, TC=2
Seismic – AS1170.4 #	NA	P=1/500 Soil=Ce, Z=0.1	P=1/500 Soil=Ce, Z=0.1
Design Temperature	-10/+65DegC		
Lifting Lugs - Qty	2	3	3
Design Factor k2	1.6	1.6	1.6
Hold Down Lug	Min 2	As Required	As Required
CB Thickness	Min 3.5mm	Min 3.5mm	Min 3.5mm
CB Construction (minimum)	Veil + 1200gsm CSM	Veil + 1200gsm CSM	Veil + 1200gsm CSM
CB Resin System	Hetron 992FR	Hetron 992FR	Hetron 992FR
CB Cure System	BPO & DMA	BPO & DMA	BPO & DMA
Structure Resin System	Hetron 992FR	Hetron 992FR	Hetron 992FR
CB Post Cure	80 Deg C @ 4hrs	80 Deg C @ 4hrs	80 Deg C @ 4hrs
QA/QC Requirements			
Formal Calculations	NR	Yes	Yes
Design Record	Yes	NA	NA
Fabricators CoC	Yes	Yes	Yes
3rd Party DVS	Yes	Yes	Yes
3rd Party Inspection	NR	Min 2	Min 3
ITP	NR	Yes	Yes
MDR	Yes	Yes	Yes
Burn-off - Construction	NR	Yes	Yes
Material Test Records	Yes	Yes	Yes

Notes

Tank type description is a nominal description and does not specifically relate to the intended use.

‘* Cfig = 1.2 for wind pressure, 0.85 for external pressure

‘# Full sloshing analysis to be performed on roof where insufficient freeboard exists.

A2.6 PROJECT SPECIFIC DESIGN SPECIFICATION MATRIX

TANK DATA			
Tank Type	Emergency	Day	Storage
Tank Size	<2500L	>2500L<7500L	>7500L
Media	As Per Project Specification		
Media Density	As Per Project Spec.	As Per Project Spec.	As Per Project Spec.
Design Density	Media Density x 1.05	Media Density x 1.1	Media Density x 1.15
Wind – AS1170.2 *	NA	Region A2, TC=2	Region A2, TC=2
Seismic – AS1170.4 #	NA	P=1/500 Soil=Ce, Z=0.1	P=1/500 Soil=Ce, Z=0.1
Design Temperature	As Per Project Spec.	As Per Project Spec.	As Per Project Spec.
Lifting Lugs - Qty	2	3	3
Design factor k2	1.6	1.6	1.6
Hold Down Lug	Min 2	As Required	As Required
CB Thickness	3.5mm	3.5mm	3.5mm
CB Construction (minimum)	Veil + 1200gsm CSM	Veil + 1200gsm CSM	Veil + 1200gsm CSM
CB Resin System	Nominated By Fabricator/Resin Supplier		
CB Cure System	Resin Supplier's Recommendation		
Structure Resin System	Nominated By Fabricator/Resin Supplier		
CB Post Cure	80 DegC @ 4hrs Unless Temperature or Duration is Higher based on resin Suppliers Recommendation		
QA/QC Requirements			
Formal Calculations	NR	Yes	Yes
Design Record	Yes	NA	NA
Fabricators CoC	Yes	Yes	Yes
3rd Party DVS	Yes	Yes	Yes
3rd Party Inspection	NR	Min 2**	Min 3**
ITP	NR	Yes	Yes
MDR	Yes	Yes	Yes
Burn-off Construction	NR	Yes	Yes
Material test Records	Yes	Yes	Yes

Notes

Tank type description is a nominal description and does not specifically relate to the intended use.

'* Cfig = 1.2 for wind pressure, 0.85 for external pressure

'** Only 1 inspection required for sugar, CIP or wastewater tanks.

'# Full sloshing analysis to be performed on roof where insufficient freeboard exists.