Engineering

Technical Standard

TS 0730 – Stainless Steel Durability, Fabrication and Erection

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Government of South Australia

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Only the current revision of this Standard should be used which is available for download from the SA Water website.

Documents Superseded by this Standard

- SAW-ENG-STR-TEM-TSB-009 Technical Specification Stainless Steelworks.

Significant/Major Changes Incorporated in This Edition

Nil.

This is the first issue of this Technical Standard.

Document Controls

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1 Introduction

SA Water is responsible for operation and maintenance of a large portfolio of engineering infrastructure.

This standard has been developed to assist in the design, detailing, construction, and maintenance of this infrastructure.

1.1 Purpose

The purpose of this standard is to detail SA Water minimum requirements to ensure that assets covered by the scope of this standard are designed, detailed, constructed and maintained to consistent standards and attain the required asset life.

1.2 Glossary

The following glossary items are used in this document:

Term	Description
ACA	Australian Corrosion Association
AISI	American Iron and Steel Institute
AS	Australian Standards
AS/NZS	Joint Australian/New Zealand Standard
ASSDA	Australian Stainless Steel Development Association
ASTM	American Society for Testing and Materials
AWS	American Welding Society
CC	Construction Category (CC1, CC2, CC3, CC4)
Cl^-	The chemical symbol for "Chloride"
Cl_2	The chemical symbol for "Chlorine"
Cr	The chemical symbol for "Chromium"
CRC	The Corrosion Resistance Class
CRF	The Corrosion Resistance Factor
Cu	The chemical symbol for "Copper"
EN	Euronorm
ISO	International Organization for Standardization
MIC	Microbially Influenced Corrosion
Mo	The chemical symbol for "Molybdenum"
N	The chemical symbol for "Nitrogen"
Nb	The chemical symbol for "Niobium"
Ni	The chemical symbol for "Nickel"
NiDI	Nickel Development Institute
pH	Potential of hydrogen, used to specify the acidity or basicity (alkalinity) of an aqueous solution
PRE	The Pitting Resistance Equivalent
R_a	Surface Roughness
SA Water	South Australian Water Corporation
SCC	Stress Corrosion Cracking

Term	Description
TG	SA Water Technical Guideline
Ti	The chemical symbol for "Titanium"
TS	SA Water Technical Standard
UNS	Unified Numbering System

1.3 References

1.3.1 Australian & International

The following table identifies Australian and International standards and other similar documents referenced in this document:

Number	Title
General Standards for Stainless Steel	
AS 1449	Wrought alloy-steels—Stainless and heat-resisting steel plate, sheet and strip
AS 4037	Pressure Equipment – Examination and Testing
AS 4041	Pressure Piping
AS 4458	Pressure Equipment - Manufacture
AS 4673	Cold-formed stainless steel structures
AS/NZS 5131	Structural steelwork – Fabrication and erection
ASTM A240	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels and for General Applications
ASTM A480	Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip
ASTM A478	Standard Specification for Chromium-Nickel Stainless Steel Weaving and Knitting Wire
AWS A5.22	Stainless steel electrodes for flux cored arc welding
AWS A5.4	Stainless steel electrodes for shielded metal arc welding
AWS A5.9	Bare stainless steel welding electrodes and rods
EN 10028-7	Flat products made of steels for pressure purposes - Part 7: Stainless steels
EN 10088-1	Stainless steel compositions and physical properties
EN 10088-2	Stainless steel sheet, plate and strip chemical compositions and mechanical properties
EN 10088-3	Stainless steel bar chemical compositions and mechanical properties
EN 10088-4	Stainless steel flat products (sheet, strip, plate) for construction purposes
EN 10088-5	Stainless steel long products for construction purposes
EN ISO 9445-1	Continuously cold-rolled stainless steel. Tolerances on dimensions and form. Narrow strip and cut lengths
EN ISO 9445-2	Continuously cold-rolled stainless steel. Tolerances on dimensions and form. Wide strip and plate/sheet
EN 10058	Tolerances for flat bars
EN 10059	Tolerances for square bars
EN 10060	Tolerances for round bars
EN 10061	Tolerances for hexagon bars

Number	Title
EN 10278 T	Tolerances for bright drawn, ground, turned and polished stainless steel round, hexagon, square and flat bars
EN 10017	Tolerances for wire rod
EN 10218-2	Tolerances for wire
EN 10264-4	Stainless steel for wire ropes
EN 10296-2	Chemical compositions and mechanical properties of welded tube
EN 10297-2	Chemical compositions and mechanical properties of seamless tube
ISO 3506	Mechanical properties of corrosion-resistant steel fasteners – Part 1: Bolts, screws and studs
NiDI 11 024	Stainless steels in architecture, building construction
NiDI 9001	Cleaning and descaling stainless steel
NiDI	Stainless steel for structural applications
NiDI 9002	Welding of stainless steel and other joining methods
SEI/ASCE 8-02	Specification for the design of cold-formed stainless steel structural members
Finishes	
ASTM A270	Standard Specification for Seamless and Welded Austenitic and Ferritic/Austenitic Stainless Steel Sanitary Tubing
ASTM A480	Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip
ASTM A793	Standard Specification for Rolled Floor Plate, Stainless Steel
ASTM A947M	Standard Specification for Textured Stainless Steel Sheet
Cleaning, Passivation and Testing	
ASTM A262	Standard Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels
ASTM A380	Standard Practice for Cleaning, Descaling and Passivation of Stainless Steel Parts, Equipment and Systems
ASTM A923	Standard Test Methods for Detecting Detrimental Intermetallic Phase in Duplex Austenitic/Ferritic Stainless Steels
ASTM A967	Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts
ASTM A1084	Standard Test Method for Detecting Detrimental Phases in Lean Duplex Austenitic/Ferritic Stainless Steels
Fasteners, Fittings, Anchors	
AS 5216	Design of post-installed and cast-in fastenings in concrete
ASTM A193	Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications
ASTM A194	Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
ASTM A774	Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Service at Low and Moderate Temperatures
ASTM A951	Standard Specification for Steel Wire for Masonry Joint Reinforcement
ASTM A962	Standard Specification for Common Requirements for Bolting Intended for Use at Any Temperature from Cryogenic to the Creep Range
ASTM A1082	Standard Specification for High Strength Precipitation Hardening and Duplex Stainless Steel Bolting for Special Purpose Applications

Number	Title
ASTM C1242	Standard Guide for Selection, Design, and Installation of Dimension Stone Attachment Systems
ASTM F593	Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs
ASTM F594	Standard Specification for Stainless Steel Nuts
ASTM F788	Standard Specification for Surface Discontinuities of Bolts, Screws, Studs, and Rivets, Inch and Metric Series
ASTM F836M	Standard Specification for Style 1 Stainless Steel Metric Nuts
ASTM F837	Standard Specification for Stainless Steel Socket Head Cap Screws
ASTM F879	Standard Specification for Stainless Steel Socket Button and Flat Countersunk Head Cap Screws
ASTM F880	Standard Specification for Stainless Steel Socket, Square Head, and Slotted Headless-Set Screws
EN 15048-1	Non-preloaded structural bolting assemblies - Part 1: General requirements
EN ISO 3506-1	Mechanical properties of corrosion-resistant stainless steel fasteners - Part 1: Bolts, screws and studs (ISO 3506-1)
EN ISO 3506-2	Mechanical properties of corrosion-resistant stainless steel fasteners. Nuts
EN ISO 3506-3	Mechanical properties of corrosion-resistant stainless steel fasteners - Part 3: Set screws and similar fasteners not under tensile stress (ISO 3506-3)
EN ISO 3506-4	Mechanical properties of corrosion-resistant stainless steel fasteners - Part 4: Tapping screws (ISO 3506-4:2009) Mechanical properties of corrosion-resistant stainless steel fasteners - Part 4: Tapping screws (ISO 3506-4)
EN ISO 16048	Passivation of corrosion-resistant stainless steel fasteners (ISO 16048)
EN ISO 7046-2	Countersunk flat head screws (common head style) with type H or type Z cross recess – Product grade A - Part 2: Steel screws of property class 8.8, stainless steel screws and non-ferrous metal screws (ISO 7046-2)
Wire	
ASTM A492	Standard Specification for Stainless Steel Rope Wire
ASTM A555	Standard Specification for General Requirements for Stainless Steel Wire and Wire Rods
Structural Components: Tubing	
ASTM A269	Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
ASTM A511	Standard Specification for Seamless Stainless Steel Mechanical Tubing and Hollow Bar
ASTM A554	Standard Specification for Welded Stainless Steel Mechanical Tubing
ASTM A789	Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service
ASTM A1016	Standard Specification for General Requirements for Ferritic Alloy Steel, Austenitic Alloy Steel, and Stainless Steel Tubes
Pipe	
ASTM A312	Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
ASTM A358	Standard Specification for Electric-Fusion-Welded Austenitic Chromium-Nickel Stainless Steel Pipe for High-Temperature Service and General Applications
ASTM A409	Standard Specification for Welded Large Diameter Austenitic Steel Pipe for Corrosive or High-Temperature Service

Number	Title
ASTM A778	Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products
ASTM A790	Standard Specification for Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe
ASTM A928	Standard Specification for Ferritic/Austenitic (Duplex) Stainless Steel Pipe Electric Fusion Welded with Addition of Filler Metal
ASTM A999	Standard Specification for General Requirements for Alloy and Stainless Steel Pipe
Castings	
ASTM A351	Standard Specification for Castings, Austenitic, for Pressure-Containing Parts
ASTM A890	Standard Specification for Castings, Iron-Chromium-Nickel-Molybdenum Corrosion-Resistant, Duplex (Austenitic/Ferritic) for General Application
Structural Shapes, Bar, and Higher Strength Sheet/Strip	
ASTM A276	Standard Specification for Stainless Steel Bars and Shapes
ASTM A484	Standard Specification for General Requirements for Stainless Steel Bars, Billets, and Forgings
ASTM A666	Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate and Flat Bars
ASTM A1069	Standard Specification for Laser and Laser Hybrid Welded Stainless Steel Bars, Plates, and Shapes
Welding	
AS/NZS 1167.2	Welding and brazing—Filler metals. Part 2: Filler metal for welding
AS/NZS 1554.6	Structural steel welding. Part 6: Welding stainless steels for structural purposes
AS/NZS 3992	Pressure equipment - Welding and brazing qualification
AS/NZS 4854	Welding Consumables – Covered Electrodes for Manual Metal Arc Welding of Stainless and Heat-Resisting Steels - Classification
AWS D1.6	Structural Welding Code -Stainless Steel
AWS A4.2	Standard Procedures for Calibrating Magnetic Instruments to Measure the Delta Ferrite Content of Austenitic and Duplex Austenitic-Ferritic Stainless Steel Weld Metal
AWS A5.4	Specification for Stainless Steel Electrodes for Shielded Metal Arc Welding
AWS A5.11	Specification for Nickel and Nickel-Alloy Welding Electrodes for Shielded Metal Arc Welding
AWS A5.9	Specification for Bare Stainless Steel Welding Electrodes and Rods
AWS A5.22	Specification for Stainless Steel Electrodes for Flux Cored Arc Welding and Stainless Steel Flux Cored Rods for Gas Tungsten Arc Welding
AWS B2.1.014	Standard Welding Procedure Specification (WPS) for Shielded Metal Arc Welding of Carbon Steel to Austenitic Stainless Steel, (M-1 to M-8 or P-8), 10 through 18 Gauge, in the As-Welded Condition, With or Without Backing
AWS B2.1.013	Standard Welding Procedure Specification (WPS) for Shielded Metal Arc Welding of Austenitic Stainless Steel, (M-8 / P-8), 10 through 18 Gauge, in the As-Welded Condition, With or Without Backing
AWS B2.1.010	Standard Welding Procedure Specification (WPS) for Gas Tungsten Arc Welding of Carbon Steel to Austenitic Stainless Steel, (M-1 to M-8 or P-8), 10 through 18 Gauge, in the As Welded Condition, With or Without Backing

Number	Title
AWS B2.1.009	Standard Welding Procedure Specification (WPS) for Gas Tungsten Arc Welding Austenitic Stainless Steel (M-8 / P-8), 10 through 18 Gauge, in the As-Welded Condition, With or Without Backing
AWS B2.1.006	Standard Welding Procedure Specification (WPS) for Gas Metal Arc Welding of Carbon Steel to Austenitic Stainless Steel, (M-1 to M-8 or P-8), 10 through 18 Gauge, in the As-Welded Condition, With or Without Backing
AWS B2.1.005	Standard Welding Procedure Specification (WPS) for Gas Metal Arc Welding Austenitic Stainless Steel, (M-8 / P-8), 10 through 18 Gauge, in the As-Welded Condition, With or Without Backing
AWS D10.4	Recommended Practices for Welding Austenitic Chromium Nickel Stainless Piping and Tubing
EN 1011-3	Welding. Recommendations for welding of metallic materials. Arc welding of stainless steels
ISO 3834	Quality requirements for fusion welding of metallic materials - Comprehensive quality requirements

1.3.2 SA Water Documents

The following table identifies the SA Water standards and other similar documents referenced in this document:

Number	Title
TS 0101	Safety in Design
TS 0109	Infrastructure Design
TS 0110	Durability Design (when published)
TS 0420	Welding Requirements (Metals)
TS 0800	Materials in Contact with Drinking Water

1.4 Definitions

The following definitions are applicable to this document:

Term	Description
Accepted	Determined to be satisfactory by SA Water's Representative
Cast -in Fitting	An object that passes through the concrete or is embedded in the concrete to facilitate a connection to the containment structure
Construction Category	Classified set of requirements specified for the construction of the works as whole of an individual component or of a detail of a component as per AS/NZS 5131.
Constructor	The organisation responsible for constructing and installing infrastructure for SA Water whether it be a third party under contract to SA Water or an in-house entity.
Contract Documents	A set of documents supplied to Constructor as the basis for construction; these documents contain contract forms, contract conditions, specifications, drawings, addenda, and contract changes
Corrosion	Deterioration of a metal by a chemical, electrochemical or electrolytic reaction within its service environment(s).

Term	Description
Designer	The organisation responsible for designing infrastructure for SA Water whether it be a third party under contract to SA Water or a Constructor, or an in-house entity A Designer is a person who effects design, produces designs or undertakes design activities as defined in the *Work Health and Safety Act 2012 (SA)*.
Durability	The capability of structures, products or materials of continuing to be useful after an extended period of time and usage. In the context of performance-based design of structures, durability refers to the fulfilment of the performance requirements within the framework of the planned use and the foreseeable actions, without unforeseen expenditure on maintenance and repair.
Erection	All activities required to assemble the works on-site as part of the overall construction works.
Fabrication	All activities required to produce and deliver a component. As relevant, this comprises procurement, preparation and assembly, welding, mechanical fastening, transportation, surface treatment, corrosion protection, inspection and documentation thereof.
Fabricator	The organization engaged by SA Water or Constructor to carry out welding/fabrication and or erection activities on/for SA Water infrastructure.
Manufacturer	A person, group, or company that owns and operates a manufacturing facility that provides materials for use in SA Water infrastructure
Material	A product used for fabricating a component and which remains as part of it, e.g., stainless steel members, mechanical fasteners and welding consumables.
Non-Conformance	Failure to meet an expectation that is stated, implied or obligatory.
Pipe	The word "pipe" is used to apply to tubular products of dimensions commonly used for pipeline and piping systems. Because pipe is used to convey fluids, it is always cylindrical. Pipes subject to internal pressure or external pressure or both are designed in accordance with AS 4041. Pipes not subject to pressure are designed in accordance with AS/NZS 1554.1 for Steel and AS/NZS 1554.6 for Stainless Steel.
Responsible Discipline Lead	The engineering discipline expert responsible for TS 0730 defined on page 3 (via SA Water's Representative)
SA Water's Representative	The SA Water representative with delegated authority under a Contract or engagement, including (as applicable): • Superintendent's Representative (e.g., AS 4300 & AS 2124 etc.) • SA Water Project Manager • SA Water nominated contact person
'Shall' and 'Should'	In this Standard the word 'shall' indicates a requirement that is to be adopted in order to comply with the Standard. The word 'should' indicate practices which are advised or recommended.
Supplier	A person, group or company that provides goods for use in SA Water infrastructure
Supplier Declaration of Conformity (SDoC)	A document issued by the supplier declaring that the products supplied comply with the requirements of the relevant Australian Standard and that the documentation required by the Standard is available for issue.
TDRF	Technical Dispensation Request Form This form is part of SA Water's Technical Dispensation Request Procedure, which details the process by which those required to comply, or ensure compliance, with SA Water's technical requirements may seek dispensation from those requirements.

Term	Description
Terminology	• Where an obligation is given and it is not stated who is to undertake these obligations, they are to be undertaken by the Constructor. • Directions, instructions and the like, whether or not they include the expression “the Constructor shall” or equivalent, shall be directions to the Constructor, unless otherwise specifically stated. • Where a submission, request, proposal is required and it is not stated who the recipient should be, it is to be provided to SA Water’s Representative for review. • Each word imparting the plural shall be construed as if the said word were preceded by the word "all". • Each word implying persons shall, where appropriate, also be construed as including corporations. • "Authorised", "approval", "approved", "selected", "directed" and similar words shall be construed as referring to the authorisation, approval, selection or direction of SA Water’s Representative in writing. • "Allow" shall mean that the cost of the item referred to is the responsibility of the Constructor. • "Provide" shall mean "supply and install". • “Submit” shall mean “submit to the SA Water Representative or their nominated delegate”. • Submissions, requests, proposals are to be provided at least 10 business days prior to work commencing or material ordering (unless noted otherwise). • “Informative” shall mean “provided for information and guidance”
Tolerance	The difference between the permissible maximum (or upper) limit of size or dimension and the permissible minimum (or lower) limit of size or dimension.
Tube	The words “tube” or “tubing” often refer to tubular products that may be used to convey fluids, but rigid tubes are often used as structural elements; such a tube may be rectangular or cylindrical. Tubes or tubing used to convey fluids that are subject to internal pressure, external pressure or both, are designed in accordance with AS 4041. Rigid tubes used as structural members are designed in accordance with AS/NZS 1554.1 for steel and AS/NZS 1554.6 for Stainless Steel.

2 Scope

2.1 Scope & Application of this Technical Standard

This Technical Standard specifies SA Water's minimum requirements for stainless steel structures, including:

- Quality requirements (Section 3)
- Durability and grade selection (Section 4)
- Material specification (Section 6)
- Fabrication (Section 7)
- Transportation and erection (Section 8).

Stainless steel structures covered by this standard include:

- Pipework
- Fittings and fixtures
- Structural steelwork
- Bolts, fasteners and washers.

Requirements, in addition to this Standard, relating to stainless steel welding and fabrication are further specified in TS 0420 Welding Requirements (Metals).

2.2 Works Not in Scope

This Technical Standard does not cover the following:

- Welding (refer TS 0420)
- Pressure vessels
- Stainless steel reinforcement in concrete works (refer TS 0710).

2.3 Technical Dispensation

Departure from any requirement of this Technical Standard shall require the submission of Technical Dispensation Request Form (TDRF) for the review and approval (or otherwise) of SA Water Principal Engineer listed in Page 3, on a case-by-case basis.

The Designer shall not proceed to document/incorporate the non-conforming work before the Principal Engineer has approved of the proposed action in writing via the Technical Dispensation Request Form (TDRF).

SA Water requires sufficient information to assess dispensation requests and their potential impact. The onus is therefore on the proponent to justify dispensation request submissions and provide suitable evidence to support them.

Design works that are carried out without being appropriately sanctioned by SA Water shall be liable to rejection by SA Water and retrospective rectification by the Designer/Constructor.

3 Quality Requirements

3.1 Quality Management System

The Constructor shall establish and maintain a Quality Assurance System in accordance with AS/NZS ISO 9001 - Quality Management Systems.

The Constructor and its major sub-constructors and suppliers shall, from the commencement of the Contract until the Date of Practical Completion, establish, file and maintain quality records that demonstrate implementation of the Constructor's Quality Management System (QMS), for inspection by SA Water's Representative.

3.2 Quality System Audits

Internal audits in accordance with the requirements of AS/NZS ISO 9001 shall be undertaken by the Constructor to ensure compliance with the Quality Management System.

SA Water's Representative may also carry out audits of the Constructor's quality system and/or site records by way of review and verification of Constructor's documentation, quality assurance measures or inspection and testing records.

3.3 Quality Plan

The Constructor shall submit, within 10 working days of the Date of Acceptance of Tender, a draft Quality Plan. This document is to include details of the Constructor's proposals for the management and control of quality for the Contract. Receipt of the draft Quality Plan provided under this clause constitutes a **HOLD POINT.**

A finalised Quality Plan shall be submitted within 10 working days of receiving comments from SA Water's Representative.

The Quality Plan shall provide for quality assurance activities on site and provide for dedicated site quality control resources (that do not undertake the remediation works) to plan, manage and undertake quality control testing of the entire works.

As a minimum, the Quality Plan shall include the following, but not limited to:

- A complete description of the stainless steel structure/element and its location in relation to the total project
- A team chart containing the names of key personnel, their function and responsibilities during the project, the chain of command that is to apply and the lines of communication that are to be used
- Arrangements for the coordination with other parties throughout the project and for the monitoring of their performance and progress
- The identification of functions to be delegated to sub-constructors and any other outside organisation
- The identification and proof of competence of qualified personnel to be employed on the project, including welding supervisors, welding inspection personnel, welders and welding operators
- Arrangements for controlling variations, changes and concessions that may be agreed during the project
- A general management document which shall contain a review of the Standard requirements against process capabilities

- Procedures to manage all incoming documentation issued for construction and documentation issued by SA Water. Such procedures should include a method for the identification of the current revision status and should prevent the use of invalid or obsolete documents by in-house personnel or by sub-constructors
- Procedures should be documented for providing or obtaining (as appropriate) documentation prior to construction, which should include the following:
  - Certificates for all materials and consumables to be employed on the project
  - Weld procedure specifications and qualification records (refer TS 0420)
  - Method statements for all activities identified in this Standard
  - Design calculations for any temporary works necessitated by the erection method statements
  - Arrangements for the scope and the timing of any required second or third-party approval or acceptance of documentation prior to construction
  - Delivery schedules for components delivered to site, together with identification with respect to location within the completed structure.
- Procedures should be documented for providing documentation of the construction process which should include the following:
  - All materials and consumables traceable to completed components
  - Inspection and test reports and any action taken to deal with nonconformities in relation to the preparation of joint faces prior to welding, welding and completed weldments, pickling and passivation, geometrical tolerances of manufactured components, surface preparation, calibration of equipment including those used for the control of tensioning of mechanical fasteners
  - Pre-erection survey results leading to acceptance that the site is suitable for erection of steelwork to commence
  - Dimensional surveys of the structure and action taken to deal with any nonconformities
  - Certificates for completion of erection and handover.
- Procedures should be documented which identify a method of identifying all mandatory tests and inspections that are necessary for the project or are required by this Standard, or by any referenced Standard or by the Constructor's quality system. Such procedures should include the following:
  - The scope of the tests and inspections required
  - Acceptance criteria
  - Actions for dealing with nonconformities, corrections and concessions.
  - Certificates for completion of tests and handover.
- Quality documentation prior to construction, which shall be produced before execution of the construction step to which they relate.

3.4 Construction Category

Construction Categories, Types of Traceability and Traceability Levels for the Fabrication of Stainless Steel shall be as described in TS 0420.

Note: A copy of the test certificates or Supplier Declaration of Conformity (SDoC) with purchasing information shall be maintained, and a copy provided to SA Water's Representative for all purchased components for all categories.

3.5 Work Identification & Traceability

The Constructor shall divide the works into lots for the purpose of:

- Positive identification and traceability of all work activities, measurements and tests
- Submission of work to SA Water's Representative via of a conformance/non-conformance report
- Submission of Technical Dispensation Request Form (TDRF) for any proposed deviation from a requirement(s) of this standard.
- Monitoring the quality of the works
- Rejection of work

The Constructor shall define a system of lot numbering which is practical for the Works, and which shall be logical, suit the specific application and shall be consistent with any specified computerised system.

All work and/or activities shall be able to be readily identified with the relevant lot and comply with AS/NZS 5131 for the appropriate Construction Category.

The lot identification system, site records and sample numbering system shall allow test results to be positively identified with the lot they represent.

3.6 Work Method Statement

The Constructor shall prepare and submit a detailed work method statement (WMS) for all work activities like preparation, assembly and fabrication, which details controls to be exercised to ensure satisfactory achievement of Contract requirements, where the absence of such procedures could adversely affect quality of the work.

Where appropriate, such procedures may be included in the Inspection and Test Plans (ITPs) or other documentation.

Work Method Statements shall be submitted to the SA Water Representative at least 10 working days before construction of the relevant work commences, unless alternative times are specified elsewhere in the Contract. Review and acceptance of the WMS provided under this clause constitutes a **HOLD POINT**.

The work method statement shall include, but is not limited to, the following:

a) Purpose and scope of the activity

b) Work item or work lot identification

c) Details of when, where, how and by whom the work will be done

d) The sequence of operations, in accordance with the construction sequence as nominated in this Technical Standard

e) Plant, equipment and materials proposed

f) Detailed requirements applicable to the work activity documented

g) Quality Assurance (including testing) measures to be implemented

h) Details of any temporary works associated with the project, including general arrangements, dimensions, and relevant design details and certifications

i) All matters affecting the safety of the site including control of access to the site, isolations and management of vehicles and other plant

j) How the activity will be controlled and recorded.

The work method statement shall include identification of hazards/risks associated with the works or the site, and corresponding measures to eliminate the hazards. Where the risks cannot be eliminated, risk control and/or manage method shall be specified to reduce them so far as is reasonably practicable. The work method statement and hazard/risk identification shall encompass all site works and temporary works required to facilitate the intended activities.

Construction of the work shall be undertaken in accordance with the submitted work method statement. Any revisions to the accepted WMS shall be submitted to the SA Water Representative for review and acceptance with details including, but not limited to, the following:

- Why the Work Method Statement has required alteration
- Assessment of any new hazards (whether safety, quality or others) associated with any change to the work method
- Actions to be taken to mitigate hazards identified in point b) above.

3.7 Inspection & Test Plan

The Constructor shall prepare and submit inspection and test plan(s) (ITPs) for all significant construction activities, where the absence of such procedures could adversely affect quality of the work. ITP requirements for welding activities are defined in TS 0420.

ITPs shall explicitly reference acceptance criteria and all performance requirements of the Contract and be prepared by suitably qualified and experience personnel.

- Personnel involved in preparation of ITPs should include material suppliers, fabricators, installers and design engineers as appropriate to the works being undertaken
- Constructors are encouraged to standardise ITPs for commonly encountered work activities or for projects/programs across which the same work activities are repeated.

The Constructor shall submit ITPs to the SA Water Representative and/or the Designer's Representative not less than 10 working days before the work activity commences. Review and acceptance of ITPs provided under this clause constitutes a **HOLD POINT**.

The content of ITPs shall include, but not be limited to, the following:

a) Description of the work activity/sequence of activities

b) Work item or work lot identification

c) Specification requirements/reference

d) Title of the person responsible for activity and verification of an ITP item

e) Witness, hold and surveillance points

f) Relevant checklists, forms or procedures

g) Quality assurance activities, including test type, tolerances or other acceptance criteria

h) Identification of relevant test procedure/s and quality records

i) Details of test equipment to be used for specified tests

j) Sequence and frequency of tests

k) Identification of records (including photographic records) to be maintained of particular tests.

The Constructor shall provide SA Water’s Representative and/or the Designer's Representative with one copy of each signed off ITP (including accompanying records) within 5 working days of completion of the activity to which the ITP relates.

3.8 Hold Points & Witness Points

3.8.1 Hold Points

The minimum required Hold Points are detailed within Appendix A of this Technical Standard. Additional Hold Points are at the discretion of SA Water's Representative, the Designer's Representative, or the Constructor.

Hold points represent a critical stage of the work that requires release by the SA Water Representative and/or the Designer's Representative before works can proceed further. The process for hold points release is provided below:

a) For Hold Points associated with design or documentation submissions, these shall be submitted to the SA Water Representative and/or the Designer's Representative for release within the nominated timeframes

b) For Hold Points associated with inspections, the Constructor shall submit a request for a Hold Point inspection when work is at such a stage and is ready for inspection. A minimum of 48 hours' notice shall be provided before the hold point is reached.

- This request should also contain photographic evidence of the works that:
  - Consist of "jpg" files with a minimum size of 4 megapixels
  - Clearly denote where the image was taken
  - Are provided with a time and date stamp
- Submission of the photographic evidence may allow the hold point to be released without physical inspection having to occur, at the discretion of the SA Water Representative and/or the Designer's Representative.

c) If after the Hold Point inspection further work is required prior to proceeding, submit a request for re-inspection by SA Water's Representative and/or the Designer's Representative prior to written approval being given.

d) Subject to prior approval of SA Water Representative, the Constructor-nominated Quality Representative can release the project-specific hold points provided all records including photographic evidence are kept and furnished for inspection at a later date. However, SA Water representative reserves the right to undertake a random audit inspection and ask for trial works that demonstrate the competencies of those execute the works as well as the Constructor-nominated Quality Representative inspecting the work.

3.8.2 Witness Points

The minimum required Witness Points are detailed within Appendix A of this Technical Standard. Additional Witness Points are at the discretion of SA Water's Representative, the Designer's Representative or the Constructor.

a) Witness points represent a point at which compliance of the works with the drawings, WMS or ITP is to be verified.

b) The Constructor shall provide a minimum of 24 hours' notice to the SA Water Representative and/or the Designer's Representative of a witness point being reached, with attendance by the Representative to be at their discretion.

3.9 Non-Conformance

The Constructor shall promptly advise the SA Water Representative and/or the Designer's Representative of any non-conformance, together with its location and proposals for corrective action where:

a) There is potential for progress of the work to be seriously affected

b) The proposed action to correct the non-conformance will result in work not complying with the requirements of the Technical Standard

c) The non-conformance may cause a health and safety hazard

d) The non-conformance has resulted from a deficiency in the drawings or Technical Standard

e) Material or serious environmental harm has occurred.

Each such notification shall include details of:

- The action proposed for correction of the non-conformance, or the arrangements made for its disposition
- The amendments to the quality system to mitigate recurrence of the non-conformance.

The Constructor shall not proceed to cover up or otherwise incorporate the non-conforming work before SA Water's Representative and/or the Designer's Representative has approved of the proposed action in writing via Technical Dispensation Request Form (TDRF), completion and submission of which shall be undertaken by the Designer's Representative.

Works that are carried out without being appropriately sanctioned by SA Water's Representative and/or the Designer's Representative may be classed as defective work. Such work or material is liable to rejection by the Representative who may require the defective work to be removed and replaced.

3.10 Quality Records

The Constructor or their major sub-Constructors or suppliers shall establish, file and maintain quality records which demonstrate implementation of the Constructor's Quality System, for inspection by SA Water.

The Constructor shall have handed over to SA Water the following records, or certified copies thereof:

- The allocation of tasks and authority during the various phases of the project
- The procedures, methods and work instructions to be applied
- An inspection and test plan specific to the works
- A procedure for handling changes and modifications
- A procedure for handling nonconformities
- A procedure for handling requests for concessions
- A procedure for handling disputes related to quality
- Any hold points or requirements to witness inspections or tests, and any consequent access requirements
- A procedure for document control and control of records
- A procedure for corrective and preventative actions
- A procedure for quality audits
- A review of contractual requirements
- A technical review of contractual requirements.

3.11 Shop Drawings

3.11.1 Scope

The shop drawings shall be in accordance with the relevant parts of the AS 1100 series and shall:

- Accurately and completely transfer the information from the design drawings
- Provide for the development of accurate, detailed dimensional information which allows for the accurate fit-up of components during erection.

Each shop detail drawing shall be identified utilising a numbering system allowing traceability throughout the duration of the works. Revisions shall be uniquely identified and dated, with the scope of each revision clearly identified.

Where Requests for Information (RFIs) are issued as part of the process of producing shop detail documentation, a written record of inquiries and responses shall be maintained.

The shop drawings shall show clear and complete information on each assembly, component and connection of the work. The information shall include:

- Identification
- Steel type and grade
- Dimensions of items
- Required camber, where applicable
- Fabrication methods including, where applicable, hot- or cold-forming and post-weld heat treatment
- Location, type and size of welds or bolts
- Weld categories and bolting categories
- Orientation of members
- Location of temporary connections
- Surface preparation methods, pickling and passivation, details to prevent crevices and contact with dissimilar materials
- Procedures necessary for shop and site assembly
- Lifting and support points for handling and transport
- Temporary bracing, if required for handling and transport
- Required fixings for building elements
- Procedures for erection including temporary bracing
- Set out of items relative to project grid and rise level
- All set out points as shown on structural and architectural drawings and their dimensions relative to grid
- Particular welding and material testing requirements as nominated by the engineer
- Marking plans for all items including holding down bolts, shear studs and chemical anchors.

3.11.2 Approval of Shop Drawings

The Constructor shall arrange for shop drawings to be verified by qualified personnel, other than those directly involved in the drafting of the shop drawings.

PDF shop drawings, reviewed by the Designer and certified by the Constructor as complying with project requirements, shall be submitted to SA Water Representative at least ten (10) working days before fabrication commences. Submission of these documents represents a **HOLD POINT**.

The Constructor shall be responsible for the correctness of the shop drawings. Submission of the shop drawings to SA Water Representative shall not relieve the Constructor of its responsibilities under the Contract.

3.12 As-Built Documentation

Sufficient documentation shall be prepared during construction to demonstrate that the works have been carried out according to the design drawings and this specification.

The Constructor shall submit SA Water Representative a PDF copy of the "Work as Executed" shop drawings within four (4) weeks of the completion of fabrication and erection of the stainless steel members.

4 Durability Considerations

4.1 General

Unlike carbon steels, life expectancy of stainless steels is not determined by subsequent protective treatments, but by initial selection of materials, the design process and the fabrication procedures, and by their suitability for the environmental conditions.

The limit of corrosion resistance for a given stainless steel depends on its alloying elements and the microstructure resulting from the fabrication process, which means that each grade has a slightly different response when exposed to a corrosive environment. Care is therefore needed to select the right grade of stainless steel for a given application.

The most common reasons for stainless steel to fail to perform as well as expected regarding corrosion resistance are:

- Incorrect assessment of the environment or exposure to unexpected conditions, e.g., Unsuspected contamination by chloride ions, exposure to high/low pH or higher than expected surface accumulations
- Stainless steel fabrication techniques (e.g., Welding, heat treating and heating during forming) that alter the microstructure (e.g., chromium carbide formation on grain boundaries; incomplete weld heat tint removal, or surface contamination may increase susceptibility to corrosion
- High surface roughness or incorrectly orientated finish.

Good understanding of the corrosion mechanism and durability risks associated with stainless steel are required to inform selection of an appropriate grade of stainless steel for a particular application, or to correctly apply good detailing practices.

Six possible types of corrosion mechanisms are briefly described in the next section.

4.2 Pitting

Pitting is a localized form of corrosion that can occur due to exposure to specific environments, most notably those containing chloride ions. It is believed that pitting occurs because chloride ions penetrate the passive film in weak spots. However, this is still debated among experts.

In addition to chloride content, the probability of a service environment causing pitting depends on factors such as the temperature, corrosive pollutants and particulate, acidity or alkalinity, the content of oxidizing agents, and the presence or absence of oxygen.

The pitting resistance of a stainless steel is dependent on its chemical composition. Chromium (Cr), molybdenum (Mo) and nickel (Ni) all enhance the resistance to pitting by strengthening the stability of the passive film. Nitrogen (N) and nickel (Ni) stabilize the austenitic phase. The Pitting Resistance Equivalent (PRE) gives an approximate empirically derived estimate of pitting resistance and is defined as:

$$PRE = \%\,wt\,Cr + 3.3(\%\,wt\,Mo) + 16(\%\,wt\,N)$$

Note: PRE calculation can only be used for austenite's. Austenite's always contain some nickel; therefore, nickel isn't part of the equation as it is inherently an alloying element in all austenites. Other equations for PRE\ exist, these include the alloying elements Nb and W, and are mainly used for estimation of resistance to high temperature corrosion.

The PRE of a stainless steel is a useful guide to its corrosion resistance relative to other stainless steels but should only be used as a rough indicator. Small differences in PRE can easily be overshadowed by other factors that also influence corrosion pitting resistance. Therefore, the PRE should not be the only factor in selection. Refer Table 1 below.

Grade AISI 304 (1.4301) has the lowest PRE of the austenitic grades. It exhibits surface corrosion in applications with low to moderate coastal exposure and is unsuitable for environments with spray/mist, splashing and immersion. It may also show unacceptable levels of pitting in industrial atmospheres.

For low to moderate exposure to industrial pollution, or coastal environment (C4), grade AISI 316/316L (1.4401/1.4432) is preferred. When pollution or salt exposure is higher, duplex 2205 (1.4462), super duplex 2507 (1.4410) r Ni-based superalloys are generally an option. For immersion in sea water stainless steels with a PRE >40 is considered to be resistant against pitting corrosion.

Table 1: PRE for Common Austenitic & Duplex Stainless Steels

Steel Designation		Chromium wt%	Molybdenum wt%	Nitrogen wt%	PRE
AISI	EN				
Austenitic					
304	1.4301	17.5-19.5	NS	0.11max	17.5-19.5
316/316L	1.4401/4	16.5-18.5	2.0-2.5	0.11max	23.1-26.8
254SMO	1.4541	19.5-20.5	6.0-6.5	0.18-0.22	
Duplex					
2304	1.4362	23	0.2	0.1	25.3
2205	1.4462	21.0-23.0	2.5-3.5	0.10-0.22	30.8-38.1
Super duplex					
2507	1.4410	24.0-26.0	3.0-4.0	0.24-0.35	37.7-44.8

4.3 Crevice Corrosion

Crevice corrosion occurs in tight, unsealed crevices where there is a continuous film of electrolyte both within and outside the crevice. The crevice must be fine enough to allow entry of electrolyte and dissolved chloride yet prevent diffusion of oxygen into the crevice.

Crevice corrosion can be avoided by sealing crevices or eliminating them. The severity of a crevice is very dependent on its geometry: the narrower and deeper the crevice, the more severe the corrosion conditions. The underlying reason is the limited oxygen diffusion to the bottom of the crevice.

Joints that are not submerged should be designed to shed moisture. Some stainless steels, including 304 and 316, are susceptible to crevice corrosion when chlorides or other salts are present in the environment. More corrosion resistant austenitic and the duplex steels are less susceptible, and performance will be dependent on the conditions, especially the temperature.

The severity of corrosion in submerged crevices is generally worse than in corrosive above-water atmospheric environments that have wetting and drying cycles or are regularly slightly moist. Submerged tight crevices are more aggressive because the diffusion of oxidants necessary for maintaining the passive film is restricted.

Crevices typically occur between nuts and washers or around the thread of a screw or the shank of a bolt. Crevices can also occur in welds that fail to penetrate and under deposits on the steel surface. In principle, pitting and crevice corrosion are similar phenomena, but the attacks start more easily in a crevice than on a free surface.

Applying any labels or paintwork on exposed above ground stainless steel pipework shall be avoided to prevent crevice corrosion. Alternative pipe labels / tags shall be used, for example, fixed to a pipe flange, pipe support or an independent element from the pipe.

As in pitting corrosion, the alloying elements chromium, molybdenum and nickel enhance the resistance to attack and thus the resistance to crevice corrosion increases from grade 304 through 316 to 2205 and 2507.

4.4 Bimetallic (Galvanic) Corrosion

Bimetallic corrosion is liable to occur when dissimilar metals (or electron conductors which includes carbon) are in electrical contact in any electrolyte, including rainwater, condensation etc. If an electrical current flows between the two, the less noble metal (the anode) corrodes at a faster rate than would have occurred if the metals were not in contact. In general, the potential difference between the 2 metals needs to be >50 mV for significant corrosion to occur over the asset life.

This form of corrosion is particularly relevant when considering joining stainless steel and carbon or low alloy steels, weathering steel, or aluminium. It is important to ensure the filler metal is at least as noble as the most corrosion-resistant material (usually stainless steel). Likewise, if connected with fasteners, the bolting material should be equivalent to the most corrosion-resistant metal. Galvanic corrosion between different types of stainless steel is hardly ever a concern, and then, only under fully immersed conditions.

Bimetallic corrosion can be prevented by eliminating current flow by:

- Insulating dissimilar metals, i.e., breaking the conductive path
- Preventing electrolyte bridging, i.e., breaking the conductive path by paint or other coating. Where protection is sought by this means and it is impracticable to coat both metals, then it is preferable to coat the more noble one (i.e., stainless steel in the case of a stainless/carbon steel connection)

The rate of galvanic corrosion depends on the relative cathode: anode- ratio that is in contact with the electrolyte. The rate is higher for a large cathode: anode ratio. For example, a galvanised screw (anode) in a stainless steel sheet (cathode) will corrode the more quickly the bigger the stainless steel sheet is. This is because of high local current densities.

Special attention should be paid to the use of paints or other coatings on the anode. If there are any small pores or pinholes in the coating, the small anode area provides a very large cathode/anode area ratio, and severe corrosion of the anode may occur. This is, of course, likely to be most severe under immersed conditions. In these situations, it is preferable to paint the cathode also up to a distance of at least 75 mm away from where the metals are in contact so that any pores lead to small area ratios.

Adverse area ratios are likely to occur with fasteners and at joints. Carbon steel bolts in stainless steel members shall be avoided because the ratio of the area of the stainless steel to the carbon steel is large and the bolts will be subject to aggressive attack. Conversely, the rate of attack on a carbon steel or aluminium member by a stainless steel bolt is negligible. It is usually helpful to draw on previous experience in similar sites because dissimilar metals can often be safely coupled under conditions of occasional condensation or dampness with no adverse effects, especially when the conductivity of the electrolyte is low.

The prediction of these effects is difficult because the corrosion rate is determined by a number of complex variables. The use of electrical potential tables ignores the presence of surface oxide films and the effects of area ratios and different solution (electrolyte) chemical compositions. Therefore, uninformed use of these tables may produce erroneous results. They should be used with care and only for initial assessment.

The general behaviour of metals in bimetallic contact in rural, urban, industrial and coastal environments is fully documented in BS PD 6484 Commentary on corrosion at bimetallic contacts and its alleviation.

4.5 Stress Corrosion Cracking

The development of stress corrosion cracking (SCC) requires the simultaneous presence of tensile stresses and specific environmental factors unlikely to be encountered in normal building atmospheres. The stresses do not need to be very high in relation to the proof stress of the material and may be due to loading, residual effects from manufacturing processes such as welding, or bending. Ferritic stainless steels are not susceptible to SCC. Duplex stainless steels usually have superior resistance to stress corrosion cracking than the austenitic stainless steels. Higher alloy austenitic stainless steels such as grades 904L (1.4539), Alloy 926 (1.4529), 254 SMO (1.4547) and Alloy 24 (1.4565) have been developed for applications where SCC is a corrosion hazard.

Caution should be exercised when stainless steel members containing high residual stresses (e.g., due to cold working) are used in chloride rich environments (e.g., marine, offshore). Highly loaded cables in chloride-rich environments may be susceptible to SCC, depending on the grade of stainless steel.

4.6 General (Uniform) Corrosion

Under normal conditions typically encountered in structural applications, stainless steels do not suffer from the general loss of section that is characteristic of corrosion in non-alloyed irons and steels.

Reference shall be made to tables in Manufacturers' literature; alternatively, the advice of a specialist corrosion engineer should be sought, particularly if the stainless steel is to come into contact with chemicals.

4.7 Intergranular Corrosion (Sensitisation) & Weld Decay

When austenitic stainless steels are subject to prolonged heating in the range 450°C to 850°C, the carbon in the steel diffuses to the grain boundaries and precipitates chromium carbide. This removes chromium from the solid solution and leaves a lower chromium content adjacent to the grain boundaries. Steel in this condition is termed "sensitized". The grain boundaries become prone to preferential attack on subsequent exposure to a corrosive environment. This phenomenon is known as "weld decay" when it occurs in the heat affected zone of a weldment.

There are three ways to avoid intergranular corrosion:

- Use steel having a low carbon content, like 316L
- Use steel stabilised with titanium or niobium e.g., 321 (1.4541), 316Ti (1.4571), 441 (1.4509), 444 (1.4521) or 445 (1.4621), because these elements combine preferentially with carbon to form carbides, thereby reducing the risk of forming chromium carbide
- Use heat treatment, however this method is rarely used in practice.

Regarding austenitic or duplex stainless steels, a low carbon content (0.03% maximum) stainless steel should be specified when welding sections to avoid sensitisation and intergranular corrosion. Intergranular corrosion is now very uncommon in austenitic or duplex stainless steels because modern steel making practice ensures low carbon contents and thus avoids the problem.

Ferritic stainless steels are more prone to sensitization due to welding than austenitic stainless steels. Therefore, even with a low carbon content, it is still important to use a stabilized ferritic grade for welded sections.

5 Grade Selection

The selection of an appropriate stainless steel grade must consider the service environment, fabrication requirements like bend radii and welding, surface finish, and the maintenance of the structure.

The first step in material selection is to characterise the service environment, including reasonably anticipated deviations from the nominal design conditions. In addition to exposure to corrosive substances, operational, climate and design details that can influence performance must be considered as well as the expected service life. For example, in exterior applications, exposure to heavy cleaning rain (or degree of sheltering), moisture levels (e.g., humidity, rain heaviness, fog), airborne particulate levels, salt spray (e.g., a rocky coast), splashing or immersion in chloride (salt) water, and similar factors must be considered.

Candidate grades can then be chosen to give overall satisfactory corrosion resistance in the anticipated environment. The selection of a suitable steel should consider which possible forms of corrosion might occur. Consideration should then be given to mechanical properties, ease of fabrication, availability of product forms, surface finish and costs.

5.1 Grade Selection for Atmospheric Exposure - Austenitic & Duplex Stainless Steels

SA Water has adopted the EN 1993-1-4 specified procedure for the selection of stainless steel in atmospheric exposure.

Please note, the procedure does not take into account:

- grade/product availability
- surface finish requirements, for example for architectural or hygiene reasons
- methods of joining/connecting.

The procedure assumes that the following criteria will be met:

- the service environment is in the near neutral pH range (pH 4 to 10)
- the structural parts are not directly exposed to, or part of, a chemical process flow stream
- the service environment is not permanently or frequently immersed in seawater.

If these conditions are not met, specialist advice shall be sought.

The procedure involves the following steps:

- Determine the Corrosion Resistance Factor (CRF) for the environment (Table 2, Table 3 and Table 4)
- Determine the Corrosion Resistance Class (CRC) from Table 5.
- Use Table 6 to select appropriate grades for the corresponding CRC. The choice of a specific grade within a CRC will depend on other factors in addition to corrosion resistance, such as strength and availability in the required product form.

The procedure applies to components exposed in external environments.

For components in internally controlled environments, the CRF is 1.0. An internally controlled environment is one which is either air-conditioned, heated or contained within closed doors.

Multi-storey car parks, loading bays or other structures with large openings should be considered as external environments.

The CRF depends on the severity of the environment and is calculated as follows:

$$CRF = F_1 + F_2 + F_3$$

Where:

F_1 = Risk of exposure to chlorides from salt water (Table 2)

F_2 = Risk of exposure to sulphur dioxide (Table 3)

F_3 = Cleaning regime or exposure to washing by rain (Table 4)

Different parts of the same structure may have different exposure conditions, for example one part may be fully exposed and another part fully sheltered. Each exposure case should be assessed separately.

The procedure assumes that the requirements of TS 0420 are followed in relation to welding procedures and post weld cleaning, and avoidance or removal and cleaning of contamination of the stainless steel surfaces after thermal or mechanical cutting. Failure to do so may reduce the corrosion resistance of welded parts.

Table 2: Corrosion Factor F_1 Risk of Exposure to Chlorides

F_1	Risk of Exposure	Atmospheric Corrosivity Category to AS 4312
1	Internally controlled environment	C1
0	Low risk of exposure	C2
-3	Medium risk of exposure	C3
-7	High risk of exposure	C4
-10	Very high risk of exposure	C5
-15	Very high risk of exposure	CX

Table 3: Corrosion Factor F_2 Risk of Exposure to Sulphur Dioxide

F_2	Risk of Exposure	Average Gas Concentration
0	Low risk of exposure	<10 µg/m³
-5	Medium risk of exposure	10 - 90 µg/m³
-10	High risk of exposure	90 - 250 µg/m³

Table 4: Corrosion Factor F_3 of Cleaning Regime/Exposure to Washing by Rain

F_3	Cleaning Regime or Exposure to Washing by Rain	Note
0	Fully exposed to washing by rain	**if $F_1 + F_2 \geq 0$, then $F_3 = 0$**
-2	Specified cleaning regime	
-7	No washing by rain or no specified cleaning	

Table 5: Determination of Corrosion Resistance Class

Corrosion Resistance Factor (CRF)	Corrosion Resistance Class (CRC)
CRF = 1	I
0 ≥ CRF > -7	II
-7 ≥ CRF > -15	III
-15 ≥ CRF ≥ -20	IV
CRF < -20	V

Table 6: Grades in Each Corrosion Resistance Class

Corrosion Resistance Class (CRC)				
I	II	III	IV	V
1.4003 (304L)	1.4301 (304)	1.4401 (316)	1.4439 (317LMN)	1.4565 (Alloy 24)
1.4016 (304L)	1.4307 (304L)	1.4404 (316L)	1.4462 (2205)	1.4529 (25-6Mo)
1.4512 (409)	1.4311 (304LN)	1.4435 (316L)	1.4539 (904L)	1.4547 (254SMO)
	1.4541 (329)	1.4571 (316Ti)		1.4410 (2507)
	1.4318 (301LN)	1.4429 (926)		1.4501 (327)
	1.4306 (304L)	1.4432 (316L)		1.4507 (255)
	1.4567 (304 Cu)	1.4162 (LDX2101)		
	1.4482 (32001)	1.4362 (2304)		
		1.4062 (DX2202)		
		1.4662 (LDX2404)		
		1.4578 (-)		

5.2 Grades & Designations of Stainless Steel

Stainless steel is the name given to a family of corrosion and heat resistant steels containing a minimum of 13% wt. chromium.

There is a wide range of stainless steels with varying levels of corrosion resistance and strength. This array of stainless steel properties is the result of controlled alloying element additions, each affecting mechanical properties and the ability to resist different corrosive environments.

With a combination of the chromium content above 13 wt%, a clean surface and exposure to air or any other oxidizing environment, a transparent and tightly adherent layer of chromium-rich oxide forms spontaneously on the surface of stainless steel. If scratching or cutting damages the film, it reforms immediately in the presence of oxygen. Although the film is very thin, about 5×10^{-6} mm, it is both stable and nonporous. As long as the stainless steel is corrosion resistant enough for the service environment, it will not react further with the atmosphere. For this reason, it is called a passive film. The stability of this passive layer depends on the composition of the stainless steel, its surface treatment, and the corrosiveness of its environment. Its stability increases as the chromium content increases and is further enhanced by alloying additions of molybdenum and nickel.

Stainless steels can be classified into five groups in accordance with their microstructure, which results primarily from their chemical composition. Each group has different properties, particularly in respect of strength, corrosion resistance and ease of fabrication. For an estimation as to what type of steel phase a particular steel composition is, refer to the Schaeffler diagram.

5.2.1 Austenitic Stainless Steels

The most widely used austenitic stainless steels are based on 17 to 18% wt. chromium and 8 to 11% nickel additions. In comparison to structural carbon steels, which have a body-centred cubic atomic (crystal) structure, austenitic stainless steels have a face-centred cubic atomic structure. As a result, austenitic stainless steels, in addition to their corrosion resistance, have high ductility, are easily cold formed, and are readily weldable. Relative to structural carbon steels, they also have significantly better toughness over a wide range of temperatures. They can be strengthened by cold working, but not by heat treatment. Their corrosion performance can be further enhanced by higher levels of chromium and additions of molybdenum and nickel, as well as the addition of alloying elements that strengthen the austenitic phase, like nitrogen.

Steels of this group are the most common in structures, particularly grades 304 and 316 and their low carbon variants, 304L and 316L. The low carbon 'L' variants of grades 304 and 316 contain a maximum of 0.03% wt. carbon. This greatly reduces their susceptibility to sensitization by the heat of welding. The use of 'L' grades generally gives no significant advantage for section thicknesses less than about 6 mm.

5.2.2 Ferritic Stainless Steels

The chromium content of the most popular ferritic stainless steels is between 10.5 wt% and 18 wt%. Ferritic stainless steels contain either no or very small nickel additions and their body-centred atomic structure is the same as that of structural carbon steels. They are generally less ductile and less weldable than austenitic stainless steels. The forming and machining properties of ferritic stainless steels are similar to those of structural carbon steel. They can be strengthened by cold working, but to a more limited degree than the austenitic stainless steels. Like the austenitic grades, they cannot be strengthened by heat treatment. Typical applications are in interior and mild exterior atmospheric conditions. They have good resistance to stress corrosion cracking and their corrosion performance can be further enhanced by additions of molybdenum. They offer a corrosion resistant alternative to many light gauge galvanized steel applications. Ferritic grades are generally used in gauges of 4 mm and below.

5.2.3 Duplex (Austenitic-Ferritic) Stainless Steels

Duplex and super duplex stainless steels have a mixed microstructure of austenite and ferrite, and so are sometimes called austenitic-ferritic steels. They typically contain 20 to 26 wt% chromium, 1 to 8 w% nickel, 0.05 to 5 wt% molybdenum, and 0.05 to 0.3 wt% nitrogen. They are about twice as strong as austenitic steels in the annealed condition which can make section size reduction possible. They are suitable for a broad range of corrosive environments. Although duplex stainless steels have good ductility, their higher strength results in more restricted formability, compared to the austenitic alloys. They can also be strengthened by cold working, but not by heat treatment. They have good weldability and good resistance to stress corrosion cracking. They can be seen as being complementary to ferritic stainless steels, as they are more likely to be used in heavier gauges.

5.2.4 Martensitic Stainless Steels

Martensitic stainless steels have a similar body-centred cubic structure as ferritic stainless steel and structural carbon steels, but due to their higher carbon content, they can be strengthened by heat treatment. Martensitic stainless steels are generally used in a hardened and tempered condition, which gives them high strength, and provides moderate corrosion resistance. They are used for applications that take advantage of their wear and abrasion resistance and hardness, like cutlery, surgical instruments, industrial knives, wear plates and turbine blades. They are less ductile and more notch sensitive than the ferritic, austenitic and duplex stainless steels. Although most martensitic stainless steels can be welded, this may require preheat and post weld heat treatment, which can limit their use in welded components.

5.2.5 Precipitation Hardening Stainless Steels

Precipitation hardening steels can be strengthened by heat treatment to very high strengths and fall into three microstructure groups depending on the grade: martensitic, semi-austenitic and austenitic. These steels are not normally used in welded fabrication. Their corrosion resistance is generally better than the martensitic stainless steels and similar to the 18% chromium, 8% nickel austenitic stainless steels. Although they are mostly used in the aerospace industry, they are also used for tension bars, shafts, bolts and other applications requiring high strength and moderate corrosion resistance.

5.2.6 Stainless Steel Designations

Table 7 provides the correlations between EN 10088 and US designations.

Table 7: Correlation Between Stainless Steel Designations

US Designations		Steel grade to EN 10088	
ASTM Type	**UNS**	**No.**	**Name**
Austenitic			
304	S30400	1.4301	X5CrNi18-10
304L	S30403	1.4307, 1.4306	X2CrNi18-9
316	S31600	1.4401	X5CrNi Mo17-12-2
316L	S31603	1.4404, 1.4432	X2CrNiMo17-12-2
904L	N08904	1.4539	X1NiCrMoCu25-20-5
321	S32100	1.4541	X6CrNiTi18-10
Alloy 24	S34565	1.4565	X2CrNiMnMoN25-18-6-5
(304 Cu)	S30430	1.4567 *	X3CrNiCu18–9-4
316Ti	S31635	1.4571	X6CrNiMoTi17-12-2
-	-	1.4578 *	X3CrNiCuMo17–11–3-2
254 SMO	S31254	1.4547	X1CrNiMoCuN20-18-7
Lean Duplex			
2304	S32304	1.4362	X2CrNiN23-4
329	S32900	1.4460	
LDX2101	S32101	1.4162	X2CrMnNiN21-5-1
LDX2404	S82441	1.4662 *	X2CrNiMnMoCuN24–4-3–2
Duplex			
2205	S32205	1.4462	X2CrNiMoN22-5-3
Super Duplex			
2507	S32750	1.4410	X2CrNiMoN25-7-4
Zeron 100	S32760	1.4501 *	X2CrNiMoCuWN25–7-4
Ferritic			
430	S43000	1.4016	X6Cr17
431	S43100	1.4057	X16CrNi16-2
441+	S43940	1.4509	X2CrTiNb18
409	S40900	1.4512	X2CrTi12
444	S44400	1.4521	X2CrMoTi18-2

Notes:

All the above steels are in EN 10088-4/5 except for those marked with *, which are currently only in EN 10088-2/3.

Commonly used trade names.

+ 441 is a common trade name for this grade but not an ASTM type.

5.3 Grade Selection for Buried / Below Ground Applications

Buried Stainless Steel material has substantial additional risks compared to above ground Stainless Steel, as there is greater potential for contact with more aggressive/corrosive environments and low oxygen, and therefore is not preferred by SA Water (refer TS 0109).

Soils differ in their corrosiveness depending on moisture level, pH, aeration, presence of chemical contamination, microbiological activity and surface drainage.

If the stainless steel material must be buried, a TDRF is to be submitted, with due consideration of the details provided in this Section to ensure design life is achieved.

Stainless steels generally perform well in a variety of soils and especially well in soils with high resistivity, although some pitting can occur in low resistivity, moist soils. The presence of aggressive chemical species such as chloride ions as well as types of bacteria and stray current (caused by local direct current electric transportation systems such as railways or tram systems) can cause localised corrosion. The development of stray current can be suppressed with a proper electrical insulation of the pipe (coatings or wrappings) and/or cathodic protection.

Where a structure is situated both below and above ground, undertake one of the following:

- Select a common grade of stainless steel for the entire structure. Select a material that will provide the required asset life in both environments
- Select different materials for the below ground and above ground environment. Transition from one to the other at approximately 500mm above the finished surface level. Where different metals are to be joined, ensure that dissimilar metal corrosion risks are adequately controlled by insulating one metal from the other.

For grade selection purposes, it is recommended to consider the corrosion resistance of buried stainless steel firstly in relation to the presence of chloride ions and secondly according to the soil resistivity and pH, assuming poorly drained soils in all cases.

Table 8 recommends suitable grades for different soil conditions where the following is true:

- no stray currents,
- no anaerobic bacteria, and
- the pH >4.5.

Table 8: Buried Soil Conditions (ASSDA FAQ 7)

<table>
<tr><th rowspan="2">Resistivity (Ohm-cm)</th><th colspan="4">Maximum Chloride ion Concentration Cl^- (ppm or mg/L)</th></tr>
<tr><th>200</th><th>1,000</th><th>2,000</th><th>15,000</th></tr>
<tr><td>>5,000</td><td colspan="2">304 / 304L</td><td>316 / 316L / 2304</td><td>2205</td></tr>
<tr><td>2,000 - 5,000</td><td colspan="2">316 / 316L / 2304</td><td>2205</td><td>2507 (super duplex)</td></tr>
<tr><td>1,000 - 2,000</td><td colspan="2">2205</td><td colspan="2">2507 (super duplex)</td></tr>
<tr><td><1,000</td><td colspan="4">2507 (super duplex)</td></tr>
</table>

Once a grade is selected, the following should be considered:

- Uniform soil packing is required as variable compaction can induce differential aeration effects
- Avoid organic materials in the fill around buried stainless steel as they can encourage microbiological attack
- Avoid carbon-containing ash in contact with metals in soils. Localised galvanic attack of the metal can occur
- Oxygen access is critical. Having good drainage and sand backfill provides this. A sand-filled trench dug through clay may become a drain and it is not appropriate. Stainless

steels generally retain their passive film provided there is at least a few ppb of oxygen, i.e., 1000 times less than the concentration in water exposed to air

- Chlorides are the most frequent cause of problems with stainless steels. In soils, the level of chlorides vary with location, depth and, in areas with rising salinity, with time. High surface chlorides may also occur with evaporation. This is a problem for all metals although stainless steels are not usually subject to structural failure.

5.4 Grade Selection for Aqueous Environments

5.4.1 General

Chloride and chlorine are two common water chemistry components that challenge the successful application of stainless steel. Other factors, like pH and temperature, may also come into play when selecting stainless steel grades.

Chloramines (in place of free chlorine) may work in favour of stainless steel because of the higher associated pH values. At higher pH (≥8) and under deaerated conditions, crevice corrosion mechanisms are unlikely to occur for the stainless-steel materials.

Water sources with extreme water quality conditions, like brine solutions and seawater, where the chloride content exceeds 18,000 mg/L, or where the amount of free chlorine in solution is 7 mg/L or higher, typically require the use of the “super-austenitic” and “super duplex” stainless steel alloys.

As per the Nickel Institute guidelines for continuous exposure of various grades of stainless steel at ambient temperatures (~20°C) and neutral pH (pH~ 7).

Table 9: Aqueous Environments

Condition	Alloy
< 50 ppm chlorides (water)	304
< 200 ppm chlorides (water)	316
200 – 1,000 ppm chlorides (water)	316 / 2205
1,000 – 3,600 ppm chlorides (water)	2205 / 6% Mo super-austenitic and super-duplex grades
> 3,600 ppm chlorides (Brackish water)	6% Mo super-austenitic and super-duplex grades

5.5 Grade Selection for Water & Wastewater Treatment

5.5.1 Synergistic Effects of Chlorine, Chloride & Temperature

Significant stainless steel failures have been observed when both chlorides and chlorine were present in concentrations that previous data (looking at the constituents separately) indicated should not have been cause for concern.

Therefore, careful consideration shall be taken in selecting materials for service in aggressive chlorinated waters.

5.5.2 Microbiologically Induced Corrosion (MIC)

In stagnant and slow flowing water conditions, slimes and bacterial films can attach themselves to crevices and rough surfaces, as in the case of rough inside weld surfaces (root passes), where poor welding has been performed and resulted in incomplete through-wall welds.

Under stagnant conditions, this allows for attachment of slime formers, mould growers, microbial acid producers, sulphate producers, and metal ion oxidizers. Their rates of incubation and growth are then dependent upon the availability such water quality constituents as sulphates, iron, manganese or chlorides present in the feed water. Such microbial actions will result in pitting attack.

To help mitigate MIC issues, the following shall be considered:

- Reviewing and understanding the potential issues caused by source water chemistry (chlorides, sulphate, manganese, and iron, including bacterial presence and pH) and formulating solutions accordingly
- The specification of a higher molybdenum alloyed material or higher PRE alloy for replacement material or chosen initially if the environmental conditions have been clearly defined
- The specification of weld quality controls, bacterial filters and periodic "shock" chlorination treatments
- Careful consideration for stagnate water, especially after the equipment has undergone hydrostatic testing and when construction of well casings has been completed. In the case of hydrostatic testing, the test water should be drained, flushed out and the line or equipment blown dry. The same consideration should apply to equipment or process lines that are going to be taken out of service for some time or alternated in service with a duplicate piece of equipment.

5.5.3 Chlorine & Other Oxidants

Being added to water as a disinfectant, chlorine, next to oxygen, is the primary oxidant present in cooling waters, potable waters, and wastewaters. Chlorine can be added to water in several different forms, such as chlorine gas, liquid sodium hypochlorite, and calcium hypochlorite granules. Chlorine dissociates to form hypochlorous acid and hypochlorite. As more chlorine is added, the free chlorine (hypochlorous acid) concentration in a solution increases with some converted to chloramine when reacting with ammonia and ammoniated compounds.

The extent to which the free chlorine is converted to chloramine will affect the corrosivity of the water. The greater conversion of free chlorine to chloramines will result in an alkaline solution (pH values of 7.0 to 8.5) and less corrosive condition.

The higher the chlorine residual in water, the stainless steel becomes more vulnerable to crevice corrosion or pitting of the base metal.

Ozone is another oxidizing agent which can be used separately or in conjunction with chlorine. Type 316L has been the preferred materials of construction for ozone generators.

5.5.4 Saline Waters

Brackish water, seawater, and brine discharges are high-chloride environments typical of desalination applications. These have the following general characteristics:

- Brackish water: 3,600 – 18,000 mg/L chlorides
- Seawater: 18,000 - 20,000 mg/L chlorides
- Hyper-saline (brine) discharges: > 20,000 mg/L chlorides.

As chloride concentrations play a key role in crevice and pitting corrosion, its effect on corrosion rates in stainless steel can be quantified by the PRE.

5.5.5 Hydrogen Sulphide

Hydrogen sulphide gas is generated in the digesters and throughout much of a Wastewater Treatment Plant, contributing to the corrosion that occurs in copper alloys, aluminium and carbon steel. Stainless steel has a negligible corrosion rate when exposed to moist hydrogen sulphide, considering the other factors listed in Clause 5.5.

5.6 Grade Selection for Drinking Water Use

Table 10 can be used as a guideline for selecting stainless steel for different free chlorine-chloride environments, noting that the requirements of TS 0800 shall also apply for materials used in drinking water applications.

Table 10: Chloride & Free Chlorine Concentrations at Ambient Temperature

Chloride Concentration	Free Chlorine Concentration	Recommended Grade
$Cl^- < 200$ mg/L	$Cl_2 < 2$ mg/L	316/316L
	$Cl_2 <= 3$ mg/L	316/316L or LDX 2101
$Cl^- < 1000$ mg/L	$Cl_2 < 2$ mg/L	316/316L or LDX 2101
	$Cl_2 <= 5$ mg/L	Austenitic or Duplex with PRE >= 25 (2205)
$Cl^- < 10,000$ mg/L	$Cl_2 < 2$ mg/L	Austenitic or Duplex with PRE >= 43 (2507)
	$Cl_2 <= 5$ mg/L	Austenitic or Duplex with PRE > 43 (SMO254)
$Cl^- >= 10,000$ mg/L	$Cl_2 <= 0$ mg/L	Consult a Corrosion Specialist

Notes:

- A safety factor of 2.0 is applied to chloride concentration
- No safety factor is applied to chlorine concentration
- Use of this table does not constitute a guarantee that selecting steels will prevent corrosion
- A specialist assessment shall be sought.

5.7 Grade Selection for High Temperature

Consider using heat-treated pipe (ASTM A312) or tube (ASTM A269) rather than unannealed pipe or tube (ASTM A778) for materials to be used in temperatures greater than 200°C.

For temperatures greater than 400°C consider using Ni-based superalloys.

Duplex stainless steels should not be used at temperatures above 250°C in order to avoid sigma phase embrittlement.

5.8 Design for Corrosion Control

The most important step in preventing corrosion problems is selecting an appropriately resistant stainless steel with suitable fabrication procedures for the given environment. However, after specifying a particular steel, much can be achieved in realising the full potential of the steel's resistance by careful attention to detailing (refer Figure 1).

Anti-corrosion strategies shall be considered at the planning stage and during detailed design.

A corrosion control checklist is provided in Table 11 .

Not all recommendations would give the best detail from a structural strength point of view, and neither are they intended to be applied in all environments. In particular, in environments of low corrosivity or where regular maintenance is carried out, many would not be required.

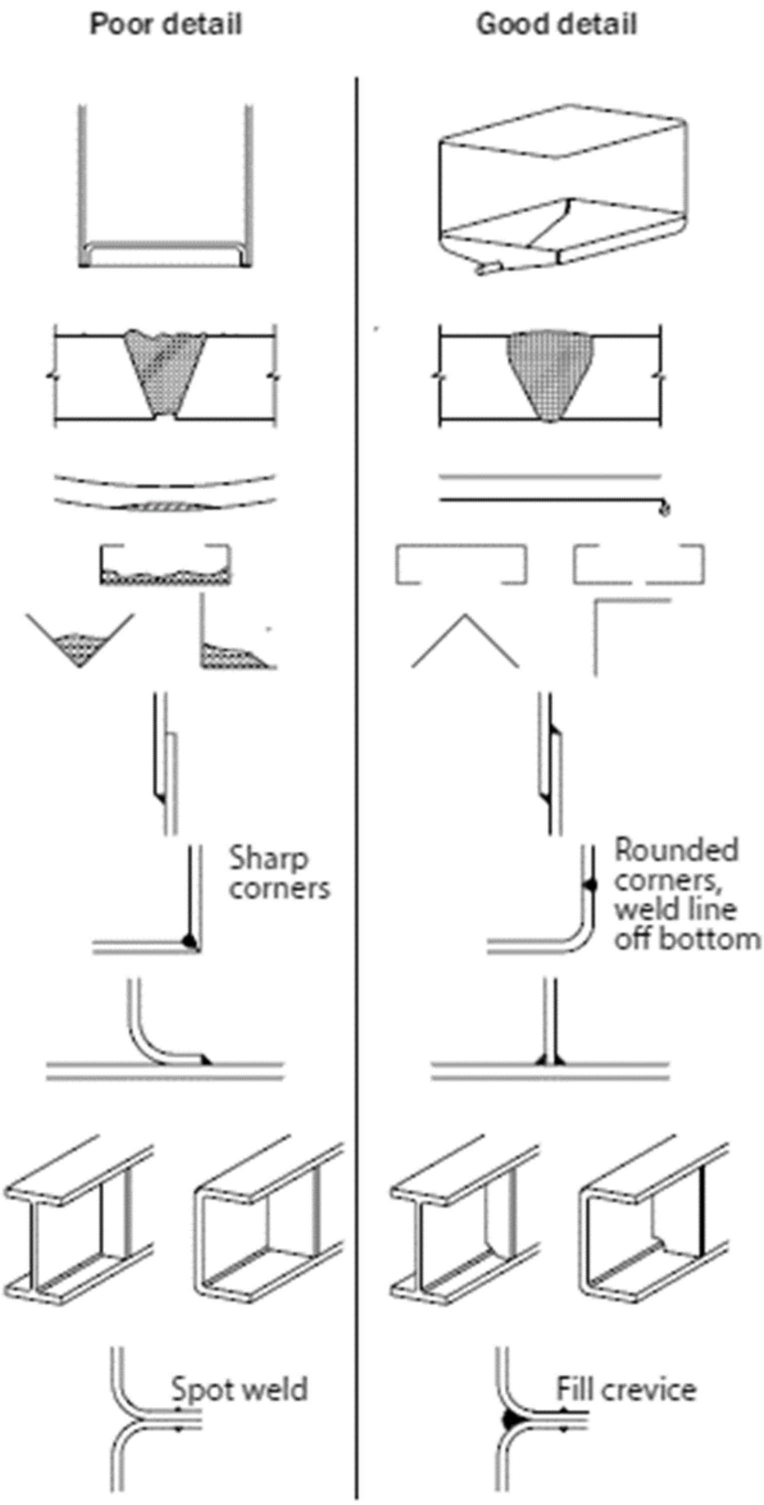

Figure 1: Detailing for Durability

Table 11: Corrosion Control Checklist

Avoid dirt, moisture and corrosive deposit entrapment
• Orient angle and channel profiles to minimise the likelihood of deposit or moisture retention • Provide drainage holes, ensuring they are of sufficient size to prevent blockage • Avoid horizontal surfaces • Specify a small slope on gusset stiffeners which nominally lie in a horizontal plane • Use tubular and bar sections (seal tubes with dry gas or air where there is a risk of harmful condensates forming) • Specify smooth finishes, or, if rougher finishes are unavoidable, orient the grain vertically if possible.
Avoid or seal crevices
• Use welded rather than bolted connections when possible • Use closing welds or mastic fillers • Preferably dress/profile welds to smooth the surface • Prevent biofouling • Use flexible inert washers or high quality sealants for above ground, non-immersed bolted connections.
Reduce the likelihood of stress corrosion cracking in those specific environments where it may occur
• Minimise fabrication stresses by careful choice of welding sequence • Shot peen (but avoid the use of iron/carbon steel shot to avoid surface embedment of carbon steel particles).
Reduce likelihood of pitting
• Remove weld spatter • Pickle stainless steel to remove heat tint. Strongly oxidising chloride-containing reagents such as ferric chloride shall be avoided; instead, a pickling bath or a pickling paste, both containing a mixture of nitric acid and hydrofluoric acid, shall be used. Welds shall always be cleaned up to restore corrosion resistance. Other means such as mechanical cleaning with abrasives or glass beads blasting, or local electrolysis may also be used to clean heat tint and welds. • Avoid pick-up of carbon steel particles (e.g., use workshop area and tools dedicated to stainless steel) • follow a suitable maintenance programme.
Reduce likelihood of bimetallic corrosion
• Provide electrical insulation between bolted metals with inert materials such as neoprene • Use paints appropriately • Minimise periods of wetness • Use metals that are close to each other in electrical potential.
Mitigate microbiologically induced corrosion (MIC)
• Avoid stagnant water conditions • Drain promptly and completely after hydrostatic testing is completed and when the facility is shut down • Dry piping where practical, or alternatively run the system for 1-2 hours per day for circular flow • Provide a design that allows the complete draining of all stainless steel pipe systems and vessels • Avoid dead legs, low points, and areas that cannot be drained completely during shutdown or standby • Apply special care in raw water systems. Ensure velocities minimize sediment deposits. Provide for inspection and sediment flushing • Use reference standards and specify practices that require full penetration welds with smooth internal contours • Require manufacturing and installation practices that prevent or remove heat tint oxide at welds • If field welds are necessary, require radiographic testing (or borescope examination) and post-weld descaling and passivation • Consider using electropolished stainless steel in areas or applications susceptible to MIC or high chloride levels.

Increase resistance to chloride crevice corrosion and pitting
• Select stainless steel materials with an appropriate PRE for the chloride concentration using the guidelines provided in this standard and seek expert advice • Avoid exposing stainless steel to chlorine vapor or air from the headspace of basins containing chlorinated water • Provide isolation between dissimilar metals to eliminate galvanic corrosion. Select appropriate fasteners of compatible stainless steel materials.

6 Materials

6.1 Stainless Steel Pipe & Tubing

Stainless steel pipe and tubing shall comply with the requirements of the reference standard listed in Table 12.

Table 12: Reference Standards: Stainless Steel Pipe & Tubing

Common Name	PRE*	Pipe			Tube
		Material Standard	Manufacturing Standard	Dimensional Standards (Where Applicable)	
Austenitic Stainless Steel					
304 **	20	ASTM A240	≥ 3" ASTM A778 < 3" ASTM A312	General Service: AWWA C220 High Pressure, Desalination: ASME B36.19	ASTM A269
304L **	20				
316 **	25				
316L **	25				
Duplex Stainless Steel					
LDX 2101	27	ASTM A240	ASTM A790	ASME B36.19	ASTM A789
2205	34		General Corrosive Service: ASTM A790 Corrosive Service: ASTM A928		
Super Duplex Alloys					
2507	43	ASTM A240	General Corrosive Service: ASTM A790 Corrosive Service: ASTM A 928	ASME B36.19	ASTM A789
Ferralium 255	39		ASTM A790		
Zeron 100	41				
Super-Austenitic Alloys					
AL6XN	46	ASTM A240	ASTM A312	ASME B36.19	ASTM A269
254 SMO	43				
654 SMO	57				
Other					
416	‡	†	†	†	†
17-4PH	‡	†	†	†	†
Super Alloys					
Hastelloy C-22	65	ASTM B575	ASTM B619	ASME B36.19	ASTM B622
Hastelloy C-276	68				
Inconel 625	52				

Notes:

* PRE: Pitting Resistance Equivalent

** Types 304/304L and 316/316L stainless steels are also offered as "dual certified" material, which offers the material properties of low carbon stainless steel, making it suitable for welding (flat & rolled products), with nitrogen additions to provide and meet the minimum mechanical properties offered by standard material.

† For general water industry applications, this alloy is only used as bar stock in valves, pump shafts, bolts, etc.

‡ PRE is not applicable to 416, or 17-4PH (no austenitic microstructure)

6.2 Stainless Steel Pipe Fittings

Stainless steel pipe fittings shall comply with the requirements of the reference standard listed in Table 13.

Table 13: Reference Standards: Stainless Steel Pipe Fittings

<table>
<tr><th rowspan="2">Common Name</th><th rowspan="2">Cast Name</th><th rowspan="2">UNS No. (Cast)</th><th rowspan="2">PRE</th><th colspan="2">Pipe flanges, fittings, and valves</th></tr>
<tr><th>Manufacturing Standard</th><th>Dimensional Standard (Where Applicable)</th></tr>
<tr><td colspan="6">Austenitic Stainless Steel</td></tr>
<tr><td>304 *</td><td>CF8</td><td>J92600</td><td>20</td><td>Wrought, < 3": ASTM A403,
Class WP Forged, all sizes: ASTM A182</td><td rowspan="4">General Service:
Fittings with welded ends: AWWA C226
Fittings with flanged ends ≥ 2": AWWA C228
High Pressure, Desalination Service:
Fittings with welded ends ≥ 3": ASME B36.19
Fittings with flanged ends ≥ 3": ASME B16.5
Fittings < 3": ASME B16.11</td></tr>
<tr><td>304L *</td><td>CF3</td><td>J92500</td><td>20</td><td>Wrought, ≥ 3": ASTM A774
Wrought, < 3": ASTM A403,
Class WP Forged, all sizes: ASTM A182</td></tr>
<tr><td>316 *</td><td>CF8M</td><td>J92900</td><td>25</td><td>Wrought, < 3": ASTM A403,
Class WP Forged, all sizes: ASTM A182</td></tr>
<tr><td>316L*</td><td>CF3M</td><td>J92800</td><td>25</td><td>Wrought, ≥ 3": ASTM A774
Wrought, < 3": ASTM A403,
Class WP Forged, all sizes: ASTM A182</td></tr>
<tr><td colspan="6">Duplex Stainless</td></tr>
<tr><td>LDX 2101</td><td>†</td><td>†</td><td>27</td><td>Wrought, all sizes: ASTM A815
Forged, all sizes: ASTM A182</td><td>Fittings with welded ends ≥ 3": ASME B36.19
Fittings with flanged ends ≥ 3": ASME B16.5
Fittings < 3": ASME B16.11</td></tr>
<tr><td>2205</td><td>CD3MN</td><td>J92205</td><td>34</td><td rowspan="4">Wrought, all sizes: ASTM A815
Forged, all sizes: ASTM A182</td><td rowspan="4">Fittings with welded ends: ASME B36.19
Fittings with flanged ends: ASME B16.5</td></tr>
<tr><td>2507</td><td>CE3MN</td><td>J93404</td><td>43</td></tr>
<tr><td>Ferralium 255</td><td>CD3MCuN</td><td>J93373</td><td>39</td></tr>
<tr><td>Zeron 100</td><td>CD3MWCuN</td><td>J93380</td><td>41</td></tr>
<tr><td>AL6XN</td><td>CN3MN</td><td>J94651</td><td>46</td><td>Wrought, all sizes: ASTM B366
Forged, all sizes: ASTM A182</td><td>Fittings with butt welded ends: ASME B16.9
Fittings with threaded ends: ASME B16.11
Fittings with socket ends: ASME B16.11
Fittings with flanged ends: ASME B16.5</td></tr>
</table>

Common Name	Cast Name	UNS No. (Cast)	PRE	Pipe flanges, fittings, and valves	
				Manufacturing Standard	Dimensional Standard (Where Applicable)
Super duplex Alloys - Super-Austenitic Alloys					
254 SMO	CK3MCu	J93254	43	Wrought, all sizes: ASTM A403 Forged, all sizes: ASTM A182	Fittings with welded ends: ASME B36.19 Fittings with flanged ends: ASME B16.5
654 SMO	†	†	57	†	†
Other					
416	‡	‡†	§	‡	‡
17-4PH	‡	‡†	§	‡	‡
Super Alloys					
Hastelloy C-22	CX2MW	N26022	65	Wrought, all sizes: ASTM B366 Forged, all sizes: ASTM B564	Fittings with butt welded ends: ASME B16.9 Fittings with threaded ends: ASME B16.11 Fittings with socket ends: ASME B16.11 Fittings with flanged ends: ASME B16.5
Hastelloy C-276	CW12MW	N30002	68		
Inconel 625		N06625	52		

Notes:

* Types 304/304L and 316/316L stainless steels are also offered as "dual certified" material, which offers the material properties of low carbon stainless steel, making it suitable for welding (flat & rolled products), with nitrogen additions to provide and meet the minimum mechanical properties offered by standard material

† No UNS designation or ASTM standards exist for fittings or cast materials

‡ For general water industry applications, this alloy is only used as bar stock in valves, pump shafts, bolts, etc.

§ PRE is not applicable 416, or 17-4PH.

6.3 Stainless Steel Cast Shapes & Equipment

Stainless steel cast shapes and equipment shall comply with the requirements of the reference standard listed in Table 14.

Table 14: Reference Standards: Stainless Steel Cast Shapes & Equipment

Common Name	Cast Name	UNS No. (Cast)	PRE	Castings
Austenitic Stainless Steel				
304 *	CF8	J92600	20	ASTM A351
304L *	CF3	J92500	20	
316 *	CF8M	J92900	25	
316L*	CF3M	J92800	25	
Duplex Stainless				
LDX 2101	†	‡	27	†
2205	CD3MN	J92205	34	General Application: ASTM A890 Pressure Containing Parts: ASTM A995

Common Name	Cast Name	UNS No. (Cast)	PRE	Castings
Super duplex Alloys				
2507	CE3MN	J93404	43	General Application: ASTM A890 Pressure Containing Parts: ASTM A995
Ferralium 255	CD3MCuN	J93373	39	
Zeron 100	CD3MWCuN	J93380	41	
Super-Austenitic Alloys				
AL6XN	CN3MN	J94651	46	General Application: ASTM A743 Severe Corrosion Applications: ASTM A744
254 SMO	CK3McuN	J93254	43	
654 SMO	†	†	57	†
Other				
416	‡	‡†	§	‡
17-4PH	‡	‡†	§	‡
Super Alloys				
Hastelloy C-22	CX2MW	N26022	65	ASTM A494
Hastelloy C-276	CW12MW	N30002	68	
Inconel 625		N06625	52	

Notes:

* Types 304/304L and 316/316L stainless steels are also offered as "dual certified" material, which offers the material properties of low carbon stainless steel, making it suitable for welding (flat & rolled products), with nitrogen additions to provide and meet the minimum mechanical properties offered by standard material.

† No UNS designation or ASTM standards exist for fittings or cast materials.

‡ For general water industry applications, this alloy is only used as bar stock in valves, pump shafts, bolts, etc.

§ PRE is not applicable to, 416, or 17-4PH.

6.4 Stainless Steel Bar Shapes & Fasteners

Stainless steel bar shapes and fasteners shall comply with the requirements of the reference standard listed in Table 15.

Table 15: Reference Standards: Stainless Steel Bar Shapes & Fasteners

Common Name	PRE	Bar Shapes	Fasteners
Austenitic Stainless Steel			
304*	20	ASTM A276[§§]	ISO 3506
304L *	20	ASTM A276	ISO 3506
316*	25	ASTM A276	Bolts (General Service): ASTM F 593, Group 2, Condition CW Bolts (High Pressure Service): ASTM A 193 Nuts (General Service): ASTM F 594, Group 2 Nuts (High Pressure Service): ASTM A 194 ISO 3506
316L*	25	ASTM A276	Bolts (General Service): ASTM F 593, Group 2, Condition CW Nuts (General Service): ASTM F 594, Group 2 ISO 3506

<table>
<tr><th>Common Name</th><th>PRE</th><th>Bar Shapes</th><th>Fasteners</th></tr>
<tr><td colspan="4">Duplex Stainless</td></tr>
<tr><td>LDX 2101</td><td>27</td><td rowspan="2">ASTM A276</td><td>‡</td></tr>
<tr><td>2205</td><td>34</td><td>ISO 3506</td></tr>
<tr><td colspan="4">Super duplex Alloys</td></tr>
<tr><td>2507</td><td>43</td><td rowspan="3">ASTM A276</td><td>ISO 3506</td></tr>
<tr><td>Ferralium 255</td><td>39</td><td>‡</td></tr>
<tr><td>Zeron 100</td><td>41</td><td>‡</td></tr>
<tr><td colspan="4">Super-Austenitic Alloys</td></tr>
<tr><td>AL6XN</td><td>46</td><td rowspan="3">ASTM A276</td><td>‡</td></tr>
<tr><td>254 SMO</td><td>43</td><td>‡</td></tr>
<tr><td>654 SMO</td><td>57</td><td>‡</td></tr>
<tr><td colspan="4">Other</td></tr>
<tr><td>416</td><td>**</td><td>ASTM A582</td><td>§</td></tr>
<tr><td>17-4PH</td><td>**</td><td>ASTM A564</td><td>§</td></tr>
<tr><td colspan="4">Super Alloys</td></tr>
<tr><td>Hastelloy C-22</td><td>65</td><td rowspan="2">ASTM B574</td><td>‡</td></tr>
<tr><td>Hastelloy C-276</td><td>68</td><td>‡</td></tr>
<tr><td>Inconel 625</td><td>52</td><td>ASTM B446</td><td>‡</td></tr>
<tr><td colspan="4">* Types 304/304L & 316/316L stainless steels are also offered as “dual certified” material, which offers the material properties of low carbon stainless steel, making it suitable for welding (flat & rolled products), with nitrogen additions to provide and meet the minimum mechanical properties offered by standard material.
** PRE is not applicable to 416, or 17-4PH.
† For general purposes, 304 and 304L fasteners are not recommended for water industry applications. See following note.
‡ For general purposes, when the fasteners are not submerged, 316 or 316L bolt material is acceptable. Where additional corrosion resistance is desired (e.g., submerged or corrosive atmosphere), fasteners fabricated from suitable material for the exposure are recommended. Otherwise, consult a corrosion engineer.
§ For general water industry applications, this alloy is only used as bar stock in valves, pump shafts, bolts, etc.
§§ There are 2 major specs for bar, one is A276, and the other is A479. These are valid for all the alloys down to and including 654SMO.</td></tr>
</table>

All bolts, nuts and washers shall be either electropolished or passivated in accordance with ASTM A380. Nuts shall be lubricated with an anti-seize lubricant subject to the approval of SA Water.

The anti-seize compound shall be serviceable up to 80°C and UV stable. Anti-seize compounds containing graphite or other elemental carbon shall not be used. (Note: some anti-seize compounds sold as marine grade contain graphite and are not suitable for use with stainless steel).

6.5 Chain & Wire Rope

Stainless steel lifting chains, master links, dee shackles, clevis shackles, clevis hooks, lifting eye hooks and lifting points shall:

- Comply with AS 4797- Stainless Steel Chain for Lifting Purposes
- Be constructed from minimum Grade 50 grade 316L (low carbon) stainless steel or any higher grade of low carbon stainless steel as required to suit the conditions
- Contain welded or forged joints where practical
- Come with test certificates indicating that the item(s) have been tested to AS 4797
- Have a certified Safe Working Load (SWL) equal to or greater than the forces to which the item will be subjected
- Come with SWL permanent markings as per AS4797
- Be used within the Manufacturer's documented limitations.

Stainless steel wire rope shall:

- Not be used for lifting people or heavy objects (e.g., pumps) unless:
    - Assessed and deemed appropriate as part of Safety in Design (refer TS 0101) and
    - Designed with an appropriate factor of safety and consideration of inspection/maintenance requirements.
- Comply with AS 3569 - Steel wire ropes - Product specification
- Use swages / crimps which are constructed from 316 or any higher grade of stainless steel required to suit the conditions.

6.6 Materials in Contact with Drinking Water

All stainless steel related materials shall comply with TS 0800 – "Materials in Contact with Drinking Water". A compliance certificate shall be provided before proceeding with the works covers the requirements for materials in contact with potable water.

6.7 Material Testing & Verification

Prior to the commencement of fabrication, the Constructor or Fabricator shall provide the SA Water Representative with copies of stainless steel material test certificates, showing the chemical properties and results of all mechanical testing for the material being used. This constitutes a **HOLD POINT** under this Standard.

If material test certificates are not available, then the Constructor shall submit a TDRF to SA Water accompanied by test data for tensile strength and elongation, cold and temper bend tests and chemical analysis in accordance with the appropriate standard at no expense to SA Water.

- Minimum testing requirements are 2% of each size and grade of product with a minimum sample size of one for each size and grade of the stainless steel. Stainless steel fabrication shall not commence until the SA Water has reviewed and approved the material test certificates or material testing as appropriate.
- The material testing shall be carried out by a NATA approved testing centre and in accordance with the relevant American Society for Testing and Materials (ASTM) standards and the ASSDA 'Guide for Stainless Steels'.
- On site verification can be conducted via Positive Material Identification (PMI) instrument.

6.7.1 Stainless Steel Bolts, Nuts & Washers

6.7.1.1 Grade

Stainless steel bolts, nuts and washers shall be Grade 316 (UNS S31600, A4 classification) and be minimum class 70 (i.e., A4-70) or ASTM A320 Gr B8 or similar for piping.

All stainless steel bolts and nuts shall conform to the requirements of ISO 3506. Materials manufactured to other standards will be accepted provided the material comply with the appropriate ISO standard.

Stainless steel bolts and nuts shall have ISO coarse pitch metric rolled threads. To reduce the likelihood of galling the following shall be implemented:

- Bolting materials should be in the cold worked condition (i.e., not softened)
- Rolled thread, as opposed to machined threads, shall be used
- Fine threads and tight-fitting thread forms shall not be used
- Anti-seize lubrication shall be used
- Lock welding of nuts is not permitted.

Table 16 contains a list of acceptable fastener materials to use based on the structural material to avoid galvanic corrosion. This is recreated from "An Introduction to Corrosion and Control" published by the Australian Corrosion Association (ACA).

Table 16: Fastener Selection to Avoid Galvanic Corrosion (ACA, 1998)

Structural Material	Fastener Material					
	Zn coated steel	Aluminium	Carbon Steel	Copper, Brass, Bronze	Monel	304/316 stainless steel
Galvanized Steel	Recommended	Satisfactory	Satisfactory	Not recommended	Satisfactory	Satisfactory
Aluminium	Satisfactory	Recommended	Satisfactory	Not recommended	Satisfactory	Recommended * Note
Carbon Steel	Recommended	Not recommended	Satisfactory	Recommended	Recommended	Recommended
Copper	Not recommended	Not recommended	Not recommended	Recommended	Recommended	Variable
Monel	Not recommended	Not recommended	Not recommended	Not recommended	Recommended	Variable
304/316 Stainless Steel	Not recommended	Not recommended	Not recommended	Not recommended	Variable	Recommended

Note:

* When using aluminium materials and stainless steel bolts, enlarge the bolt holes, therefore ensure that the stainless steel fasteners are adequately isolated with washers.

6.7.1.2 Material Certificate

The bolt supplier shall supply the Fabricator with a certified material test certificate outlining the chemical composition and mechanical properties of all bolts being supplied for a given project. The test certificate and MDR provide a means to broadly locate a batch of bolts, to ensure any defects with the batch that are later identified can be readily addressed. If multiple batches are used, traceability down to each individual bolt is not expected, but the general location of their use is required.

The material test certificates for each batch of bolts shall be reviewed and approved by the Designer prior to being used. This constitutes a **WITNESS POINT** under this Standard.

6.7.1.3 Installation

As with high-strength bolts, proper joint fit-up that does not induce bending into the bolts, selection of proper bolt length to allow full nut engagement, and requirements related to the use of washers must be adhered to.

Galling and seizure of stainless steel bolts shall be further avoided through appropriate consideration of the following:

- Slowing the installation RPM speed
- Ensuring the threads are as smooth as possible
- The use of dissimilar standard grades of stainless steel (grades which differ in composition, work hardening rate and hardness). For example, use grade A2-C2, A4-C4 or A2-A4 bolt-nut combinations as outlined in EN ISO 3506.

Lock welding of the nut to the bolt is not permitted, as the materials are formulated for strength and not for fusion welding. Upsetting the bolt threads (i.e., making them thicker at the ends) may be an acceptable alternative in a situation where the nuts are to be locked in place. Alternatively, incorporate nylon locking nuts or double nuts as appropriate.

7 Fabrication

7.1 General

All structural stainless steel components shall be generally fabricated in accordance with AS/NZS 1554.6 and TS 0420.

All stainless steel piping components shall be generally fabricated in accordance with AS/NZS 3992 and TS 0420. The requirements of TS 0420 shall take precedence over other requirements.

Any cutting or shaping of stainless steel plates and sections after the stainless steel has left the mill is regarded as fabrication work and must be carried out in accordance with the requirements of this specification.

7.2 Fabricator Requirements

The stainless steel fabricator shall comply with the quality requirements specified in this Technical Standard and TS 0420, and preferably be accredited and registered with the Australian Stainless Steel Development Association (ASSDA) or be an Approved Fabricator in accordance with TS 0420.

7.3 Handling & Storage of Stainless Steel

To avoid contamination and damage to stainless steel products being installed in SA Water infrastructure, the following requirements are to be satisfied:

- All stainless steel works shall be undertaken in a separate building to carbon steel where possible. If this is not practicable, suitable guidance from ASSDA shall be followed as a minimum.
- Stainless steel material shall not be stored in contact with carbon steel.
- Stainless steel material shall be wrapped, or otherwise protected during transport, to avoid contamination. If an adhesive plastic film is used all traces of adhesive shall be removed from the steel with a suitable solvent.
- Uncontaminated slings shall be used in lifting stainless steel components and not chains. Grinding, cutting and welding shall not be carried out over open bundles of stainless steel components. The steel shall be inspected immediately after delivery for any surface damage.
- Where the steel has a protective plastic or other coating, it shall be left on as long as possible; the protective plastic or coating shall be removed just before final fabrication.
- Where plastic strippable adhesive backed film is used instead of loosely wrapped plastic sheeting, it must be UV rated to prevent premature deterioration and residual adhesive surface contamination. Furthermore, the film life must be monitored such that it is removed within the Manufacturer's suggested service life (typically up to 6 months).
- Storage in salt-laden humid atmospheres shall be avoided. If this is unavoidable, packaging should prevent salt intrusion. Strippable films should never be left in place if surface salt exposure is expected because they are permeable to both salt and moisture and create the ideal conditions for crevice corrosion.
- Storage racks shall not have carbon steel rubbing surfaces and should, therefore, be protected by wooden, rubber or plastic battens or sheaths. Sheets and plates should preferably be stacked vertically; horizontally stacked sheets may get walked on with a risk of iron contamination and surface damage.

- Carbon steel lifting tackle, e.g., chains, hooks, and cleats should be avoided. Again, the use of isolating materials, or the use of suction cups, will prevent iron pick-up. The forks of forklift trucks should also be protected.
- Contact with chemicals including acids, alkaline products, oils and greases (which may stain some finishes) should be avoided.
- Only tools dedicated to stainless steel should be employed (this particularly applies to grinding wheels and wire brushes). Note that wire brushes and wire wool should be of stainless steel and generally in a grade that is equivalent in terms of corrosion resistance (e.g., do not use ferritic or lower alloyed austenitic stainless steel brushes on a more corrosion resistant stainless steel). Tools previously used on carbon steel shall not be used for stainless steelwork.
- As a precaution during fabrication and erection, it is advisable to ensure that any sharp burrs formed during shearing operations are removed,
- Consideration should be given to any requirements needed in protecting the finished fabrication during transportation.

7.4 Straightening

All structural stainless steel shall be straight before being drilled, welded or worked. Straightening of either fabricated or as-manufactured stainless steel, if necessary, shall be carried out by means of steady pressure being applied by rollers or presses. Straightening shall not be carried out by means of hammering or by heating unless approved via a TDRF.

7.5 Cutting

Care shall be taken in marking out plates and sheets to avoid wastage in cutting. Note that more wastage may result if the material has a polishing grain (or a unidirectional pattern), which has to be maintained in the fabrication. Some marking pens/crayons will prove difficult to remove, or cause staining, if used directly on the surface (rather than on any protective film). All markers should be checked before use, as well as any solvents used to remove marks.

Chloride free paint shall be used for marking austenitic, duplex, and super duplex stainless steel material.

Stainless steel may be cut using usual methods (e.g., shearing and sawing). If possible, cutting (and machining in general) should be carried out when the metal is in the annealed (softened) state, to limit work hardening and tool wear. Stainless steel grinding wheels (such as Inox) should be used for grinding stainless steel materials. These grinders shall also not be used to grind carbon steel.

Plasma arc techniques are particularly useful for cutting thick plates and profiles up to 125 mm thick and where the cut edges are to be machined (e.g., for weld preparation).

Water jet cutting is appropriate for cutting material up to 200 mm thick, without heating, distorting or changing the properties of the stainless steel.

Laser cutting is suitable for stainless steel, particularly when tighter tolerances are required or when cutting non-linear shapes or patterns; good quality cut edges can be produced with little risk of distortion to the steel.

For cutting straight lines, guillotine shearing may be used. By using open ended guillotines, a continuous cut greater in length than the shear blades can be achieved, although at the risk of introducing small steps in the cut edge.

Oxyacetylene cutting is not satisfactory for cutting stainless steel unless a powder fluxing technique is proposed and approved via a TDRF.

All burrs left by sawing, cutting or shearing shall be removed before fabrication or assembly. The surface shall be ground flush with adjacent metal and shall be smooth, solid and continuous.

Any edge left in a cut condition is to be dressed to remove sharp edges. Thermally cut edges (plasma or laser cutting) will have reduced corrosion resistance and damaged material must be removed through grinding and pickling (see TS 0420).

Thermal cutting will be completed on a stainless steel bed where possible. If not, iron contamination must be removed from surfaces adjacent to the cut edge.

7.6 Edge Preparation

Edge preparation is required where welding is to be carried out along the edge of any of the following materials:

- Sheared edges of material 12 mm or thicker
- Rolled edges of plates or flats thicker than 16 mm
- Toes of angles or rolled shapes thicker than 16 mm.

Edges shall be trimmed back by 6 mm, to prepare the edge for welding.

Edge preparation shall be performed by either planning or plasma cutting. Edges to be welded shall not be sheared.

Preparation of edges by oxyacetylene cutting shall, wherever possible, be carried out by machine.

All butt weld preparation shall be prepared by machining, grinding or plasma cutting, followed by grinding.

All cutting shall be generally as smooth and regular as that produced by edge planning and the edge shall be left free of slag.

No rough edges shall be allowed to remain, and uneven outer edges shall be dressed off to a true line with approval.

7.7 Cold forming

Stainless steel can be shaped by commonly used cold forming techniques such as bending, spinning, pressing and deep drawing. For structural applications press brake bending is the most relevant technique though, for high volume thin gauge products, roll forming may be more economic.

For bending stainless steel, the following internal radii is generally recommended as minimum (where t is the thickness of the material):

- t for austenitic grades
- 2t for duplex grades
- 2t for ferritic grades.

When bending circular tubes, the following conditions should usually be met:

- The outer tube diameter to wall thickness ratio d/t should not exceed 15 (to avoid costly tooling)
- The bend radius (at the centreline of the tube) should not be less than 1.5d or d + 100 mm, whichever is larger
- Any welding bead should be positioned close to the neutral axis to reduce the bending stresses at the weld.

Advice should be sought from a specialist fabricator regarding whether a higher d/t ratio or lesser bend radius could be specified. Alternatively, appropriate pre-production tests shall be carried out to ensure that bending does not cause mechanical damage and the dimensional tolerances are acceptable.

For tubes of d < 100 mm, a less restrictive condition of the bend radius may be applicable, e.g., the radius should not be less than 2.5d. Note that the implications of curvature on the buckling resistance may need to be considered by the designer.

7.8 Holes

Holes may be drilled, punched or laser cut.

Punched holes should be avoided for use in corrosive environments due to the presence of the work hardened edge; the use of a round tipped centre punch is not permitted. Punching of holes in material having a thickness greater than 10 mm will not be permitted.

If drilling is unavoidable, positive cutting must be maintained (using sharp bits with correct angles of rake and cutting speeds) to avoid work hardening. All holes in materials with a thickness greater than 10 mm shall be drilled.

All holes shall be finished accurately to size and in the position shown on the drawings. All holes shall be cleaned of all burrs and rough edges.

The axis of the holes shall be at right angles to the surface through which they pass, except where otherwise shown on the drawings.

Standard holes for bolts shall be used for joining stainless steel members. The maximum clearances in standard holes are:

- 1 mm for nominal bolt diameter < 12 mm
- 2 mm for nominal bolt diameter >= 12 mm.

Larger holes may be used, provided backup plate washers of appropriate size and thickness are used as specified in AS 4100. Backup plate washers shall have a standard hole to suit the bolt that is to be used.

Where top hat isolation washers are required between dissimilar metals, the bolt hole diameters shall be oversized to suit, and backup plate washers shall be used.

7.9 Bending Plate

Bending of stainless steel plate shall be carried out in a press to produce clean straight bends with no distortion in the adjacent flat surfaces.

Prior to bending, any rags present on sheared edges shall be removed by grinding or filing to prevent the possibility of plate splitting on the outside corner.

7.10 Stainless Steel Cover Plates

Stainless steel cover plates made from material of thickness 9 mm and below shall be fabricated from stainless steel with a Class 2B mill finish (refer Section 7.11).

Stainless steel cover plates made from material of thickness 10 mm and above shall be fabricated from stainless steel with a HRAP (Hot Rolled, Annealed and Pickled) finish (refer Section 7.11).

7.11 Finishing

The surface finish of stainless steel is an important design criterion and shall be clearly specified by the Designer. Where not specified, all stainless steel elements shall have a 2B finish, at a minimum, to meet corrosion resistance criteria and for aesthetic appeal.

It is generally most cost effective for polishing houses to apply those finishes prior to fabrication; hot-formed angles and channels, tube, pipe, and plate can be polished before they are welded or otherwise connected to other components.

Surface finishes are applied for both aesthetic reasons and to improve the corrosion resistance as they remove materials that may accumulate on the surface of the metals. This process also changes the roughness profile of the metal to decrease bacteria's adhesion to the metal's surface. This can be achieved via mechanical polishing, electropolishing and/or blasting.

Surface roughness (R_a) is used to measure the roughness profile to determine the level of surface finish required. Finish types are classified in ASTM A480 and contain the process required to achieve a specific appearance and surface roughness. The critical surface roughness for corrosion of stainless steel is usually determined as R_a = 0.5 µm.

Table 17: Common Stainless Steel Finishes (ASSDA, 2012)

Finish Type (ASTM A480)	Description	Process	Ra (µm)
2D	Matte, non-reflective finish.	Cold rolling followed by annealing and descaling	0.13 -1.0
2B	Bright, moderately reflective finish. Most common finish	Cold rolling, annealing, descaling followed by light roll pass through polished rolls.	0.06 – 0.51
BA	Approaches mirror -like appearance.	Cold rolling, annealing in a controlled atmosphere furnace.	0.01 – 0.10
No. 4	General purpose polished finish.	Polished with a series of abrasive belts. Grit no. 120-180	0.18 – 0.64
No. 8	Most reflective finish commonly produced on sheet.	Polished with series of successively finer abrasives. Grit no. 500	0.019 – 0.1

The surface of the steel should be restored to its corrosion resisting condition by removing all scale and contamination by pickling in an acid bath (refer to TS 0420). Pickling will loosen any scale, enabling it to be brushed off with a bristle brush, but it may change the appearance of the finish to a more matt or dull finish. Pickling will also dissolve any embedded iron or carbon steel particles, which, if not removed, can show up as rust spots on the stainless steel surface.

Abrasive treatments such as grinding, polishing and buffing, produce unidirectional finishes and, thus, the blending of welds may not be easy on plates/sheets with normal rolled surfaces. The surface shall be free of contaminants in the assembled structure. Particular consideration shall be given to the possibility of contamination arising from work on adjacent carbon steelwork, especially from grinding dust or sparks from abrasive cutting. Either the stainless steel should be protected by removable plastic film, or final cleaning after completion of the structure should be specified.

7.12 Geometric Tolerances

7.12.1 General

Tolerances shall comply with the requirements of Section 7.12.2 as applicable.

7.12.2 Fabricated Items

All stainless steel shall be fabricated to the tolerances detailed in Table 18:. All manufacturing tolerances shall be in accordance with the relevant standards.

Table 18: Fabrication Tolerances

Location	Tolerance (mm)
Length of Member (Rafter, purlin etc.)	± 2
Height of Member (Column, post etc.)	± 2
Centre of Holes	± 2
Line of Plan Dimension	± 2

7.13 Inspection & Acceptance

Not less than three (3) working days after the completion of the fabrication of the stainless steel component, the SA Water's Representative the product shall be notified that the component is available for inspection. Qualification and Inspection requirements are defined in TS 0420. This constitutes a **HOLD POINT** under this Standard.

8 Transportation & Erection

8.1 General

SA Water has adopted the requirements of AS/NZS 5131 "Structural steelwork—Fabrication and erection" for the erection of all stainless steel.

The Constructor shall be fully familiar with the requirements of AS/NZS 5131.

Specific requirements from AS/NZS 5131 are outlined in Section 8.2, together with a reference to the applicable clause in AS/NZS 5131.

The steelwork erection Constructor shall supply and install all temporary bracing and any other elements necessary for the safe erection of the structure.

The Constructor shall be responsible for the temporary stability of the structure during construction.

The use of any site welding or site welded connections shall be submitted to SA Water for review and approval.

The recent guide published by the Australian Steel Institute: 'Practical guide to planning the safe erection of steel structures' provides guidance on the erection planning process, assignment of responsibilities and risk management. During the installation of stainless steel elements efforts need to be made to avoid damage (scratches and gouges) which can impact corrosion resistance and surface finish of the stainless steel structures.

After installation the completed structure shall be inspected for surface imperfections and contaminants. If discovered, imperfections shall be removed, and the corrosion resistance chemically restored by either pickling, passivation or electropolishing.

8.2 Structural Steelwork Erection Requirements

Requirements for structural steelwork erection are shown in Table 19.

Table 19: Stainless Steelwork Erection Requirements

Structural Steelwork Erection Requirements	Clause in AS/NZS 5131
Site Planning	
Lifting Equipment: Steelwork erection Constructor shall ensure registered lifting equipment has proof of registration available for inspection on site. Steelwork erection Constructor to provide proposed locality plans of lifting equipment in relation to the SA Water assets for approval. Critical services including pipework shall be considered in the lifting study to not adverse effect its integrity.	11.2.5
Erection Sequence Methodology: An Erection Sequence Methodology (ESM) shall be prepared and provided to the Superintended for approval.	11.5.1
Temporary Erection (Trial Assembly): No additional requirements.	11.5.10
Supports	
Temporary Shims and Packers: Temporary shims and packers used during erection shall be removed.	11.6.3
Grouting at Supports: No additional requirements.	11.6.4
Erection Drawings: No additional requirements.	11.7

8.3 Transportation & Delivery

The Transportation Plan (which may also be termed the Logistics Management Plan) outlines the sequence for delivery of components to site, to suit the Erection Sequence Methodology (ESM) and site constraints for storage and handling of the steelwork prior to erection. These documents shall be supplied as per Section 3.

The Transportation Plan and schedule shall be provided by the Fabricator to the SA Water's Representative not less than seven (7) working days before any shipping begins. This constitutes a **WITNESS POINT** under this Standard.

The structural stainless steel fabricator shall schedule, coordinate and sequence transportation and delivery in cooperation with the erection of the structural stainless steel by the erection Constructor.

The Constructor shall perform all work necessary to ensure safe loading, transportation, unloading and storage of stainless steel. The Work shall consist of loading at the Fabricator's plant, transporting to the site, and unloading and storing at the site, including temporary works for access.

Stainless steel shall be loaded for shipping in such a manner that it can be transported and unloaded at its destination in the correct orientation for erection without being excessively stressed, deformed, or otherwise damaged.

Stainless steel material shall be wrapped or otherwise protected during transport to avoid contamination. If an adhesive plastic film is used all traces of adhesive shall be removed from the steel with a suitable solvent.

Stainless steel shall be stockpiled in such a manner to avoid excessive stress, deformation or other damage while stored.

8.4 Cleaning

Many cleaning agents considered "aggressive" can be used to clean stainless steel of various contaminants originated during transport and handling compared to other metals. Cleaning materials such as strong halides, iron tools, and abrasive materials are not used as these may damage the stainless steel surface.

Further treatments to the surface of stainless steel structures require a clean surface and as such selecting a verified method is critical. A list of recommended cleaning methods for common contaminants can be found in Table 20, reproduced from ASMI – Stainless Steel for Design Engineers.

Cleaning of stainless steel shall not be confused with the post welding treatments required for stainless steel in TS 0420. Due to the hazardous nature of the chemicals involved, these treatments are not to be carried out on site.

8.5 Maintenance

8.5.1 Maintenance

Although stainless steel is a low maintenance material, this does not mean it requires no maintenance, however the degree of maintenance required will be less for higher/more corrosion resistant grades of stainless steel. A regular cleaning and maintenance procedure should be developed for stainless steel components based on the grade and service environment.

For example, higher grades might only require a regular wash to remove surface deposits from the structure in service of protecting the passive chrome oxide layer. Lower grades might require washing more frequently, or the use of applicable cleaning methods (see 8.4) if substances that may cause sticky deposits are present in the environment (e.g., airborne pollutants)

Where possible, stainless steel structures should be designed to utilise rain to wash off contaminants, and surfaces with little access to rain should be washed more frequently.

Table 20: Recommended Cleaning Methods For Stainless Steel (ASMI, 2008)

Contaminant	Recommended Methods	Comments
Exterior Soiling	Soap, detergent, dilute ammonia	Use a soft cloth or sponge, clean water, dry with forced air or a dry cloth.
Fingerprints	Detergent and warm water, hydrocarbon solvent	Wax and oil polishes minimize fingerprinting. Glass cleaner is appropriate for mirror finishes.
Grease, oil	Hydrocarbon solvent	Alkaline cleaners may also be used in severe cases, but many require cleaning the entire surface to maintain visual uniformity.
Severe stains, discolouration, rust	Non-scratching creams/polishes	Do not use hydrochloric acid containing products. Hypochlorite bleaches must be well rinsed to avoid pitting.
Hard water scale, mortar	10-15% phosphoric acid, sulfamic acid containing, or oxalic-containing cream/polish	Neutralise with ammonia, rinse and dry. Do not use hydrochloric acid containing products.
Paint	Alkaline, trisodium phosphate, hydrocarbon solvent	Follow Manufacturer's directions.

8.5.2 Tea Staining

Tea staining occurs when stainless steel is exposed to conditions that are too aggressive for the installed stainless steel grade but not aggressive enough to promote pitting. Conditions that are promoting tea staining include

- Presence of corrosive substance (e.g., chlorides or sulphates)
- Atmospheric conditions
- Surface orientation and design
- Surface roughness
- Stainless steel grade
- Maintenance
- Tea staining can occur when water which is high in chlorides is used to wash the stainless-steel surface or in areas within 5km of the coastline, increasing in severity the closer the structure is to the ocean.

Tea staining appears as a visual discolouration of the metal surface; however, it is not indicative of a serious corrosion risk. An example of what this might look like can be found in Figure 2.

Tea staining can be avoided and mitigated using the following techniques and procedures:

- Select a material with strong corrosion resistance. Grade 316 stainless should be selected at a minimum.
- The surface finish of the material should be as smooth and shiny as possible. Keeping the surface roughness below 0.5 µm should yield ideal results.

- Regular washing as per appropriate maintenance schedule to remove salt deposits before they dry. (See 8.4) When tea staining occurs despite these measures, other methods such as coatings might be required.
- A clear nylon polymeric resin can be applied to stainless steel after rigorous cleaning and drying of the structure if tea staining continues to be an issue and the aesthetic finish of the structure is deemed important.

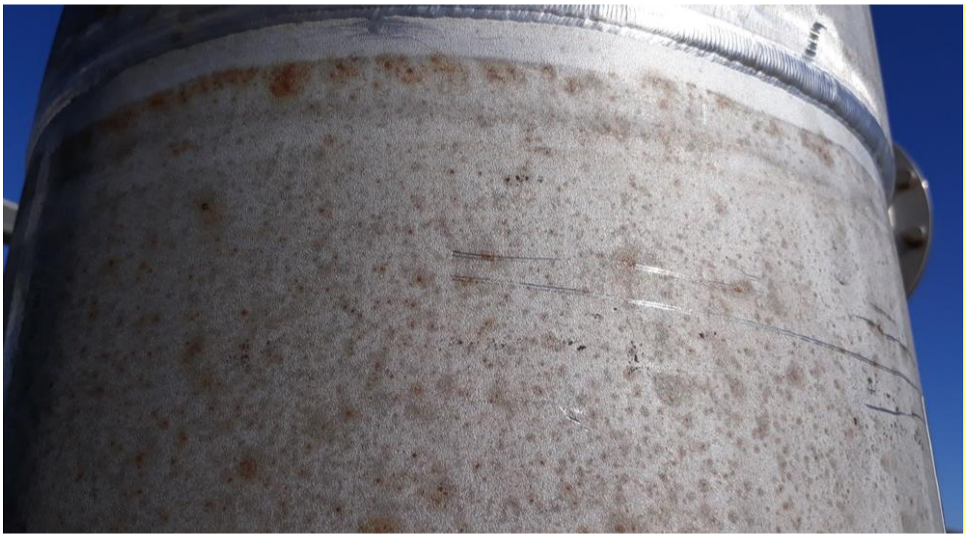

Figure 2: Example of Tea Staining (ASSDA, 2008)

9 Hazards

All risks and hazards from fabrication, welding, mechanical fastening and erection shall be identified and managed to ensure that all work is carried out in a manner that does not endanger the health and safety of personnel.

In particular, due consideration shall be given to the following:

- Requirements relating to welding activities (see AS 1674.1 and AS 1674.2), including the control of emitted fumes
- Requirements relating to the safety of the works as specified in various sections of this Standard including but not limited to handling, cutting, edge preparation, cold forming, transport and erection
- Requirements to use dangerous chemicals for picking and passivation, such as hydrofluoric acid and nitric acid. Pickling and passivation are not to be carried out onsite.

Appendix A : Schedules of Hold Points, Witness Points & Identified Records

A1 Schedule of Hold Points & Witness Points

Clause	Type	Description
3.3	Hold	Review and acceptance of Quality Plan, including AS/NZS 4020 certificates where applicable - 10 working days before the relevant work commences
3.6	Hold	Review and acceptance of Work Method Statement - 10 working days before the relevant work commences
3.7	Hold	Review and acceptance of Inspection and Test Plan - 10 working days before the relevant work commences
3.11	Hold	Review and acceptance of Shop Drawings - 10 working days before the relevant work commences
6.7	Hold	Stainless Steel Material Test Certificate
6.7.1.2	Witness	Bolts, nuts and washers Material Certificate to be reviewed and accepted by the Designer.
7.13	Hold	Welding inspection
8.2	Hold	Erection sequence methodology
8.3	Witness	Transportation Plan and Schedule

A2 Schedule of Identified Records

Section	Description of Identified Record
3.12	As-Built Documentation
7.2	Fabricator Requirements
7.13	Weld Maps