

ASSDA

FOOD CODE OF PRACTICE



CODE OF PRACTICE FOR THE FABRICATION AND INSTALLATION OF STAINLESS STEEL
PROCESS PLANT AND EQUIPMENT IN THE FOOD AND BEVERAGE INDUSTRIES

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DISCLAIMER Whilst this specification is intended to encourage standardisation of fabrication practices and to supplement contract and specification documents, it is recommended users obtain competent advice for each specific application. Whilst reasonable care has been taken in its compilation, neither ASSDA nor any of its members or Accredited Fabricators, agents or servants accept responsibility for its content or for the manner in which the specification may be applied in specific instances.

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PREFACE

This Code of Practice is a co-operative venture by the food industry. Used in conjunction with the ASSDA Accreditation scheme, it will standardise fabrication practices in Australia and improve efficiency and reliability by raising the standard of delivered quality.

The Code of Practice can be broken into four sections, as follows:

- › Scope, definitions, interpretation, document hierarchy and supplier systems required;
- › Design requirements with both general rules and specific items for process equipment, process piping and other piping;
- › Seven sections on fabrication requirements for:
 - › Overall necessities of grade, materials care, welding and finishing procedures;
 - › Process vessel fabrication whether by the supplier or others;
 - › A substantial section on the handling, welding and finishing of process tubing at ambient or elevated pressures; and
 - › Sections on the fabrication of non-product contact pipework at low or high pressures.
- › Concluding sections dealing with practicalities such as transport, installation, commissioning and insurance.

The document includes four appendices which list relevant Standards, a discussion on the pros and cons of autogenous and filler metal use in welding of tubing, the requirements for purged welding of tube and a discussion on commonly used valves and fittings in Australia. This document is not intended to replace accepted national and international standards but rather to weave their requirements into the design and fabrication process for food and beverage plant. The Code of Practice is intended as a step forward from and a more precise prescription than the more generic advice offered by the well known “Blue Book” published by ASSDA’s sister organisation, NZSSDA.

This document has drawn on the work of many large and small operators in the industry and their assistance is gratefully acknowledged. They include:

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1 INTRODUCTION

1.1 PREAMBLE

Since its formation in 1992, ASSDA has promoted the correct use of stainless steels. This work has included the provision of technical advice, writing standards and codes of practice and the establishment of an Accreditation scheme. In 2004, ASSDA was asked to consider means of improving the quality of fabrication in the food industry with particular reference to welder qualification in the dairy derived processed food sector. Discussions with asset owners showed that standards were quite varied across the sector and that fabrication quality was causing significant losses in time and operating costs. The problems were broader than welder qualification and included cases where there was no fabrication specification or it was provided by the fabricator.

This Code of Practice is a co-operative venture by the food industry to standardise fabrication practices in Australia and thus to improve efficiency and reliability by raising the standard of delivered quality. Since it was first published in 2006 (as the ASSDA Food Specification), there have been a number of comments and suggestions on the content and form of this publication. This revision addresses these comments and updates other sections based on changes in standards and developments in materials and processes

1.2 SCOPE

This Code of Practice covers the requirements for the design, fabrication, inspection, transport and installation of stainless steel plant and equipment used in the food industry. It is intended to provide a technical basis and to supplement the purchaser's specification and contract. The default condition is that the purchaser shall set the performance criteria and the design shall be set by the supplier.

2 INTERPRETATION

2.1 DEFINITIONS

ABRADE/GRIND/POLISH

Abraded/ground/polished surfaces have all had metal removed by use of abrasives. This leaves a surface where roughness is determined by the abrasive size and type, pressure applied, lubrication etc. in contrast to mill finishes where roughness is less for thinner materials. The scratches may be randomly oriented or approximately parallel.

CIP

An acronym for 'Clean in Place'. This term applies to automatically (computer) controlled washing and rinsing systems that deliver pre-described washing/rinsing fluids to specific process plant items and/or process piping systems. For a particular plant, the process is defined as a specified and proven range for flow, temperature, reagent concentration and exposure time.

CLEAN

The absence of soil on product contact surfaces as determined by visual and analytical methods. Note that some product based soils cannot be removed completely by normal cleaning methods. Note also that the acceptable measurement of "clean" will be determined by the respective asset owner.

CLEANABILITY

The suitability of materials of construction, design and fabrication required to assure that the process equipment can be freed of soil either by manual or CIP processes. Where process plant and equipment is to be sanitised and/or sterilised through the application of heat, then all components of the process system shall be designed and constructed to cope with the internal stresses generated so that there is compliance to the performance criteria described in this document.

CREVICE

A narrow but deep gap which traps product with the potential for product contamination. Crevices may also be initiating locations for corrosion in liquids or when exposed to moist atmospheres.

CORROSION RESISTANT

A combination of surface finish and material selection which will not degrade due to corrosion during its predicted service life. The description applies for exposure to the conditions encountered in the intended environment, including contact with product, cleaning and sanitising chemicals, steam, or sterilisation compounds/ solutions.

DEAD LEGS

A dead leg is a section of pipe that is difficult to clean because it is blanked off. They usually arise from planned provision for expansion or inadequately executed modifications to existing plant. A pipe with low flow may also be difficult to clean, but it is not a dead leg.

ELECTROPOLISHING

Electropolishing is an electrochemical process normally carried out in an acidic bath off site. It applies a current to remove metallic contamination, strengthen the passive film, slightly reduce the surface roughness and round peaks or sharp edges to improve cleanability.

NON-PRODUCT CONTACT SURFACE

All exposed surfaces from which splashed product, liquids, or other materials cannot drain, drop, diffuse or be drawn into or onto the product, product contact surfaces, open packages, or the product contact surfaces of package components.

OWNER/PURCHASER

The "owner" of the assets (or operation) or the organisation that will operate the processing system, or the organisation's authorised representative. The owner may be the purchaser of the asset or may be dealing through an intermediary.

PIPE

Throughout this document “pipe” refers to a hollow product defined by its Nominal Pipe Size (NPS) or Diameter Nominal (DN) and a wall thickness which may be described by a “schedule” grade. Typically, pipe has thicker wall than “tube” (see definition below).

PRODUCT CONTACT SURFACE

All surfaces which are exposed to the product, and surfaces from which liquids may drain, drop, diffuse, splash, or be drawn into the product.

SANITISE

This is a process applied to a cleaned surface that is capable of reducing the numbers of the most resistant human pathogens by between 5 and 7 orders of magnitude. The process may be manual or automatic and may use hot water, steam or approved sanitising agents.

SHADOW AREAS

Areas on product contact surfaces where cleaning solutions will not flow or are restricted from flowing.

SHALL AND SHOULD

The word “shall” is understood as mandatory and the word “should” as advisable or recommended to comply with the requirements of this specification.

SIP

See also CIP. Also known as “Steam in Place” or “Sterilise in Place”.

SOIL

Unwanted organic residue or inorganic matter usually on a product contact surface.

STERILISATION

A process applied to clean product contact surfaces that ensures the destruction of all vegetative micro-organisms and inactivates the relevant microbial spores. A sterilised surface has also been sanitised.

SUPPLIER

Person or company who has been requested by the purchaser/owner to provide equipment or services defined.

SURFACE ROUGHNESS

Surface roughness is a measure of the micro level undulations of a surface. The most common measure is Roughness Average (R_a). It is usually measured by an instrument which draws a fine pointer over the surface, calculates the average profile and determines the average deviation from this line. Previously it was known as CLA or AA. Other parameters (such as R_z or R_{max}) are sometimes used to assess maximum peak heights and “stickability” of organic materials. Pointer instruments are not reliable for measuring near mirror finishes and optical methods may be used.

TUBE

Throughout this document “tube” is defined as a hollow product defined by its outside diameter and its specific wall thickness and is usually manufactured to AS 1528.1. In most cases it is thin walled tube.

2.2 UNITS

The System Internationale (SI) units of measurement shall be employed on all drawings, specifications, schedules, and any other technical documentation.

2.3 CONFLICT IN DOCUMENTATION

Should there be any conflict between the documents contained in or referred to in this Code of Practice, then the order of precedence shall be:

- a) Statutory Authority
- b) Purchaser's Specification
- c) This Code of Practice
- d) Other Process Specification
- e) Australian Standards
- f) International Standards

Should the supplier identify any such conflict, he shall immediately advise the purchaser in writing and shall obtain the purchaser's agreement to the proposed method of resolution before proceeding.

3 SYSTEMS

3.1 SUPPLIER ACCREDITATION

Fabrication for the food industry requires specific knowledge and skills. For fabrication involving the use of stainless steel products of any grade, fabricators who are ASSDA Accredited or equivalent shall be used. Evidence supporting equivalent knowledge and competence must be supplied where it is proposed to use a fabricator who is not ASSDA Accredited. The required competencies and the expected organisational requirements are listed in the ASSDA Accreditation application documents available for free download from www.assda.asn.au.

3.2 QUALITY SYSTEMS

The supplier shall provide a description of its quality system to the purchaser. The purchaser reserves the right to modify the quality system where he deems it necessary to produce the appropriate outcome. The purchaser also reserves the right to partner with the supplier to develop the final specification.

3.3 OCCUPATIONAL HEALTH AND SAFETY (OH&S) AND ENVIRONMENTAL COMPLIANCE

The supplier shall have systems in place to ensure compliance with the relevant OH&S, public health and environmental regulations, codes of practice and laws. While there is a nationwide framework, detailed regulations vary between states and territories.

3.4 SUPPLIER CAPABILITY PROFILE

The supplier shall provide a capability statement covering past work and comparable references, competence and availability of equipment and personnel, and any other information supporting the supplier's ability to satisfactorily complete the job.

3.5 APPROVALS AND REQUIRED INSPECTIONS

The owner's specification shall provide details of codes or standards which must be satisfied beyond the statutory design, OH&S and environmental requirements. This includes but is not limited to bodies that may need to inspect or approve food equipment or installations. The allocation of cost and time involved shall be agreed between owner and supplier.

4 DESIGN REQUIREMENTS

4.1 DESIGN SCOPE

This Code of Practice is intended to define the minimum requirements only and shall not limit any supplier's responsibility to complete a satisfactorily operating piece of equipment or installation, nor exclude suggestions or improvements. The design shall meet the required outcomes for throughput, capacity and process time. In addition, the design shall incorporate aspects that give it the required cleanability.

4.2 GENERAL DESIGN CONSIDERATIONS

These general considerations apply to all fabricated and installed items and shall be considered in conjunction with the specific component requirements.

4.2.1 PRODUCT CONTACT SURFACES

All interior surfaces of plant and equipment shall be self-draining to avoid the creation of pockets or pools of product or liquid during operation or cleaning. At least a 3 degree slope is required. A dead leg length shall be no longer than 1.5 x the pipe diameter. Corners shall be radiused to facilitate drainage.

Any design features that create a crevice open to the product or a hollow body adjacent to the product shall be avoided. In addition, threads shall not contact product.

The design of the plant or equipment shall ensure that all surfaces in contact with the product are readily accessible for inspection, cleaning and maintenance. Where agreed, provisions shall be made to remove or expose parts for cleaning and/or inspection.

Spray type CIP equipment shall be designed to ensure that all surfaces can be adequately cleaned. Attention shall be directed to the possibility of internal fittings or ledges masking surfaces or creating shadow areas on surfaces, or having integral shadow areas themselves.

All lids or access covers shall be designed so that when opened, contaminants on the exterior of the equipment or lids/covers are prevented from entering the plant or equipment.

Dry-mix product plant has similar requirements with the added necessity of avoiding condensation, contamination by lubricants or adjacent washing processes, bridging in hoppers, preventing static sparks and considering the slope of product stacks.

4.2.2 NON-PRODUCT CONTACT SURFACES

Crevices and residue collection points shall be avoided.

The design shall ensure that all non-product contact surfaces can be readily cleaned. During cleaning of non-product contact surfaces, no material from these surfaces shall be able to contaminate product contact surfaces.

All non-product contact surfaces and supporting structures shall be designed to shed water and prevent any risk of harbouring dirt or pests. Horizontal surfaces are undesirable. Particular attention should be paid to the positioning and orientation of shapes such as channels or angles and also protruding weld profiles. To control "stickability" of organic materials, surface roughness parameters such as R_z or R_{max} may be specified.

All ancillary equipment and services relating to the plant or equipment shall be located sufficiently clear of the plant or equipment to allow proper maintenance and cleaning. Adequate space shall be provided between processing equipment and between equipment and the walls so that access for cleaning and inspection is not impaired.

Equipment not attached flush to a wall shall be set at least 0.6m away from any wall.

Tanks, vessels or equipment not mounted flush to the floor or plinth shall have a minimum of 300mm clearance between the base of the item and the floor to allow the floor beneath and the underside of the equipment to be cleaned and inspected.

4.2.3 OTHER REQUIREMENTS

The design shall avoid creating areas where pooling and subsequent evaporative drying of moisture can occur, leading to a concentration of undesirable residues.

Due consideration should be given to possible galvanic corrosion effects arising from contact between dissimilar metals and alloys or metals and conductive non-metals such as graphite seals. Suitable allowances shall be made for thermal expansion and contraction between various grades of stainless steels and other materials, e.g. in stiffeners supporting plant or equipment. The effect of heat flow on the thermal expansion of materials with thickness variations shall also be considered. Multiple thermal cycles (e.g. by steam cleaning followed by cool rinsing) may cause long term thermal fatigue. Mechanical fatigue may arise from pumps, mixers or other vibrations. AS/NZS 1554.6 - 2012 has recommendations for controlling fatigue in welded structures.

Stairways, handrails, platforms and walkways shall be designed, fabricated and installed in accordance with the current Australian Standard AS 1657.

The requirements of AS/NZS 2865 *Safe Working in a Confined Space* shall be addressed. These are listed in APPENDIX D – Means of entry and exit of AS/NZS 2865. State regulations on confined space entry may impose more stringent conditions.

Insulation required for vessels or pipes operating at non-ambient temperatures shall be chloride free, fitted to avoid interference with normal operating and maintenance procedures and shall be protected from water and physical damage by an outer cladding. The cladding (and any other cladding applied for hygienic reasons) shall be smooth, continuous and impervious. If chloride containing water could wet insulation over austenitic stainless steel vessels consistently hotter than 55°C, further protection such as coatings or aluminium wrapping shall be considered. NACE RP0198 provides further guidance. In circumstances where heat loss is not an issue, consideration of barriers for personnel protection may be considered instead of insulation.

In the design phase, consideration shall be given to safe access for inspection and maintenance of equipment. Consideration shall also be given to a means (e.g. dismantling, borescope) of final inspection of, and possible debris removal from, the product contact surfaces prior to commissioning.

Consideration is required of lighting levels to allow the state of cleanliness of the plant to be assessed.

4.2.4 DESIGN RESPONSIBILITY

If requested by the purchaser, all drawings and relevant calculations pertaining to the design of the item(s) shall be submitted to the purchaser for review prior to commencement of fabrication. The purchaser will sign off on cleanability, OH&S requirements, process function, materials selection and the environmental requirements. The purchaser shall not certify the fabricator's design or calculations, but merely the general arrangement drawings.

Operation of the installed plant (including cleaning methods and frequency) is the responsibility of the asset owner. The plant design shall be based on the operating practices as specified by the purchaser.

Drawings shall identify all features that are crucial to the safe and proper functioning of the equipment. These include, but are not limited to, minimum radius and surface finish requirements for cleanability, as well as designing to avoid contamination by foreign matter.

The design performance and the means of measuring the actual performance shall form part of the design. The design shall include means of measurement of critical parameters.

4.2.5 WELDED JOINTS

Joint design shall consider the requirements for cleanability, corrosion resistance and mechanical durability.

Carbon steel shall not be welded directly to stainless steel component surfaces in wet areas. When joining carbon steel to stainless steel, an intermediate stainless steel doubler plate shall be used that shall not exceed the parent material's thickness.

Welds should be located away from highly stressed or cold worked areas such as knuckles. Welds should not cross as the residual longitudinal stress in the welds will cause a highly stressed region. Fillet weld attachments shall not be welded over butt welds.

Butt welds between severe thickness variances shall be avoided, with a taper ratio of 1:4 preferred. AS/NZS 1554.6:2012 has more details.

Lap joints and intermittent fillet welds shall be avoided because of crevice and contamination issues.

Heat tint not only reduces corrosion resistance, but also degrades cleanability and may increase microbial activity. Sections 5.4 to 5.6 deal with control of heat tint and, if there are excessive levels, techniques to ensure its complete removal.

4.2.6 OPERATIONAL FACTORS

Where service or life-cycle guarantees are required, the operating environment shall be specified by the purchaser including not only normal operation, but also start-up, shut down and upset limits to conditions.

4.3 TANKS, VESSELS, MIXERS, ETC.

Openings for access doors, pipe connections etc. shall be placed as far from strake joints as practicable and shall not cut into other joints without prior approval of the purchaser. The chord shall not be rolled into the knuckle and shall avoid the closest edge of the knuckle by at least 3 times the radius of the knuckle. Minimum slope angle for flat surfaces shall be 3 degrees.

Vacuum breaks and vents shall be designed to allow the air volume to return to the silo/tank after the hot wash cycle and before the cold water wash cycle. The design shall consider issues such as process and cleaning procedures, whether silo/tank doors are normally closed and if the site uses solid covers over openings. Reliance on code vent sizes may not be safe if rapid cooling and condensation is possible. Consideration shall be given to improving the surface finish or other means of facilitating flow for sticky materials.

4.4 PROCESS EQUIPMENT AND OTHER FABRICATED OR CAST COMPONENTS

Items to be manufactured by others shall be selected after consideration of ability to meet design requirements including throughput, longevity, cleanability and hygienic operation requirements, as well as compatibility with site access, other components and facility aesthetics. Arrangement and installation of equipment shall also include consideration of the adequacy of foundations and supports, product and traffic flows, efficiency of operation and access for maintenance and cleaning. The designer shall consider specific characteristics of items such as vibration from pumps, orientation of product and service connections as well as the necessity for protection of the plant from the environment or personnel from the plant operation.

Subsidiary items such as structural supports, vessel or pump supports, handrails, platforms and stairways shall be designed for appropriate life, cleanability and hygienic operation. The general avoidance of problem areas such as crevices, soil traps, hollow cavities and intermittent welds shall also apply to these non-product surfaces.

4.5 PRODUCT TUBE AND PIPING SYSTEMS

Product tubing shall be protected from mechanical damage, supported at intervals determined by tube diameter and product load, spaced at least a diameter apart when in racks and shall be self-draining with a slope that

should not be less than 1:100 and may be much steeper for dry mix or sticky mixtures. Fixings and/or routing of tubes/pipes shall allow for movement due to thermal expansion or vibration from rotating or vibrating machinery. Supports shall not trap contaminants and shall be of materials that are compatible with the tubing.

4.6 SERVICES TUBE AND PIPING SYSTEMS

4.6.1 LOW PRESSURE (INCLUDING ELECTRICAL CONDUITS, WATER, ETC.)

Where possible, tubes and pipes with similar function shall be located together. While much of this tubing or piping is not subject to internal corrosive conditions, its fabrication requires care to avoid wiring damage in conduits and weld line corrosion in stagnant services water lines. Thermal expansion, vibration, spacing, material compatibility and pipe support all require consideration as for product lines (see Section 4.5).

4.6.2 ELEVATED PRESSURE (INCLUDING STEAM, CONDENSATE, COMPRESSED AIR)

Normally designed to AS 4041. Consideration of personnel protection, thermal insulation and avoidance of soil is also required. Thermal expansion, vibration, spacing, material compatibility and pipe support all require consideration as for product lines (see Section 4.5).

4.7 TRANSPORT AND INSTALLATION

The designer shall take into account static and dynamic loads imposed during transportation and erection/installation, as well as service loads. If temporary supports are required, their location, installation and removal shall not cause contamination or induce defects.

Lifting points shall be designed and positioned to ensure the equipment can be lifted, transported and installed without causing damage to the equipment or associated plant. Restrictions of access for transport, unloading and installation shall be considered.

5 GENERAL REQUIREMENTS THROUGHOUT THE PLANT

5.1 MATERIALS GRADE SELECTION

The grade of stainless steel selected shall be the responsibility of the purchaser. All materials used as product contact surfaces shall be supplied with certification showing compliance with applicable specifications.

The following guidelines are included to assist the purchaser:

Generally plant shall be constructed from grades 304/304L or 316/316L stainless steel and specified with recognised national or international standards. Some sections refer to wrought grades. When cast grades are used, these sections shall be read to include equivalent cast grades.

Carbon content where not otherwise specified shall be $\leq 0.08\%$ for $\leq 3\text{mm}$ thickness material and $\leq 0.03\%$ for $> 3\text{mm}$ thickness material. This is to avoid sensitisation and consequent risk of corrosion in welded components.

Grade 304 stainless steel shall be considered for lighter duties and is suitable for perpetual contact with chlorides up to 200ppm at ambient temperature at neutral pH. Grade 316 stainless steel shall be considered for heavier halide duties and is suitable for perpetual contact with chlorides up to 1000ppm at ambient temperature at neutral pH. The chloride limits are increased if the pH is alkaline or the temperature is lower. Conversely, acidic pH or higher temperatures reduce the chloride resistance limits for stainless steels.

For hot water systems the purchaser will need a considered reason to use a material other than grade 2205 for extended temperature duties over 55°C. This is to avoid the potential for stress corrosion cracking (SCC). Ferritic stainless steels are also resistant to SCC but require significantly more care and expertise for satisfactory welding. Ferritic tubing is available, but is not generally used in Australia.

Modern stabilised ferritic stainless steels are also resistant to SCC, but their welding requires scrupulous cleanliness, excellent gas purging and strict adherence to heat input and interpass temperature limits. If oxidising biocides such as ozone, hydrogen peroxide, preacetic acid etc. are used, then the chloride limits will be lower if the oxidant levels are high.

Slicers, cutters and blades are usually made from martensitic stainless steels which are hardened by heat treatment in the same manner as carbon steels. They will have high hardness and good wear resistance, but relatively low toughness, and may fracture if flexed excessively or if they suffer impact loads. Typically they have lower corrosion resistance than the austenitic grades used.

If equipment is intended for cryogenic service, e.g. for snap freezing, then the possibility of low temperature embrittlement and consequent fracture may require the use of austenitic stainless steels such as 304/304L or 316/316L.

5.2 TYPES OF STAINLESS STEEL PRODUCTS USED

Most materials supplied in Australia are to ASTM standards, but the EN10088 series of standards may also be used. The EN standards generally have tighter tolerances and normally satisfy ASTM requirements.

- › Flat product: ASTM A240/240M
- › Tube and tube fittings: AS 1528 and as per purchaser's specification with regard to grade of stainless steel, its heat treatment and surface finish. Tube and tube fittings shall display this information and shall be readily identifiable. Any part tube lengths, tube offcuts and re-used tube sections shall be positively identified as conforming to the above requirements in all respects including grade, heat treatment, etc. ASTM A554 is not acceptable for fluid containment.
- › Pipe: ASTM A312 Standard specification for seamless and welded austenitic stainless steel pipes is most common in Australia.

- › Pipe fittings: ASTM A403 butt welding fittings for high pressure fixed pipelines
- › Low pressure screwed fittings: ISO 4144
- › High pressure screwed fittings: ASTM A182 (screwed and socket welded fittings). Discussion on fittings and their selection is given in *Appendix D*.
- › Conveying media: An informative note is supplied in *Appendix E*.
- › Flanges: AS 2129 (Table) or ASME B16.5 (ANSI) are used. However, flanges in product lines are not desirable. They are a potential source of contamination because it is extremely difficult to avoid a crevice.
- › Bar: ASTM A276 Stainless and heat resisting steel bars and shapes.
- › Insulation materials: Insulation is required to have very low levels of aggressive ions (particularly chlorides) as specified in ASTM A795. Installation and testing of insulation shall be to BS5970 or NACE RP0198 – Code of Practice for Thermal Insulation of Pipework and Equipment. Calculation rules for insulation are given in BS EN ISO 12241 – Thermal insulation for building equipment and industrial installations.

5.3 CARE OF MATERIALS DURING STORAGE AND FABRICATION

5.3.1 GENERAL

- › The fabricator's fabrication methods and techniques shall not cause any damage and/or failure that would lead to reducing the designed service life.
- › Stainless steel products shall be stored separately from mild steel and from other materials that can result in contamination. Contamination by carbon steel (or low alloy steel, cast iron) or by salt shall be avoided, as these reduce the corrosion resistance of the stainless steel.
- › Contamination of stainless steel products by carbon or carbonaceous materials is to be avoided especially if the material is to be welded. This includes oil, grease, crayons, marking pens and paint. Do not walk on unprotected stainless steel products as this may transfer these materials plus other soils.
- › Stainless steel product awaiting fabrication should if possible be stored inside. If stored outside it must be protected from the weather.

5.3.2 TUBE AND PIPE AND ASSOCIATED FITTINGS

- › All stainless steel tube and tube fittings shall be protected from damage, contamination and marking (scratching) during storage.
- › Tube and pipe are often very flexible - lift carefully to prevent distortion.
- › Handle and store in boxes or strapped bundles and store in well supported racks where possible.
- › Prevent damage from "clashes", particularly of weld prep ends.
- › Maintain identification markings. Requirements for batch traceability should be specified by the purchaser.
- › All tube and fittings should be stored with the protective plastic wrap provided for shipping and delivery intact, and preferably in its timber shipping container.
- › Stainless steel tube may be stored on stainless steel or plastic clad racks.
- › Tube end caps or plastic bag protection shall be kept in place at all times to avoid any internal damage or contamination.

- › If carbon steel or galvanised straps are used, they must be prevented from touching the stainless steel. Plastic or board beneath the straps can be used.
- › Plastic and stainless steel straps are available and plastic tape or electrical cable ties are lower strength alternatives.

5.3.3 WELDING CONSUMABLES

- › All welding consumables must be handled in accordance with the manufacturer's instructions and maintained clean and dry.
- › Protect MIG wire spools - these are easily broken, making the wire unusable.
- › Maintain packages in unbroken condition as long as possible.
- › Flux coated electrodes require careful storage - refer to the instructions from the manufacturer.

5.3.4 HANDLING OF STAINLESS STEELS - SAFETY ISSUES

All fabricators of stainless steel must take precautions to prevent injury to personnel. Some specific issues are listed below, but every fabricator must make their own assessments and comply with applicable regulations and laws.

- › Some product is packed under tension - the main one is cold rolled coil. Take great care in cutting straps for these products. Wear safety glasses and strong gloves as a minimum, and stand to one side of the straps.
- › Make very sure grips are attached before lifting plate.
- › Ensure product does not slip off fork lifts or out of slings - it can be slippery.
- › Be careful of dangerous product - pickling and passivating chemicals contain very strong acids.

5.4 WELDING

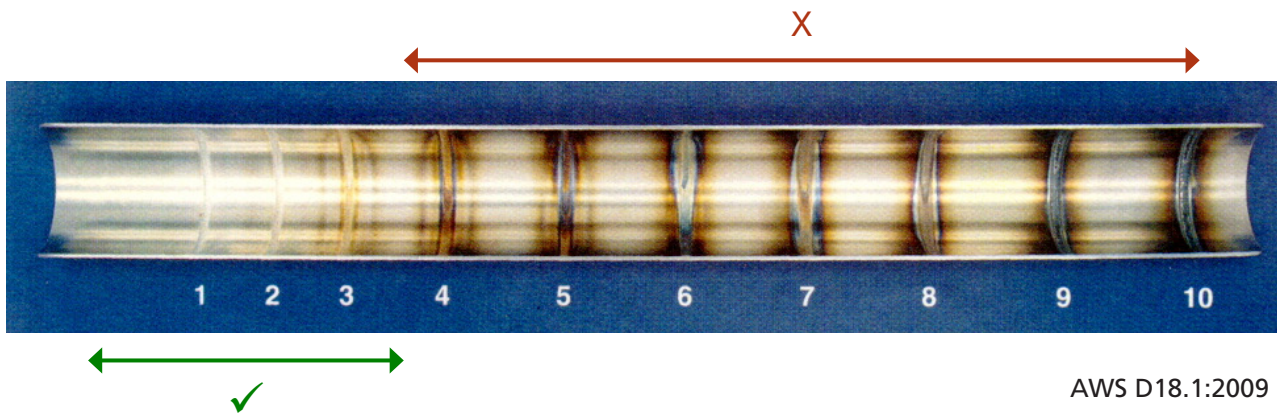
5.4.1 WELDER/JOINT QUALIFICATION

The fabricator is required to show that his welding methods are acceptable. Welders shall be required to prove their competency before welding can start on both offsite and onsite welding. All welding shall be qualified to either a pre-qualified procedure or a qualified procedure, and all welders shall be qualified to the procedures specified elsewhere in this document.

5.4.2 HEAT TINT LIMITS AND ACHIEVING THEM

The shielding and purge gas requirements shall be discussed with the purchaser's inspector prior to carrying out the procedures. Good gas shielding produces less scale and assists post weld surface finishing even in areas with good access for post-weld clean up. For areas where post-weld clean up is difficult or not possible (inside pipe or tubes, interior of a vessel with external attachments etc.), good purging is essential. A backing bar alone is not adequate and may cause carbon contamination. The purge gas used will produce a heat tint of no more than light straw (AS/NZS 1554.6) on plate and pipe/pipe fittings or (equivalently) to level 3 of Figure 2 in AWS D18.1 on tube/pipe and fittings (see next page).

This normally requires an oxygen content of 50ppm or less and maintenance of the gas purge until the weld has cooled below ~250°C. In the absence of an oxygen meter, a mildly turbulent purge of 10 volumes prior to welding has been used as a rule of thumb. With tube or pipe of more than about 150mm diameter, it is difficult to generate sufficient turbulence to ensure low oxygen levels at the metal surface. If nitrogen is used in the purge gas, the root run may suffer hot cracking in austenitics and the ferrite may be too low in duplex alloys. If welding ferritics, other than 12% chromium alloys, both purge and shielding gas must have very low oxygen and nitrogen levels to avoid corrosion problems. Alternatively, level 5 of EHEDG Guideline No. 35 may be used as a pictorial guideline as it references similar oxygen levels for acceptably low levels of heat tint.



5.4.3 WELD PREPARATION

Prior to welding, heavily oxidised surfaces must be ground back and the weld surfaces shall be cleaned free of any grease and dirt. As shown in AS/NZS 1554.6, weld preparations require more access than carbon steel because of the nickel content in austenitic and duplex alloys.

5.4.4 SAFETY IN WELDING

The safety requirements are no more stringent than for carbon steel, but should consider electrical, thermal and fume avoidance issues. The WTIA TN22 deals with electrical safety and their website has a good section on control of potential hazards caused by welding and cutting fume - but this is not specifically written for stainless steel.

5.5 MECHANICAL FINISHING DETAILS

Minimum requirements for product contact surfaces that have been mechanically treated (abraded) are listed in the table below:

TABLE 5.5 SURFACE ROUGHNESS REQUIREMENTS FOR SPECIFIC PROCESS AREAS

Aseptic and UHT processes	$R_a < 0.5\mu\text{m}$
Post pasteurisation	$R_a < 1.0\mu\text{m}$ (= HACCP)
Pre pasteurisation	$R_a < 1.0\mu\text{m}$

HACCP = Hazard Analysis and Critical Point Control

These R_a values are primarily based on cleanability but it is also possible (although less common) to specify peak heights or number of peaks per area instead or in addition. AS1554.6 allows average and/or peak roughness at the discretion of the purchaser. Abrading cast or HRAP surfaces is usually specified for cleanability reasons rather than corrosion resistance. The R_a of pickled, electropolished and mill finishes will depend on the processing history. The R_a of a cold rolled mill surface will be smaller for thinner sheet. The R_a of a machined surface is generally rougher than an abraded surface. All surfaces shall be passivated if high corrosion resistance is required.

A surface finish with $R_a < 1.0\mu\text{m}$ can normally be achieved by polishing using 180 grit polish, while a 320 grit polish is normally required for $R_a < 0.5\mu\text{m}$. Pharmaceutical and some architectural (decorative) or kitchen finishes may require a higher grit finish, i.e. 220 – 400, or higher. These grit sizes are given for guidance only as the relation between grit size and R_a depends on pressure, polishing time, age and type of abrasive, lubrication, etc. If required, a surface roughness meter shall be used.

Non-product contact areas, e.g. platforms, machinery exteriors, staircases, etc., are primarily determined by specification based on “presentation and quality” issues.

The most common finish is different in various product forms. Tanks generally are cold rolled 2B finishes with abraded strips along the welds. The actual surface roughness of cold rolled material reduces with thickness and a 3mm thick sheet would typically have an R_a of approximately $0.5\mu\text{m}$. A cold rolled, bright annealed (BA) surface is mirror like and typically 30% smoother than a 2B surface for the same thickness. Embossed surfaces are used in chutes to reduce adhesion of sticky solids. They are formed from BA or 2B micro-smooth materials with good cleanability.

Cast and HRAP (hot rolled annealed and pickled) surfaces have much higher R_a and will require substantial abrasion to achieve the specified finishes if used for product contact surfaces.

5.6 CHEMICAL FINISHING

Chemical cleaning is required prior to installation. It comprises of a degreasing/desoiling process (often by detergent or alkaline cleaner, although solvents may be used) followed either by:

- › Pickling in hydrofluoric/nitric acid (to ASTM A380) if there is heat tint or deeply embedded steel particles on a surface which is NOT to be abraded.
- › Grinding with the required size grit followed by a passivation process using nitric acid solution as per ASTM A967. Passivation shall follow the last abrasive removal of metal.
- › Electropolishing which typically reduces R_a by a few tenths of a micrometer and will smooth out rough edges improving slidability. Electropolishing is normally an offsite factory process.

Pickling will slightly increase the R_a and will cause a slightly matte appearance. Both pickling and passivation can be applied by paste rather than immersion in a bath. Bath treatments are slightly more effective. All acid treatments shall incorporate a thorough clean water rinse followed by exposure to clean air preferably for 24 hours. Surfaces must not be permitted to dry during the pickling and/or passivation process as it generally causes staining.

Portable electrocleaning has evolved from using wetted sponges through cooled sponges to carbon fibre brushes. All use a mild acid mixture and apply a low voltage current to remove weld tints after fabrication. Their effectiveness depends on operator competence. All are intended for strip cleaning of welds rather than large open areas.

6 PROCESS PLANT/EQUIPMENT FABRICATION: TANKS AND VESSELS, ETC

6.1 GENERAL

This section covers tanks, mixers, vessels, etc fabricated as part of the supply under this Code of Practice. The supplier shall bear in mind the prevention of contamination and damage during fabrication to avoid unnecessary (and aesthetically poor and potentially damaging) rectification works after fabrication. The details set out in this Code of Practice are generally the best practice carried out by a competent organisation who would comply with the requirements of the ASSDA Accreditation scheme.

6.2 PREPARATION

The material shall only be cut to size by machining, grinding, shearing, laser-cutting, water jet-cutting, or plasma arc-cutting. Material shall not be cut using "oxy-cutting" methods. All burrs and ragged edges shall be removed prior to any welding operation. Any cut edge that will be left in the as-cut condition shall be dressed to remove all sharp edges. Heavily oxidised cutting surfaces shall be ground back to raw metal prior to welding. Contamination by carbonaceous material, steel or other metals shall be avoided.

The material may be formed to the required shape by any process that will not impair the quality and properties of the material for its intended use. Cold forming or bending of the material should be by gradually applied pressure. Hammering of the material as a forming method shall be avoided. The thickness of any material should not be reduced by greater than 10% of the original thickness during any general forming operation. If greater metal loss is unavoidable (as in dished ends), the residual thickness must exceed minimum design value.

The fabrication shall be free from any mechanical damage (such as dents, scratches or bulges) that will impair its intended functions, interfere with CIP effectiveness or create potential sites for corrosion attack. Machined surfaces shall comply with the surface roughness requirements and shall be passivated after last metal removal.

Knuckle radii shall be free of kinks, ripples or dents of the above paragraphs and meet the client's aesthetic requirements. Forming marks on the non-product contact side are acceptable providing they comply with the requirements of the above clause. Internal profile marks generated by the forming process may be accepted providing they are open and accessible for cleaning.

Where possible the construction of cylindrical parts shall be from a single sheet or plate. Where two or more pieces make up a circumferential strake, these pieces shall be joined prior to commencement of the circumferential weld.

6.3 WELDING

The requirements of Section 5.4 apply to all welding. All welding shall be carried out to the requirements of AS/NZS 1554.6 with surface finishes defined by Section 5.5 of this code. AS/NZS 1554.6 (2012) has significant revisions in its Section 6 including as-welded finishes stated to be suitable for hygienic service.

Welding procedures are listed in AS/NZS 1554.6 for typical joint designs and pre-qualified procedures. Where the configuration does not comply with AS/NZS 1554.6, the weld will require a procedure test to the requirements of AS/NZS 1554.6.

All welders shall prove they can weld all required procedures and tests. Joint mock-ups are to be witnessed where required. Joint mock-ups where there is no procedure will be inspected by the purchaser's inspector and certified for use. The mock-ups will be given to the client for future reference.

During multi-pass welding, defects shall be removed by iron-free abrasives prior to subsequent weld passes.

Peening may be used on intermediate weld runs for control of shrinkage stresses in thick welds to prevent cracking. No peening shall be used on the root or surface layer of the weld or in the base metal at the edges of the weld.

6.4 INSPECTION AND WITNESSING

The purchaser's inspector, both prior to and post welding, shall inspect all of the preparation and completed welds. This inspection will cover the fit up and the heat tint before final cleaning. The inspection shall also determine compliance to the dimensional tolerances given in the table.

TABLE 6.4 DIMENSIONAL TOLERANCES FOR TANKS

Vertical Joints - stagger	Minimum 5 times the thickness of the thicker plate in the joint		
Circumference	D > 600mm ± 0.25% of circumference		
Circularity	Nominal ID	$D_{\max} - D_{\min}$	Deviation from designed form over a chord length of 0.25D
	D ≤ 900	1% of ID	0.375% of ID
	900 < D ≤ 1500	1% of ID	0.35% of ID
	D > 1500	1% of ID	0.30% of ID
	Peaking at vertical joints shall not exceed 6mm measured using a 900mm long sweepboard made to the nominal radius of the tank.		
Straightness of Cylindrical Shells	The maximum-out-of plumbness of the top of the shell relative to the bottom of the shell shall not exceed 1/200 (0.5%) of the total tank height. The measurement shall be made to the surface of the parent plate, not to a weld, fitting or other raised point.		
	Banding at horizontal joints shall not exceed 6mm measured using a 900mm long straight edge sweepboard.		
Misalignment	Longitudinal joint	t ≤ 6mm	0.5mm
		6mm < t ≤ 12mm	1.5mm
	Circumferential joints	t ≤ 6mm	0.5mm
		6mm < t ≤ 12mm	1.5mm

NOTE: If plate thickness exceeds 12mm, maximum misalignment shall be by prior agreement, but would not normally exceed 10% wall thickness.

6.5 FINISHING

Where welds are accessible and are not required to be ground flush, they shall be manually wire brushed while still warm after welding to remove thick slag and flux residues, followed by pickling. Light manual abrasion, such as by Scotchbrite®, may also be required to remove heavy tints especially if the purge was poor. Pickling chemicals shall not be left in contact with the material for a period exceeding that recommended by the manufacturer. All residues shall be completely removed using fresh, clean water. A neutraliser may be required to comply with environmental requirements for disposal and/or if the fabrication has crevices which could trap pickling acids.

Alternatively, where required, welds on the product contact side shall be ground flush and polished to the

appropriate R_a as set out in Section 5.5. The surface is abraded using successively finer grit to the required roughness. The abraded strip along a weld must be wide enough to remove any heat degraded surface oxides. The width will depend on heat input and material thickness, but 15mm either side of a butt weld centreline is frequently sufficient. A final passivation process is required to remove internal and external contaminants.

Where the purchaser requires a polished surface finish in excess of the requirements of Section 5.5, the purchaser shall provide the supplier with a sample and an agreed definition of assessment of the finish required.

The weld roots and interior heat affected zones of welds that cannot be ground and polished shall be protected from oxidation by back purging during welding as set out in Section 5.5. This is critical as heavy heat tint caused by poor purging is extremely difficult to remove by chemical pickling alone.

Reduction of parent material thickness during grinding and polishing shall not exceed the greater of 0.25mm or 5% of material thickness. During grinding and polishing, localised heat build-up or "blueing" of the material shall be avoided.

Iron-free particles shall be used for all shot or abrasive blasting processes.

If abrasive blasting is used to remove heat tint, the surface roughness is normally increased and care is required to ensure the R_a provisions are satisfied. Because blasting does not usually remove the chromium-depleted layer under heat tint, chemical finishing is required as described in Section 5.6 both to remove the chromium-depleted layer and any sulphides exposed by the metal removal. The metal flow caused by the impact of the abrasives may trap blasting debris and form crevices which promote corrosion and limit cleanability.

7 PROCESS PLANT/EQUIPMENT FABRICATION

7.1 GENERAL

The design requirements of Section 4.4 apply to items in this section. Items covered by this section are in two groups:

- › The units such as pumps, mixers, heat exchangers, valves, conveying media, etc., fabricated by others and supplied for installation; and
- › The ancillary supports, mountings, fixings, handrails, stairways, etc. required on site.

7.2 ITEMS SUPPLIED BY OTHERS

Prior to installation, documentary confirmation should be obtained that the item has been designed, fabricated and delivered in a condition to deliver the required performance. This includes visual amenity. It is also necessary to confirm that the item will fit and perform its function in the planned location.

7.3 ANCILLIARY ITEMS FABRICATED/INSTALLED ON SITE

In addition to the structural and functional adequacy of items in this group, the items shall be designed and fabricated with sanitation, simplicity and “cleanability” as prime objectives. If it is necessary to use materials that may suffer corrosion, they shall be protected by an adequate protective coating system that is appropriately coloured to provide good contrast for any soil and assist in good cleaning.

8 PROCESS (AND CIP) TUBE FABRICATION

8.1 GENERAL

This section covers the fabrication of tube systems that have product contact. It includes the selection and preparation of tube as well as welding methodology, surface finish, inspection and acceptance criteria.

8.2 PREPARATION PROCEDURES

8.2.1 SELECTION OF TUBING

All tube and tube fittings shall conform to AS 1528, and as per the purchaser's specification with regard to grade of stainless steel, its heat treatment, and surface finish.

Tube and tube fittings shall display this information and be readily identifiable.

Any part tube lengths, tube off-cuts and re-used tube sections being used shall be positively identified as conforming to the above requirements in all respects including grade, heat treatment, etc.

8.2.2 METHODS OF TUBE END CUT OFF PREPARATION

All tube (and tube fittings) ends prepared for butt welding shall be cut exactly "square" and flat (ends shall not be bevelled) using an approved tube end cutting tool with cutters (or blades) specifically for stainless steel cutting. Perpendicularity of cut ends shall be as per AS 1528.3, clause 6.3.

Tube ends may be squared up where applicable using appropriate tube squaring tools specifically designed for this purpose.

Tube ends may also be prepared by machining. In the case of wet machining, the cutting fluids shall be low in chloride, free of chlorine and approved for such use.

The use of abrasive and thermal cut off methodologies shall be avoided.

Tube end ovality shall be within the tolerance defined for outside diameter as given in AS 1528.1.

All burrs shall be removed from the inside and outside of the tube or tube fitting. Deburring of the tube shall be undertaken with tungsten carbide burr removal tools. Both internal and external de-burring tools shall be of a construction that will not scratch or mark the internal tube surface during operation. Operation of these tools shall be such that the metal thickness of the tube is not reduced at the mating face by bevelling or rounding of the corners.

Clamps, grippers, vices, etc. for holding tubes during the cutting process and other tube preparation processes shall not deform the tube or cause the tube to become oval (out of round), or mark the tube, or result in contamination.

The mating faces of tube and tube fittings to be welded shall be matched for shape (roundness), wall thickness and squareness so that the gap between the mating faces does not exceed 0.16mm as measured by feeler gauge.

8.2.3 SURFACE PREPARATION (PRIOR TO TACK-UP AND WELDING)

The area to be welded (interior and exterior surfaces) including machined tube fittings, shall be wiped clean of organic contaminants just prior to the commencement of the welding process. A lint free cloth with clean Methyl Ethyl Ketone (MEK) or acetone has been found effective.

Every care shall be taken to ensure that the weld area after preparation remains clean and that contamination and high temperature scale of the area is avoided or removed.

8.3 WELDING

8.3.1 WELDING ENVIRONMENT

All tube fabrication and welding shall be carried out in a carbon-free environment, free from grease and dirt.

All stainless steel tube and tube fittings shall be protected from damage and marking (scratching during fabrication. Tube end caps shall be kept in place at all times to avoid any internal damage or contamination. Stainless steel tube and tube fittings shall be segregated from mild steel and other materials during the fabrication processes.

The preparation, fabrication, welding, assembly works, and inspection of stainless steel tube components should be carried out in an area segregated from other activities.

The area where welding is to be carried out should be free from draughts created by open doorways, air conditioning systems and general personnel traffic/activities.

Where cutting, grinding or welding is carried out, all process equipment located in the immediate vicinity should be protected by drop sheets, screens or other appropriate measures.

8.3.2 WELDER QUALIFICATION

Welders may be qualified for welding tube either to AS/NZS 2980 Appendix F with the proviso that as-welded internal heat tint may not exceed the requirements of Section 5.4 of this code. This standard replaces the withdrawn NZS 4703.

Alternatively, welders may be qualified either using pre-qualified configurations from AS/NZS 1554.6 or by procedures qualified under clause 4.7 of AS/NZS 1554.6. In both cases, the acceptance criteria are set out in Table 8.4.5 of this code.

Other qualification pathways are subject to prior agreement by the purchaser.

8.3.3 TACK-UP

Tacking of the tube joint shall be carried out to maintain the correct alignment or fit-up.

Gas purging shall be carried out during tack welding to the same discolouration requirements given in Section 5.4 of this code. Tack welds (surface tack welds only) shall be kept as small as possible. Tack welds shall not penetrate to the inside surface of the tube. The number of tack welds shall be kept to a minimum, sufficient only to preserve the alignment of mating faces. For example, on a 100mm diameter tube, 4 to 6 welds should suffice.

Special clamps for holding tube with no deformation during tack-up may be used. The joint will need to be disassembled if the weld surface is contaminated after tacking but before welding. The surface to be welded is then required to be re-cleaned before re-welding.

8.3.4 WELDING CONSUMABLES

Welding consumables selected shall be in accordance with AS 1554.6. Autogenous welds may be permitted by the purchaser. *Appendix B* of this Code of Practice discusses the factors in selecting to use filler metal or not. All welding consumables need to be checked for damage or surface contamination. Consumables shall not be used if they show signs of damage.

8.3.5 WELD PROCEDURES

AS/NZS 1554.6 provides a series of typical joint designs and pre-qualified procedures. Where the configuration does not comply with AS/NZS 1554.6, the weld will require a procedure test, to the AS/NZS 1554.6 clause 4.7 requirements.

The welding procedure shall require a pre-purge until the required oxygen level is achieved or, in the absence of an oxygen meter, until at least 10 volumes have flowed through. Large diameter tubes require more thorough purging to ensure that the oxygen level at the metal surface is low enough. The purge shall be maintained until the weld has cooled sufficiently to avoid oxidation. Manual TIG welding shall be upwards.

Machine (orbital) welding is permitted subject to a satisfactory test weld for the conditions.

8.4 INSPECTION AND WITNESSING

8.4.1 SAMPLE WELDS

Prior to any final welding of tubes and tube fittings, sample welds should be made in the presence of the purchaser's assigned representative.

At the commencement of work each day, each individual welder should submit sample welds for the size and material assigned for that section or area of process tube system that he will be involved with at the start of that day.

Similarly, at a change of tube size during any day, each welder should again submit sample welds of the new tube size.

A record should be kept by each welder of the specific welding parameters (welding machine, weld settings, etc.) associated with his respective sample welds.

Sample welds should be cut to 30mm to 40mm in length, tagged for identification, and stored appropriately for the duration of the job.

Following the welding process, the internal and external surfaces of the weld samples shall remain in an "as-welded" condition until after inspection. They shall not be pickled, buffed, ground, wire brushed or polished. Heat affected zones, physical weld attributes and surface finish shall be evident for subsequent inspection.

8.4.2 BLIND WELD INSPECTION

During fabrication and installation of the process tube system the quality of manual "blind" tube welds shall be checked at frequencies required by the contract. A "borescope" or similar device may be used for this purpose.

If, despite the planning required by 8.4.3, some welds are inaccessible for remote inspection or unable to be reached by "borescope", equipment **may** require to be cut from the pipelines for subsequent visual inspection.

Where the removed weld is proven as acceptable the cost of rectification and re-instatement shall be borne by the purchaser.

Where a weld is deemed unsatisfactory, suspect welded tube may be removed until welds of acceptable standard are evident in the completed system. The cost of removal, replacement of defective materials, and re-instatement of the piping system shall be borne by the installation supplier.

8.4.3 INSPECTION METHODOLOGIES

Evaluation of welding is carried out on the internal (product side) and outside surfaces of the weld area. Internal inspection of pipework requires planning to ensure that access is possible at intervals during the closing of the system.

Visual inspection of the external weld surfaces under bright white light may be supplemented with dye penetrant for detection of surface defects or cracks, if required. If the external surface is only marginally compliant (see table in Section 8.4.5), then internal inspection of the weld is required.

Physical measurement of weld attributes may be required to determine compliance.

Photographic/video recording of borescope or other inspections of internal surfaces of welds provides a useful quality record, but the optics mean there are differences in appearance from direct visual inspection. Radiography or ultrasonic examination of thin wall tube may be appropriate.

8.4.4 VISUAL EXAMINATION REQUIREMENTS: EXTENT OF EXAMINATION

- 8.4.4.1 Welders shall examine every weld they make. The welding supervisor shall examine a representative sample of each welder's production to verify that the work is satisfactory.
- 8.4.4.2 Outside surfaces of all welds shall be visually examined by the fabricator's welding supervisor. Internal surfaces of welds shall be examined at frequencies stipulated by the purchaser. All ... welds that do not meet the external requirements of Section 8.4.5 shall be examined internally.
- 8.4.4.3 Product contact surfaces of internal welds shall be visually examined directly or by borescopes or similar special tools. The internal weld surfaces shall meet the requirements of 8.4.5.
- 8.4.4.4 Welds fabricated with the addition of filler metal shall be visually examined on all product contact surfaces. The product contact surfaces shall meet the requirements of Section 8.4.5.

8.4.5 VISUAL EXAMINATION: ACCEPTANCE CRITERIA PRIOR TO POST WELD FINISHING

The examination of the external (non-product contact) surface weld can provide an indication of the quality of the inside (product contact surface) weld. However, multiple stop/starts or uneven profile/width (within the requirement of Table 8.4.5) is an indicator that internal inspection might be required.

TABLE 8.4.5 AS-WELDED VISUAL ACCEPTANCE CRITERIA

WELD PROPERTY	NON-PRODUCT CONTACT	PRODUCT CONTACT
Penetration	Full	Full
Cracks (including centreline), crevices, pits, undercut nor excess protruding material	Not permitted	Not permitted
Offset or misalignment	≤ 10% of wall thickness	≤ 10% of wall thickness
Maximum depression	Least of 15%T and 0.15mm	≤ 0.3mm
Maximum protrusion	≤ 0.3mm	≤ 0.3mm
Width of manual weld face	≥ 2T (1)	≤ non-product width
Width of weld	Min. ≥ 75% of max. width	Not specified
Consistency	Start, end and width consistent with sample welds	Start, end and width consistent with sample welds
Heat tint/oxidisation	Specified by purchaser	No more than pale straw (2)
Oxide islands	Removable by post weld finishing to satisfy Section 8.5.1	A few isolated, firmly adherent islands are acceptable unless they are >1.6mm along the fusion line or clustered (3)

NOTES:

- 1. T is tube wall thickness.
- 2. Colour specified as in clause 5.4 of this code.
- 3. Islands are mainly slag oxides of Al, Ca and Si. The main concern is possible detachment of islands into product.

8.5 TUBE FINISH

8.5.1 EXTERNAL TUBE SURFACE

External tube finish shall be consistent with other visible surfaces in the plant. The external weld beads (including welds at end fittings) may be ground, buffed and/or polished if specified by purchaser.

The external weld surface shall be pickled using an effective stainless steel pickling formulation used strictly in accordance with OH&S requirements and the manufacturer's directions. The pickling agent shall be removed by thorough washing. Neutralisation may be necessary to achieve complete removal and to comply with environmental regulations. More efficient removal of tenacious residues may be possible with light mechanical (manual) abrasion such as Scotchbrite®.

Alternatively, if the external weld surface has been abrasively cleaned, it may be passivated by a nitric acid formulation as provided in ASTM A967.

8.5.2 INTERNAL TUBE SURFACES

The internal tube surfaces shall be treated by a passivation process which involves the following steps:

- › Routine soil removal by manual cleaning (whenever possible during fabrication), followed by removal of loose soil by turbulent rinsing with clean water.
- › Cleaning by circulation of caustic detergent solutions followed by rinsing with clean warm water.
- › Circulation of an effective passivating solution may be based on ASTM A967 nitric or citric acid formulations or may use proven proprietary solutions for a predetermined duration. All acid treatment shall be followed by clean air exposure (preferably for at least 24 hours).

Note that this passivation process will not remove heat tint if the purging was inadequate.

9 PROCESS (AND CIP) PIPE FABRICATION (HIGH PRESSURE)

9.1 GENERAL

This section covers the fabrication of pressurised pipe systems that have product contact. It includes the selection and preparation of pipe as well as welding methodology, surface finish, inspection and acceptance criteria. The design for pipe and fittings shall be to AS 4041 or equivalent.

9.2 PREPARATION

Pipe selection, pipe end preparation and surface preparation prior to welding shall be as described for tube in Section 8.2 except:

- › Pipe will be supplied to ASTM A312M or equivalent;
- › Butt welding pipe fittings shall be supplied to ASTM A403M or equivalent;
- › After end preparation, pipe end ovality shall be within the outside diameter tolerance of ASTM A312M.

9.3 WELDING

The welding environment, welder qualification, tack up, welding consumables and weld procedures shall be as described for tube in Section 8.3 except:

- › The general requirements of Section 5.4 shall apply;
- › Welders shall be qualified using the procedures of AS/NZS 3992;
- › Welding shall be carried out using the procedures of AS/NZS 4458;
- › Neither manual nor orbital autogenous welding may be carried out;
- › All weld passes shall be purged as per Section 5.4. Prior to each subsequent weld pass, defects shall be removed by iron-free abrasives.

9.4 INSPECTION AND WITNESSING

Sample welds, blind weld inspection, inspection methodologies and visual examination requirements shall be as described for tube in Section 8.4 except:

- › In addition to the inspection required for hygienic requirements, weld defect assessment shall follow AS 4037.

9.5 FINISHING

The external and internal pipe finish shall be as described for tube in Section 8.5.

10 PROCESS SERVICES TUBE FABRICATION (LOW PRESSURE)

10.1 GENERAL

This section covers non-product contact tube systems such as electrical and instrumentation conduits, and mechanical services tube systems carrying fluids (including but not limited to chilled water, cold water, hot water, etc.), compressed air at a pressure less than 70kPa, vents, waste, etc. at an internal pressure that does not require design to AS 4041.

10.2 PREPARATION

Tube selection, tube end preparation and surface preparation prior to welding shall be as described for tube in Section 8.2 except:

- › Spiral welded tube to ASTM A778 or equivalent may be substituted for tube supplied to AS 1528 provided that it has been pickled after fabrication. The requirement for internal weld bead treatment is relaxed, although the weld bead profile must be smooth and satisfy the requirements of Section 10.5.

10.3 WELDING

The welding environment, welder qualification, tack up, welding consumables and weld procedures shall be as described for tube in Section 8.3.

10.4 INSPECTION AND WITNESSING

Should sample welds or blind weld inspection be required, it shall be carried out as described for tube in Section 8.4. Inspection methodologies and visual examination requirements shall be as described for tube in Section 8.4 except that for internal surfaces:

- › The non-product surfaces criteria shall apply for tube not containing fluids;
- › The product contact surfaces criteria shall apply for tubing that contains fluids.

10.5 FINISHING

The external tube surface finish shall be consistent with other plant tube and pipe systems. Tubes containing fluid shall be marked with "identifiers" (preferably following AS 1345) to show function and direction of flow.

Internal finish of fluid containing tubes shall be smooth and passivated. Internal surfaces of tubes not carrying fluid need not be passivated but the weld profile shall be smooth and shall comply with the non-product surface specification of Section 8.4.5.

11 PROCESS SERVICES PIPE FABRICATION (HIGH PRESSURE)

11.1 GENERAL

This section covers non-product contact pipe such as mechanical services pipe systems carrying fluids (including but not limited to chilled water, cold water, hot water, etc.), compressed air at a pressure greater than 70kPa, vents, waste, etc. at an internal pressure that normally requires design to AS 4041.

11.2 PREPARATION

Pipe selection, pipe end preparation and surface preparation prior to welding shall be as described for tube in Section 8.2 except:

- › Pipe will be supplied to ASTM A312M or equivalent;
- › Butt welding pipe fittings shall be supplied to ASTM A403M or equivalent;
- › After end preparation, pipe end ovality shall be within the outside diameter tolerance of ASTM A312M.

11.3 WELDING

The welding environment, welder qualification, tack up, welding consumables and weld procedures shall be as described for tube in Section 8.3 except:

- › The general requirements of Section 5.4 shall apply;
- › Welders shall be qualified using the procedures of AS/NZS 3992;
- › Welding shall be carried out using the procedures of AS 4458;
- › Neither manual nor orbital autogenous welding may be carried out;
- › All weld passes shall be purged as per Section 5.4. Prior to each subsequent weld pass, defects shall be removed by iron-free abrasives.

11.4 INSPECTION AND WITNESSING

Sample welds, blind weld inspection, inspection methodologies and visual examination requirements shall be as described for tube in Section 8.4 except:

- › Inspection shall follow AS 4037.

11.5 FINISHING

The external pipe surface finish shall be consistent with other plant tube and pipe systems. Pipes shall be marked with "identifiers" (preferably following AS 1345) to show content and direction of flow.

Internal finish of pipes shall be smooth and passivated.

12 TRANSPORT AND INSTALLATION

Prior to transport to the installation site, the supplier shall ensure that the fabrication has been internally and externally cleaned to remove swarf, dirt and other contamination.

The supplier shall ensure that the fabrication is clearly identified and protected from damage and contamination during loading, transportation and unloading. Where installation forms part of the contract, the supplier shall ensure that the fabrication is protected from damage and contamination during installation. Mild steel lifting forks, hooks, chains and wire ropes shall not be permitted to come into contact with stainless steel equipment.

Suitable lifting lugs or attachments for handling during loading, unloading and installation shall be provided by the supplier. Even where such lugs or attachments are temporary the provisions of the welding standards shall apply.

Bracing shall be provided, where necessary, to prevent distortion during transportation. Transport cradles shall be suitably designed.

All silos, vessels and major pieces of equipment shall be identified with a name plate identifying the serial number and supplier. A register should be kept by the supplier.

13 INSURANCE

Responsibility for insurance during transport and storage shall be specified in the purchase documents. The default position is that the responsibility changes when the item is delivered for installation by others or, if installation is part of the contract, when the plant is handed over for commissioning tests. The hand over point must be precise, e.g. when the item is no longer resting on the tray of the truck.

14 COMMISSIONING OF PLANT AND EQUIPMENT

14.1 COMMISSIONING PLAN

The supplier shall provide a commissioning plan based on the operating conditions supplied by the purchaser. The plan shall include collection of sufficient data to confirm satisfactory operation or otherwise.

14.2 HYDROTESTING

Hydrotesting is an option for agreement between purchaser and supplier. It shall be carried out with potable water, but preferably less than 50ppm chloride. However, if there is doubt about draindown, if the material is austenitic and if service operation is to be above 55°C, then chloride levels should be less than 1ppm to avoid the risk of stress corrosion cracking. Untreated bore water, untreated river water, seawater, or contaminated recycled water shall not be used.

Water shall be drained from inside plant and process equipment promptly after hydrotesting. If the hydrotest water is to be re-used in other new plant, it shall be checked for contamination and circulated sufficiently to maintain dissolved oxygen levels. After draining the hydrotest water, check that there are no areas of ponding (stagnant water). The tester shall wipe the stainless steel equipment dry with clean cloths.

15 DOCUMENTATION

The supplier shall provide full documentation with the goods including drawings, commissioning and operating instructions, together with agreed test certificates and certifications. The document may be provided in electronic form, but at least 2 sets of documents must be in hard copy.

16 AESTHETICS/PRESENTATION

The asset owner may specify particular aesthetic requirements to maintain a house style for the facility. Such specification shall be provided with the design brief. It could include items such as the particular orientation of the machinery or pipework, curvatures of pipes or vessels, external surface finishes, label colour schemes or any other appearance and quality issues specified by the purchaser.

APPENDIX A: REFERENCED AND RELATED STANDARDS AND CODES

AUSTRALIAN STANDARDS

- › Commonwealth of Australia; Export Control (Processed Food) Orders, No.9 of 1992
- › The current Occupational Health and Safety Act applicable to the respective state or territory.
- › AS/NZS 1170.4 SAA loading code - earthquake loads
- › AS 1210 Pressure vessels
- › AS 1345 Identification of the contents of pipes, conduits and ducts
- › AS 1528 Tubes and tube fittings for the food industry
 - Part 1: Tubes
 - Part 2: Screwed couplings
 - Part 3: Butt weld tube fittings.
 - Part 4: Clamp liners with gaskets
- › AS/NZS 1554.6 Welding stainless steels for structural purposes
- › AS 1657 Fixed platforms, walkways, stairways and ladders – design, construction and installation
- › AS 1692 Tanks for flammable and combustible liquids
- › AS 1940 The storage and handling of flammable and combustible liquids: Appendix D - Tank venting a Appendix G - Storage and handling of potable spirits in bulk
- › AS/NZS 2865 Safe working in a confined space
- › AS/NZS 2980 Qualification of welders - specifically Appendix F on welding food tube
- › AS/NZS 3992 Pressure equipment – Welding and brazing qualifications
- › AS 4037 Pressure equipment – Examination and testing
- › AS 4041 Pressure piping
- › AS 4458 Pressure equipment - Manufacture
- › AS 4709 Guide to cleaning and sanitizing of plant and equipment in the food industry
- › AS 4749 NDT definitions and abbreviations

INTERNATIONAL STANDARDS AND OTHER REFERENCE MATERIAL

- › API 620 Design and Construction of Large, Welded, Low-Pressure Storage Tanks
- › API 650 Welded Steel Tanks for Oil Storage
- › ASTM A182/A182M Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
- › ASTM A240/A240M Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
- › ASTM A276 Standard Specification for Stainless Steel Bars and Shapes
- › ASTM A312/A312M Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
- › ASTM A380 Standard Practice for Cleaning, Descaling and Passivation of Stainless Steel Parts, Equipment and Systems
- › ASTM A403/A403M Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings
- › ASTM A778 Welded, Unannealed Austenitic Stainless Steel Tubular Product
- › ASTM A967 Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts
- › ANSI/ASME B31 Standards of Pressure Piping - Part 3: Process piping (AS 4041 should be used in preference)
- › ANSI/AWS D18 & D18.2 Specification for Welding of Austenitic Stainless Steel Tube and Pipe Systems in Sanitary (Hygienic) Applications
- › ASME B36.19M Welded and Seamless Wrought Stainless Steel Pipe
- › BS 5500 Specification for Unfired Fusion Pressure Vessels
- › Code of Practice for the Fabrication of Stainless steel plant and Equipment (“The Blue Book”) NZSSDA
- › EHEDG Doc. 8 Hygienic Equipment Design Criteria

- › EHEDG Doc. 9 Welding Stainless Steel to Meet Hygienic Requirements
- › EHEDG Doc. 13 Hygienic Design of Equipment for Open Processing
- › EHEDG Doc. 35 Hygienic Welding of Tubing
- › ENV 1993-4-2 Eurocode 3: Design on Steel Structures –Part 4-2: Silos, Tanks and Pipelines – Tanks
- › ENV 1993-1-6 Eurocode 3: Design on Steel Structures –Part 1-6: General Rules – Supplementary Rules for Shell Structures
- › Euro Inox Reference photo guide for stainless steel welds. Materials and applications series, Volume 14
- › Euro Inox Stainless steel in the food and beverage industry. Materials & Applications Series, Volume 7
- › IMOA Practical Guidelines for the Fabrication of Duplex Stainless Steels
- › NACE RP0198 Code of Practice for Thermal Insulation of Pipework and Equipment
- › Nickel Institute Guidelines for the welded fabrication of nickel-containing stainless steels for corrosion resistant services NiDI #11007
- › Nickel Institute Fabrication techniques for orbital tube welding NiDI#14040
- › US 3-A Sanitary Standards # 605-04: Accepted Practices for Permanently Installed Sanitary Product Pipelines and Cleaning Systems
- › US 3-A Sanitary Standards #T-613-00: Accepted Practice for Cleaning-in-Place of Process Equipment and Systems (currently a proposed standard)
- › WTIA Fume minimisation guidelines: www.wtia.com.au
- › WTIA Technical note 22, Welding electrical safety

LOCAL REFERENCE MATERIAL

- › Victorian Dairy industry Authority: Code of Practice for the Quality Assurance of Milk and Dairy Produce.

APPENDIX B: AUTOGENOUS OR FILLER METAL BUTT WELDS ON TUBE

INFORMATIVE

In corrosive environments, all welds should use appropriate filler material as specified in AS/NZS 1554.6. If there is no filler material or if a filler of the same pre-weld composition is used, then the weld will have lower corrosion resistance because of the needle-like, upset microstructure and the lower alloy content after oxidation during welding. This difference in corrosion resistance applies even after passivation. In benign environments, where even the lower corrosion resistance of the weld metal is sufficient to resist corrosion, then autogenous welding can be satisfactory.

Some purchasers insist on autogenous welding for thin wall tubing because it ensures the fitup is precise, i.e. there is no filler metal bead to hide misalignment. If poor alignment is a concern, then routine weld inspection and assessment of welder competence are better options (although they will incur an up-front cost, which is more than offset by less repair work). In contrast, inexperienced welders using filler metal may form icicles or excessive reinforcement which require rectification or, if they are not detected, are very difficult to clean in service. In tube used for wiring conduit or non-product fluids which may cause corrosion, such defects are likely to cause failures. Again, improved welder competence and inspection are suitable options if filler metal is required for particular conditions.

ORBITAL WELDING

Automated welding of tube using orbital welding equipment has a substantial history of rapid, quality production in the semiconductor and pharmaceutical industries and has also been widely used in food and beverage industry fabrication. The standard method is autogenous and it is successful because the joint must be accurately prepared and match its joining face. This accurate matching, the excellent gas blanketing and the invariance of the weld speed and heat input provide excellent quality welds. The notional disadvantages are the capital cost and the requirement for access either side of the joint. Some modern orbital welding equipment uses filler metal if the product is intended for extremely corrosive service.

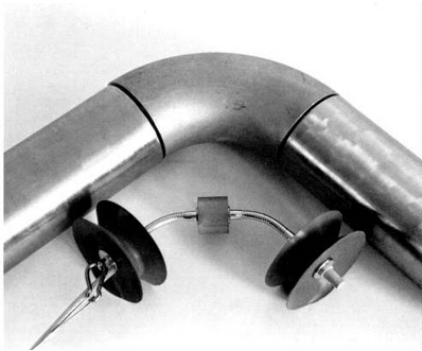
APPENDIX C: PURGE WELDING OF STAINLESS STEEL TUBE OR PIPE

BACKGROUND

This procedure is to ensure that the root of TIG welds in tube or pipe has no more than a pale straw heat tint. This level of colouration is specified in AS/NZS 1554.6 and AWS D18.1 (condition 3 - see Section 5.4) as the maximum permitted for tube to be used in the as-welded condition. It is achieved by maintaining oxygen levels <50ppm (0.005%) while the metal is hotter than 250°C. It is assumed that weld preparation, heat input and weld technique are controlled to provide a full penetration weld with a smooth, cleanable profile suitable for CIP. Mechanical orbital TIG welding equipment should give the same result if the manufacturer's instructions are followed.

MATERIALS

If a consumable is used it shall be at least as corrosion resistant as the tube or pipe material. Purge gas is normally argon but low oxygen nitrogen is also acceptable even for duplex tubing, provided there is no uncontrolled leakage into the arc. For long lengths of tube or pipe it is common to use removable dams to contain the purge gas. There are two main types of dam:



- › Water soluble paper and adhesive tape inserted on either side of the weld area before assembly and flushed away afterwards, and;
- › Rubber lipped dumbbell shaped assemblies (shown) with one end of the assembly attached to a purge feedline and cable for removal after the weld has cooled. The other dam disc contains a vent to avoid pressurising the purged area.

Custom made tapered foam discs with a rubber backing and a covering hat may also be used if externally welding a flange to a pipe.

PROCEDURE

Ensure the welder is qualified and competent to weld on the day. Carry out the weld preparation including verification that the longitudinal weld profile will permit a gas tight seal for purging.

Insert the dams into each section of the tube or pipe ensuring the feed tube and extraction wire are not tangled. Wipe the weld area with a clean wipe and volatile solvent, allow to dry and check the area is clean. Do not touch the weld area.

Align the matching faces and start the purge. The flow must be mildly turbulent. Either monitor the exit purge gas with a meter (shown) until the oxygen level is acceptable or purge until at least 10 times the dammed volume has flowed. Reduce the gas flow to avoid blowing out the weld and commence welding.

Plan the welding to minimise positional welding. If the ends are not well restrained by a jig, tack them while ensuring the tack is also gas shielded. Thicker wall materials may require a trailing shield to ensure air does not contact metal hot enough to oxidise. If external mechanical cleaning is acceptable, then a trailing shield is not required.



APPENDIX D: FACTORS TO CONSIDER WHEN SELECTING FITTINGS AND VALVES

The comments provided in this Appendix are necessarily general because of the breadth of the food and beverage industry. The products section of ASSDA's *Australian Stainless Reference Manual* has a reasonably detailed listing of fittings (including photographs) and cross sections of unions. Some suppliers have comprehensive catalogues of fittings, valves and unions on their websites. While of limited relevance to food industry pipework, the products section also contains data on pipe flanges. Note that some AS2129 "Table" flanges are also available bored to take tube.

There is a significant volume of imported equipment used in the Australian food industry. The equipment will come with valves and fittings characteristic of the country or supplier of origin. These must then interface with the connecting pipework or equipment. Whilst items may look similar, there are often sufficient differences (especially for seals in valves) that finding the matching component (or a replacement at a later date) requires some effort. Rigorous documentation of fittings and their dimensions during procurement or, at latest on delivery, significantly reduces wasted time and potential difficulties in timely repair or replacement.

For many processes, when the process fluid is waterlike and reasonably homogeneous, the fitting dimensions will be determined by the geometry and space available. However, with viscous fluids such as yoghurt or honey or with powders, sharp bends or diameter changes are likely to unduly restrict and, with powders, even block flow. Apart from process changes to control viscosity, using large radius bends or more slowly tapered reducers are obvious means of reducing flow restrictions.

Non homogenous fluids such as slurries/pastes or wine crushings may clog flow by build up on dividers (such as the edge of a butterfly valve or entrance to a heat exchanger) or protruding gaskets, seals or steps. Such discontinuities could also cause dead spots (and potential hygiene issues) in a homogenous flow, but the likelihood of problems is much greater if solids can be trapped.

Inspection of the union cross sections in ASSDA's *Australian Stainless Reference Manual* shows that some have crevices and are therefore difficult to clean, while others have shaped seals which are readily cleanable but require careful installation.

APPENDIX E: CONVEYING MEDIA – BANDS, BELTS, ROLLERS AND BASKETS (INFORMATIVE)

In conveying media/platforms, stainless steels are widely used for transport and on-belt processing in several forms:

- › Continuous, seamless belt/band in 301 or 316 with hardened pins in precipitation hardening 630;
- › Woven wire mesh belts in 300 series stainless steels;
- › Slat chain in 400 series for bottle/can handling in wet areas or wider belts in fabricated 300 series that are side chain-driven;
- › 300 series pan/tray conveyors for very specific duties such as abattoir evisceration service;
- › Various grade stainless chain, drive and sprocket smaller components that could be subject to periodic hose cleaning in wet area food plants;
- › 300 series stainless steels are also used for chutes/conveyors in fruit/vegetable washing and grading but with non-metallic transport rollers.



ASSDA ACCREDITATION SCHEME

ASSDA Accreditation gives owners and specifiers of stainless steel greater certainty that applications using stainless steel will be performed by technically competent industry specialists.

ASSDA Accreditation is an industry-based scheme designed to establish a benchmark for stainless steel fabricators to become recognised providers (ASSDA Accredited Fabricators) of a standardised level of quality.

Demand for stainless steel and its use in fabrication has grown, both in volume and in areas of application resulting in new metal fabricators moving into the stainless steel industry, sometimes with limited skills and experience in using the material.

As different skills and practices are required in fabricating stainless steel compared to other materials, there is industry concern about the quality of service provided by inexperienced operators.

The Accreditation Scheme aims to reduce the risk to end users and fabricators of exposure to the 'learning curve' of parties new to stainless steel, which parties will be better able to understand the steps necessary to convert skills and practices appropriate for other materials to stainless steel as a result of the Scheme.

ASSDA Accreditation is a sharp instrument that targets the key issues of stainless steel fabrication expertise and aims to meet the expectation of asset owners and specifiers that the job will be properly specified and trouble free.

The Scheme promotes an industry focus on the skills and performance of competently trained specialists and encourages a consistently high standard through industry self-regulation.

The Accreditation Scheme criteria requires all fabricators to conform to stringent standards of competence, training and education, personal and professional conduct, adhering to a Code of Ethics and a Code of Practice, and committing themselves to continuing competency development.

The ASSDA Accredited logo provides end users and specifiers of stainless steel with an assurance that ASSDA Accredited Fabricators are committed to the highest quality practices and professionalism.

A database of ASSDA Accredited Fabricators identified as good practitioners in stainless steel can be found in the Stainless Steel Specialists Register - visit www.assda.asn.au.

GREATER CERTAINTY. GREATER QUALITY.



ABOUT ASSDA

The Australian Stainless Steel Development Association (ASSDA) is a not-for-profit organisation that aims to increase the consumption and correct use of stainless steel in Australia.

Established in 1992, ASSDA represents over 200 member companies representing the stainless steel spectrum, including overseas mills, stockists and distributors, fabricators, engineering consultants, end-users and service providers.

ASSDA could not continue without the valuable support of its sponsors and members, who work with ASSDA to grow the market for stainless steel.

ASSDA's activities focus on:



networking

From the east to west coasts, ASSDA's seminars and conferences offer opportunities to share ideas and knowledge, discuss key issues and network with other industry professionals.



promotion

ASSDA's consistent media generation has elevated the profile and reputation of its members. Leading industry publications including *Australian Stainless* magazine, publicity and marketing activities all aim to boost interest and promote the use of stainless steel in Australia.



education

ASSDA's education vehicles include the popular Stainless Steel Specialist Course, seminars and interactive packages. ASSDA also offers free in-house architectural and engineering seminars for specifiers.



accreditation

Taking the lead to safeguard the reputation of stainless steel, ASSDA Accreditation gives asset owners and specifiers confidence that applications using stainless steel will be performed by technically competent industry specialists.



advocacy

ASSDA supports and represents the interests of member companies and the industry as a whole on a range of issues, from technical specifications and standards to local content requirements.



problem solving

ASSDA answers around 1000 technical enquiries every year, using its own technical specialist, as well as a wide network of metallurgists and stainless steel experts.

www.assda.asn.au