

Master Specification

Part ST-SS-S1

Fabrication of Structural Steelwork

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ST-SS-S1 Fabrication of Structural Steelwork

1 General

- a) This Master Specification Part specifies the requirements for the fabrication of structural steelwork, including:
- i) the documentation requirements, as set out in section 2;
 - ii) the materials requirements, as set out in section 3;
 - iii) the notice of work commencement and program requirements, as set out in section 4;
 - iv) the fabrication requirements, as set out in section 5;
 - v) the shop detailing and documentation requirements, as set out in section 6;
 - vi) the welded fabrication requirements, as set out in section 7;
 - vii) the steel cutting requirements, as set out in section 8;
 - viii) the stud sheer connector requirements, as set out in section 9;
 - ix) the bolted connection requirements, as set out in section 10;
 - x) the holding down bolt requirements, as set out in section 11;
 - xi) the mock set-up requirements, as set out in section 12;
 - xii) the damage requirements, as set out in section 13;
 - xiii) the Hold Point and Witness Point requirements, as set out in section 14; and
 - xiv) the verification requirements and records, as set out in section 15.
- b) The fabrication of structural steelwork must comply with the Reference Documents, including the following:
- i) in relation to nuts, bolts, screws and washers:
 - A. AS 1110 ISO metric hexagon bolts and screws - Product grades A and B;
 - B. AS 1111 ISO metric hexagon bolts and screws - Product grade C;
 - C. AS 1112 ISO metric hexagon nuts;
 - D. AS/NZS 1214 Hot-dip galvanized coatings on threaded fasteners (ISO metric coarse thread series);
 - E. AS 1237 Plain washers for metric bolts, screws and nuts for general purposes;
 - F. AS/NZS 1252 High strength steel fastener assemblies for structural engineering - Bolts, nuts and washers;
 - G. AS 1275 Metric screw threads for fasteners;
 - H. AS/NZS 4680 Hot-dip galvanized (zinc) coatings on fabricated ferrous articles; and
 - I. Queensland Department of Transport and Main Roads Technical Note 62 Assembly and Tensioning of High Strength Bolts and Nuts (available from: <https://www.tmr.qld.gov.au/>):
 - I. TN62 Part 1 - Class 8.8;
 - II. TN62 Part 2 - Class 10.9; and
 - III. TN62 Part 3 - Class 4.6;

- ii) in relation to steel:
 - A. AS/NZS 1163 Cold-formed structural steel hollow sections;
 - B. AS/NZS 1594 Hot-rolled steel flat products;
 - C. AS 3597 Structural and pressure vessel steel - Quenched and tempered plate;
 - D. AS/NZS 3678 Structural steel - Hot-rolled plates, floor plates and slabs;
 - E. AS/NZS 3679.1 Structural steel, Part 1: Hot-rolled bars and sections; and
 - F. AS/NZS 3679.2 Structural steel, Part 2: Welded I sections;
 - iii) in relation to welding and structural:
 - A. AS/NZS 1554 Structural steel welding;
 - B. AS 1796 Pressure equipment - Qualification of welders, welding supervisors and welding inspectors;
 - C. AS/NZS 2214 Certification of welding supervisors - Structural steel welding;
 - D. AS 4100 Steel structures;
 - E. AS/NZS 5100.6 Bridge design, Part 6: Steel and composite construction;
 - F. AS/NZS 5131 Structural steelwork - Fabrication and erection;
 - G. Australian Steel Institute: Standardised Structural Connections; and
 - H. Welding Australia Technical Notes, including:
 - I. TN01 The Weldability of Steels;
 - II. TN03 Care and Conditioning of Arc Welding Consumables; and
 - III. TN05 Flame Cutting of Steels;
 - iv) in relation to testing:
 - A. AS 1171 Non-destructive testing - Magnetic particle testing of ferromagnetic products, components and structures;
 - B. AS 1710 Non-destructive testing - Ultrasonic testing of carbon and low alloy steel plate and universal sections - Test methods and quality classification;
 - C. AS 2177 Non-destructive testing - Radiography of welded butt joints in metal;
 - D. AS 2205 Methods for destructive testing of welds in metal; and
 - E. AS 2207 Non-destructive testing - Ultrasonic testing of fusion welded joints in carbon and low alloy steel;
 - v) in relation to quality:
 - A. AS/NZS ISO 9001 Quality management systems - Requirements; and
 - B. AS/NZS ISO 3834.2 Quality requirements for fusion welding of metallic materials, Part 2: Comprehensive quality requirements; and
 - vi) in relation to Shop Drawings and documentation, AS 1101.3 Graphical symbols for general engineering, Part 3: Welding and non-destructive examination.
- c) The Contractor must ensure that the fabricating structural steelwork is certified in the appropriate category under the National Structural Steelwork Compliance Scheme (NSSCS). The certification must be provided as part of the Construction Documentation.
 - d) The Contractor must ensure that the supplier of materials pursuant to this Master Specification Part holds a valid certificate of approval issued by the Australasian Certification Authority for

Reinforcing and Structural Steels (ACRS) (refer to <https://www.acrs.net.au/>). The certification must be provided as part of the Construction Documentation.

2 Documentation

2.1 Construction Documentation

In addition to the requirements of PC-CN3 “Construction Management”, the Construction Documentation must include the following documents, procedures and instructions for the fabrication of structural steelwork:

- a) the evidence of certification, required in sections 1c)1c) and 1d);
- b) test certificates and certificates of compliance required by section 3g);
- c) the manufacturer’s certification of compliance in relation to welding consumables, as required by section 3h);
- d) evidence of the Designer’s review and acceptance of the Shop Drawings, as required by section 6.2c);
- e) the names and qualifications of all personnel to be associated in the planning, production, and inspection of all welds (except the names of welders to be qualified by testing, refer section 7.1b)ii));
- f) an Inspection and Test Plan in accordance with the requirements of section 7.6a);
- g) the process to verify the origin and quality of materials and suitability of welding consumables;
- h) the assembly, including dimensional control and details of manufacturing jigs;
- i) the cambering (where applicable) and method of determination of the beam profile which allows for deformation during fabrication;
- j) the repairs and corrections allowed under this Master Specification Part;
- k) the shop assembly, including traceability records and weld log records;
- l) the end finishing for field joints (where applicable);
- m) the proposed sequence of operations and the proposed time required for all members or parts;
- n) the system of identification of members or parts and components, and erection marks;
- o) the welding procedures;
- p) the non-destructive testing regime for visual, ultrasonic testing, radiographic examination and magnetic particle inspections as required by section 7.6h);
- q) accepted of the weld test regime by the Designer, as required by section 7.6m); and
- r) safe work method statements as required by PC-WHS1 “Work Health and Safety” that address, at a minimum:
 - i) handling and transportation of materials (refer to ST-SS-C1 “Transportation and Erection of Structural Members” if the members exceed 4.2 m in length);
 - ii) the safety requirements of AS/NZS 1554.1 Structural steel welding, Part 1: Welding of steel structures;
 - iii) precautions to protect all persons working or present near welding operations, including the control of exposure to arc radiation, hot metal, and welding fumes as well as the prevention of electric shock and fire; and
 - iv) where non-destructive tests employing industrial x-ray plant or radioactive isotopes are used, precautions to ensure that people in the vicinity are not subjected to direct or scattered radiation.

2.2 Quality Management Records

In addition to the requirements of PC-QA1 “Quality Management Requirements” or PC-QA2 “Quality Management Requirements for Major Projects” (as applicable), the Quality Management Records must include:

- a) the inspection and test results from the testing required by section 7.6; and
- b) the verification records required by Table ST-SS-S1 15-1.

3 Materials

- a) Fasteners and steel for the fabrication of structural steelwork must comply with the following:
 - i) class 4.6 bolts nuts must be in accordance with:
 - A. AS 1110 ISO metric hexagon bolts and screws - Product grades A and B;
 - B. AS 1111 ISO metric hexagon bolts and screws - Product grade C; and
 - C. AS 1275 Metric screw threads for fasteners, to tolerance Grade 8;
 - ii) class 4.6 nuts must be in accordance with:
 - A. AS 1112 ISO metric hexagon nuts; and
 - B. AS 1275 Metric screw threads for fasteners, to tolerance Grade 8;
 - iii) class 4.6 washers must be in accordance with AS 1237 Plain washers for metric bolts, screws and nuts for general purposes;
 - iv) class 8.8 bolts, nuts and washers must be in accordance with:
 - A. AS/NZS 1252 High strength steel fastener assemblies for structural engineering - Bolts, nuts and washers; and
 - B. AS 1275 Metric screw threads for fasteners, to tolerance Grade 6;
 - v) hollow steel sections must be in accordance with AS/NZS 1163 Cold-formed structural steel hollow sections, Grade L0;
 - vi) rolled plate must be in accordance with AS/NZS 1594 Hot-rolled steel flat products;
 - vii) hot-rolled steel plates must be in accordance with AS/NZS 3678 Structural steel - Hot-rolled plates, floor plates and slabs;
 - viii) hot rolled steel sections must be in accordance with AS/NZS 3679.1 Structural steel, Part 1: Hot-rolled bars and sections;
 - ix) welded steel I sections must be in accordance with AS/NZS 3679.2 Structural steel, Part 2: Welded I sections; and
 - x) quenched and tempered steel plate must be in accordance with AS 3597 Structural and pressure vessel steel - Quenched and tempered plate.
- b) All fasteners must be hot dip galvanized in accordance with:
 - i) for nuts and bolts: AS/NZS 1214 Hot-dip galvanized coatings on threaded fasteners (ISO metric coarse thread series); and
 - ii) for washers: AS/NZS 4680 Hot-dip galvanized (zinc) coatings on fabricated ferrous articles.
- c) All structural steel, associated components, and welding consumables must be manufactured by companies accredited to AS/NZS ISO 9001 Quality management systems - Requirements. The production and supply of all structural steel, associated components, and welding consumables must conform to this Master Specification Part and AS/NZS 5131 Structural steelwork - Fabrication and erection.

- d) For steelwork that is to be hot-dipped galvanized, steels with the following silicon contents are not permitted:
 - i) equal to or greater than 0.23%; and
 - ii) between 0.04% to 0.14%.
- e) Steels suitable for hot-dipped galvanizing are those with:
 - i) silicon content of $0.15\% < \text{Si} \leq 0.22\%$;
 - ii) silicon content of $\text{Si} \leq 0.04\%$; or
 - iii) silicon and phosphorous contents of $\text{Si} + 2.5\text{P} \leq 0.09\%$.
- f) Full traceability of materials, components and weld consumables used in the Contractor's Activities related to the fabrication of structural steelwork is required and must comply with AS/NZS 5131 Structural steelwork - Fabrication and erection.
- g) Materials that do not comply with the traceability requirements of section 3f) must not be used in structural members. As part of the Construction Documentation, the Contractor must provide test certificates and certificates of compliance showing that all materials conform to the testing requirements in this section 3. As a minimum, the test certificates must show the following:
 - i) applicable Reference Document (Australian Standard);
 - ii) batch no. / identification;
 - iii) results of mechanical tests (including Charpy V-notch impact tests results where "L0" or "L15" steel is specified);
 - iv) results of ultrasonic tests; and
 - v) chemical analysis, including carbon equivalent (where applicable).
- h) Welding consumables must be in accordance with AS/NZS 1554.1 Structural steel welding, Part 1: Welding of steel structures, and AS/NZS 5131 Structural steelwork - Fabrication and erection. The Contractor must provide the manufacturer's certification that the welding consumables comply with the applicable Australian Standard as part of the Construction Documentation.

4 Notice of work commencement and program

The Contract Program must show all activities involved in the structural steelwork fabrication process, including cutting, welding, shear stud connectors (where applicable) and application of protective treatment.

5 Fabrication

5.1 General

- a) Fabrication must be in accordance with:
 - i) the Design Drawings;
 - ii) AS 4100 Steel structures;
 - iii) AS/NZS 5131 Structural steelwork - Fabrication and erection; and
 - iv) AS/NZS 5100.6 Bridge design, Part 6: Steel and composite construction.
- b) All fabricated structures and components must comply with the requirements of construction category CC3 in accordance with:
 - i) AS 4100 Steel structures;

- ii) AS 5100 Bridge design; and
 - iii) AS/NZS 5131 Structural steelwork - Fabrication and erection.
- c) Treatment Grade P3 in accordance with AS/NZS 5131 Structural steelwork - Fabrication and erection must apply to fabricated structures and components.

5.2 Dimensional tolerances

- a) The Contractor must take all measurements necessary to demonstrate compliance with the requirements of this section 5.2, including Table ST-SS-S1 5-1.
- b) Measurements of lengths must be checked with a standard steel measuring tape or band and corrected to a temperature of 20°C.
- c) After fabrication, the tolerances on any cross-section or deviations from the specified dimensions must be in accordance with:
 - i) AS 4100 Steel structures;
 - ii) AS 5100 Bridge design; and
 - iii) AS/NZS 5131 Structural steelwork - Fabrication and erection.
- d) All dimensions and tolerances must be Class 2 in accordance with AS/NZS 5131 Structural steelwork - Fabrication and erection.
- e) Where parts are to fit together on assembly or erection, tolerances must be such that all parts fit together within the specified tolerances.
- f) For built-up sections, the deviations from the specified dimensions must not exceed those specified in AS/NZS 5131 Structural steelwork - Fabrication and erection.

Table ST-SS-S1 5-1 Dimensional tolerance

Property	Tolerance
Member dimensions	a) The error in any dimension for members up to and including 5 m must not exceed ± 2 mm. b) An additional allowance of ± 2 mm must be made to the above for each additional 10 m or part thereof.
Sweep (variation from straightness)	a) Must not exceed 1 mm per 1000 mm of the member length. b) The sweep must be measured between the ends of the member and must be even throughout the length of the member.
Flatness of bearing seats and plates	Out of flatness of the surfaces must not exceed 0.2 mm.
Bolted end plate connection, end plate flatness	Out of flatness of the surfaces must not exceed 0.2 mm.
Twist	The angular rotation of any cross-section relative to an end cross-section must not exceed 10 mm per 1,000 mm depth of beam or unit.
Flatness of surfaces	Deviation from flatness must not exceed 2 mm per 1,000 mm of measuring length over any portion of the surface.
Curvature tolerance	Deviation from the specified profile must not exceed ± 5 mm.

5.3 Beams

- a) The curvature of completed bridge beams must be planar and without sectional twist or buckling, or local buckling of the web or flanges outside of the tolerances specified in AS/NZS 5131 Structural steelwork - Fabrication and erection.
- b) Unless noted on the Design Drawings, the beam profile shown on the Design Drawings is the completed profile of the beam, on its side, after all welding.

5.4 Repair of surface flaws and defects

Surface flaws and Defects on plates are detrimental to their engineering use and must be:

- a) treated as a Non-Conformance and the associated Hold Point set out in PC-QA1 "Quality Management Requirements" or PC-QA2 "Quality Management Requirements for Major Projects" (as applicable) will apply; and
- b) removed in accordance with AS/NZS 3678 Structural steel - Hot-rolled plates, floor plates and slabs, and AS 3679 Structural steel. Weld metal must not be deposited to remove deep surface Defects unless prior approval of the welding and repair procedure has been obtained as part of the Non-Conformance Report submission.

6 Shop detailing and documentation

6.1 General

- a) Shop detailing and documentation must be in accordance with AS/NZS 5131 Structural steelwork - Fabrication and erection.
- b) Shop Drawings and a digital shop model must be prepared for the fabrication of all members or components.
- c) The Contractor is responsible for the preparation of Shop Drawings.

6.2 Verification

- a) Shop Drawings must be submitted to the Designer for review and acceptance prior to commencing fabrication.
- b) Once reviewed and accepted by the Designer, any changes to the accepted Shop Drawings that affect the design intent must be re-submitted to the Designer.
- c) The Designer's review and acceptance of Shop Drawings in accordance with the Design Management Plan and Construction Management Plan, including evidence that the Shop Drawings conform to the requirements of 6.3a), must be provided as part of the Construction Documentation.

6.3 Shop Drawings detail

- a) The details shown on the Shop Drawings must conform to the Design Drawings and the following:
 - i) drawings showing only the cutting dimensions of webs, flanges and the like are not considered to be Shop Drawings;
 - ii) drawings must clearly show the extent of protective coatings and show any areas that do not have a coating;
 - iii) the Shop Drawings must identify the Design Drawings, together with the revision number, on which they are based. Where the Shop Drawings depict any part of the Design Drawings, this must be clearly identified on the Shop Drawings;
 - iv) the marking plan must show the location, as appropriate, of abutments A and B, upstream and downstream, span numbers, pier numbers and north orientation;

- v) welding symbols on the Shop Drawings must be used for all welds and must conform to AS 1101.3 Graphical symbols for general engineering, Part 3: Welding and non-destructive examination;
 - vi) there must be a clear distinguishment between shop welds and field welds on the Shop Drawings;
 - vii) all splice welds must be shown on the Shop Drawings and be approved by the Designer before fabrication commences;
 - viii) the location of full section splice connections must be clearly indicated, including extensions and member length make ups;
 - ix) joints or groups of joints where it is especially important that the welding sequence and technique of welding be carefully controlled to minimise shrinkage stresses and distortion must be indicated on the Shop Drawings;
 - x) joints where no welding is permitted must be clearly indicated;
 - xi) the weld lengths specified on the Shop Drawings must be the required effective lengths;
 - xii) each member must be clearly identified, including the identification marks shown on the Design Drawings;
 - xiii) further to section 6.3a)xii), each type of component must be identified to readily distinguish it from all other types;
 - xiv) for assemblies, all associated bolting, accessories or joining details must be shown on the Shop Drawings;
 - xv) details of all holes and attachments required for temporary work such as formwork and lifting lugs must be shown;
 - xvi) methods of sealing all such holes in section 6.3a)xv) must be shown; and
 - xvii) where fracture critical members exist in a steel structure, these members must be identified on the Shop Drawings where shown on the Design Drawings, or if not shown on the Design Drawings, any fracture critical members as such must be identified, following verification by the Designer.
- b) The Contractor is responsible for the correctness of the Shop Drawings.

7 Welded fabrication

7.1 General

- a) All welding must:
 - i) be carried out in accordance with AS/NZS 1554 Structural steel welding, and AS/NZS 5131 Structural steelwork - Fabrication and erection; and
 - ii) follow the recommendations and procedures of Welding Australia.
- b) All welds must be:
 - i) SP category in accordance with AS/NZS 1554.1 Structural steel welding, Part 1: Welding of steel structures;
 - ii) prequalified in accordance with AS/NZS 1554.1 Structural steel welding, Part 1: Welding of steel structures; and
 - iii) subject to visual inspection in accordance with AS/NZS 1554.1 Structural steel welding, Part 1: Welding of steel structures.
- c) All butt welds must be complete penetration butt welds unless noted otherwise on the Design Drawings.

- d) For cruciform welds, the minimum Z-grades as set out in Appendix H of AS/NZS 1554.1 Structural steel welding, Part 1: Welding of steel structures, must be adopted.
- e) Welding through protective coatings is not permitted.
- f) The following limitations apply to fillet weld and deep penetration fillet welds where the angle between the parent material plates is less than 90°:
 - i) the weld procedure qualification must be undertaken at the shallowest angle of all acute angle welds;
 - ii) the leg length must be no greater than 10 mm when the weld is completed in a single pass; and
 - iii) where the leg length is equal to or greater than 10 mm, the weld must be welded using a multi-run weld process.
- g) The travel speed for submerged arc production welds must be within $\pm 10\%$ of the travel speed specified in the welding procedure.
- h) When using the submerged arc welding process, a flux warmer must be utilised to redry and store the consumable prior to use.

7.2 Straightening of material and components

Material and components must be straightened and made free from twist so that on assembly, mismatching and misalignment will not occur outside of the specified tolerances. The methods adopted to achieve this must be such as not to damage or alter mechanical properties, nor to impair the design or function of the material or component.

7.3 Weld profiles

The finished surface and the profile of all welding must be smooth and free from sharp edges or crevices that would be detrimental to the performance of the structure or to the protective treatment. Where a satisfactory finish has not been achieved, the weld must be replaced or repaired, or the surface must be ground until a satisfactory finish has been achieved.

7.4 Splice welding

- a) Splices at locations not shown on the Design Drawings are not permitted.
- b) All splice welds must be full strength butt welds.
- c) All splices in main girders must be shop assembled to check alignment, level, and fit of the components. Templates, if used, must be match marked before being dismantled.
- d) Field splice welding must not be carried out without prior approval from the Principal in accordance with section 7.4e).
- e) Where field splicing is proposed:
 - i) the Contractor must submit a splice welding procedure, indicating the specific element the procedure is applicable for, which will constitute a **Hold Point**. The Contractor must not undertake the weld trial in section 7.4e)ii) until this Hold Point has been released;
 - ii) the Contractor must undertake a full-size trial weld using a mock-up of plates of the same size as in the Design Documentation in accordance with the splice welding procedure required in section 7.4e)i), which will constitute a **Witness Point**;
 - iii) the Contractor must submit the relevant results from the trial weld required in section 7.4e)ii), which will constitute a **Hold Point**. The Contractor must not undertake field splicing on the relevant element until this Hold Point has been released; and
 - iv) components must be fabricated in total with all protective treatment applied prior to transport to site.

7.5 Repair of failed welds

In the event that any welds fail to meet the requirements of this Master Specification Part:

- a) this will be treated as a Non-Conformance and the associated Hold Point set out in PC-QA1 “Quality Management Requirements” or PC-QA2 “Quality Management Requirements for Major Projects” (as applicable) will apply; and
- b) where the Contractor proposes to repair the work, the Non-Conformance Report must include a detailed procedure for the repair. If the Contractor cannot demonstrate that the repair will not induce excessive distortion or residual stresses in the fabricated members, the Contractor must fabricate a replacement member.

7.6 Inspection and testing of Works

- a) The Contractor must prepare an Inspection and Test Plan covering the items in AS/NZS 5131 Structural steelwork - Fabrication and erection, and submit that Inspection and Test Plan as part of the Construction Documentation.
- b) All welding must be inspected either by a Welding Australia certified welding inspector or an International Institute of Welding (IIW) welding inspector. The welding inspector must be independent of, and not affiliated with, the Contractor.
- c) The welding supervisor and the welding inspector must not be the same person, and they must not carry out any welding.
- d) Welding inspections must comply with AS/NZS 5131 Structural steelwork - Fabrication and erection.
- e) The Contractor must ensure the fabricated steelwork is available in a position and orientation suitable for inspection and testing and must provide all assistance to the welding inspector to perform the inspection and testing.
- f) Subject to section 7.6g), not less than 24 hours prior to any steelwork being dispatched for protective coating, the Contractor must provide notification that the work is available for inspection. The notification will constitute a **Witness Point**. The steelwork must not be dispatched for protective coating until the Contractor has progressed past the Witness Point.
- g) The requirements of section 7.6f) do not apply to bridgeworks sundries which must comply with the transport notification requirements set out in ST-BF-C4 “Bridgework Sundries”.
- h) Non-destructive testing must be in accordance with AS/NZS 5131 Structural steelwork - Fabrication and erection, and AS/NZS 1554 Structural steel welding, including visual inspection, ultrasonic testing (must be 100% phased array for submerged arc welds), magnetic particle inspections, or radiographic examination.
- i) Non-destructive testing must be performed as necessary to qualify welding procedures and to ensure that those procedures are maintained throughout the duration of the Contractor’s Activities. Non-destructive testing of qualification procedures must be conducted a minimum of 48 hours after completion of the weld.
- j) The extent of magnetic particle examination testing, in accordance with AS/NZS 1554.1 Structural steel welding, Part 1: Welding of steel structures, for category SP welds, must comply with Table ST-SS-S1 7-1.
- k) The extent of radiographic examination or ultrasonic testing, in accordance with AS/NZS 1554.1 Structural steel welding, Part 1: Welding of steel structures, for category SP welds, must comply with Table ST-SS-S1 7-2.
- l) Inspection and test results from the testing required by this section 7.6 must be submitted as part of the Quality Management Records within 5 Business Days of the testing.
- m) The weld testing regime referred to in this section 7.6 must be reviewed and accepted by the Designer, with acceptance to be provided in the Construction Documentation.

Table ST-SS-S1 7-1 Extent of magnetic particle examination testing

Weld location or component (as appropriate to design)	Minimum extent of examination for each weld length
Stiffener welds at crucifix locations	100%
Field-welded or site-welded joints	100%
Stiffener fillets at site joints	100%
Edges of flange butt joints	100%
Web to flange single pass fillet welds	20% of each weld length on each girder ⁽¹⁾ , including at least 1,000 mm at: a) all ends of welds; b) support points; and c) diaphragm locations, plus intermediate portions to make up inspected length.
All T butt welds and multi-pass fillet welds to tension flanges (e.g. stiffeners, diaphragms or diaphragm stiffeners) ⁽²⁾	100%
T butt welds and multi-pass fillet welds to: a) compression flange or web plates (e.g. stiffeners, diaphragms or diaphragm stiffeners); b) diaphragm stiffener to diaphragm; and c) end plates to tension flange, compression flange and web plate ⁽¹⁾ .	20% of total length
Web to flange multi-pass fillet welds ⁽²⁾	At locations inspected by ultrasonic or radiographic methods ⁽¹⁾
T butt welds, T butt compound welds and other multi-pass fillet welds ⁽²⁾	At locations inspected by ultrasonic or radiographic methods ⁽¹⁾
All other welds	The maximum of AS/NZS 1554 Structural steel welding, recommendations
Repairs:	
a) Repaired Defects in base metal	100%
b) Remaining weld after removal of defective weld	100%
c) Repaired or replaced weld, including temporary welds	100%

Table notes:

- (1) After 3 consecutive girders have been welded without Defects or repairs to any web to flange fillet weld, magnetic particle examination frequency may be reduced, after approval from the Principal, to one weld on each web of each girder, which will constitute a **Hold Point**. If Defects requiring repair are found subsequently, in an individual web to flange fillet weld, test frequency must revert to the specified rate of 20% of each weld length on each girder, until a further application to reduce the frequency of test is approved.
- (2) Inspect over same length portions using both magnetic particle and ultrasonic or radiographic methods to the minimum extents shown in Table ST-SS-S1 7-2.

Table ST-SS-S1 7-2 Extent of radiographic or ultrasonic examination

Weld location or component (as appropriate to design)	Minimum extent of examination for each weld length
Flange butt joints	100%
Web butt joints	300 mm minimum at each end of each joint 20% of each weld length, including:
Web to flange butt joint	a) 500 mm each side of all diaphragms; and b) 1,000 mm at all weld ends; plus intermediate portions to make up inspected length.
Web to flange connections - welded, single or multi pass of 25 mm of thicker plates 350 and high grade steel	50% of the total weld length for affected welds, including 1,000 mm at: a) all ends of welds; b) lifting lug locations; and c) diaphragm locations; plus intermediate portions to make up inspected length.
All T butt welds and multi-pass fillet welds to Tension flange (e.g. stiffeners, diaphragms or diaphragm stiffeners, or base plate joint of beams, columns, masts or towers) ⁽¹⁾	100% ⁽¹⁾
T butt welds and multi-pass fillet welds to: a) compression flange or web plates (e.g. stiffeners, diaphragms or diaphragm stiffeners); b) diaphragm stiffener to diaphragm; and c) end plates to tension flange, compression flange and web plate ⁽¹⁾ .	10% ⁽¹⁾ of total welded length
All site joint welds and field welds	100%
Butt splice or T butt weld between: a) plate; b) rectangular, square or circular hollow sections, e.g. barrier railing; or c) hot rolled open sections.	50% or, if approved, at a reduced frequency of 25% ⁽²⁾
a) Butt welds between piling steel lengths (H pile, circular caissons, etc). b) Possible inclusion of wharfing piling.	10% of total number of pile splices, with 100% tested of each splice selected, including testing of the first splice welded
Butt welds and T butt welds of lifting brackets or loops	100%
Butt and T butt welds to repair or make up member lengths	100% of total weld length
Other welds	As required to demonstrate conformity to the limits for imperfections, noting that the minimum extent of examination must be not less than 10% of weld length

Weld location or component (as appropriate to design)	Minimum extent of examination for each weld length
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Table notes:

- (1) Inspect over same length portions using both magnetic particle and ultrasonic or radiography methods.
- (2) For butt welding of barrier railing splices or open sections, the Contractor may apply to reduce the inspection frequency to the lower rate, which will constitute a **Hold Point**. The application must include:
 - a) nomination of a welding preparation and procedure designed to minimise weld Defects; and
 - b) performance data demonstrating that the procedure can produce conforming welds and no nonconforming welds.

After approval, if Defects requiring repair are subsequently found in an individual splice weld, the test frequency must revert to the specified rate of 50% of each weld splice until a further application to reduce the frequency of test is approved.

9.7 Additional requirements for overseas fabrication

If the fabrication takes place outside of Australia, the following additional requirements apply:

- a) all work must be carried out under the supervision of a welding supervisor who meets at least one of the requirements of AS/NZS 1554.1 Structural steel welding, Part 1: Welding of steel structures;
- b) all welders must satisfy the conditions of AS/NZS 1554.1 Structural steel welding, Part 1: Welding of steel structures. All welding personnel require macro re-qualification on a 12-monthly basis for each weld procedure; and
- c) the fabricated steelwork must be made available for inspection in Australia prior to assembly or erection.

8 Steel cutting

- a) Surfaces produced by cutting must be finished true and smooth to the required dimensions. All burrs and sharp edges on cut surfaces must be removed.
- b) Where flame cutting is to be employed, the standard of surface condition of edges of cut plates must not be inferior to "Welding Australia Flame Cut Surface Roughness Class 2" (as defined in Welding Australia Technical Note 05 - Flame Cutting of Steels).
- c) Gouges having a depth greater than 3 mm are deemed to be "damaged" (refer section 13). All edges of flange plates must be ground to produce a 2 mm radius.

9 Stud shear connectors

9.1 General

This section 9 only applies where shear stud connectors are specified on the Design Drawings.

9.2 Qualification

- a) The stud material, the stud base, the stud welding procedure, and the welding operator must be qualified in accordance with AS 1554.2 Structural steel welding, Part 2: Stud welding (steel studs to steel), before production welding of studs commences.
- b) Submission of evidence of the qualifications required in section 9.2a) will constitute a **Hold Point**. The procedure test required in section 9.2c) must not be carried out until the Hold Point has been released.
- c) In addition to the requirements of section 9.2a), a further procedure test must be carried out to assess the stud welding procedure and welding operator. This test consists of welding 4 studs of the size and type to be used on to a test plate of similar thickness, width and condition

(i.e. rust) of the actual flange to which the studs will be welded. The following requirements apply:

- i) the reinforcement formed within the ceramic ferrule must be formed over 100% of the circumference;
 - ii) 2 studs must be tested to withstand a load representing a minimum tensile stress of 415 MPa; and
 - iii) the remaining 2 studs must be tested to AS/NZS 2205.5.1 Methods for destructive testing of welds in metal, Method 5.1: Macroscopic and microscopic examination of welds. The 2 studs must indicate complete fusion to the parent material.
- d) The test studs must pass the requirements of section 9.2c). If a stud fails any one of the tests referred to in section 9.2c), the procedure test is to be deemed a failure, and further procedure tests must be undertaken until all tests are passed.
 - e) The Contractor must provide 48 hours' prior notification to the procedure test required in section 9.2c), which will constitute a **Witness Point**. Testing must not occur until the Contractor has proceeded past the Witness Point.
 - f) The Contractor must submit results of the procedure test required by section 9.2c), which will constitute a **Hold Point**. Welding of the studs to the member must not commence until the Hold Point has been released.

9.3 Fabrication

After welding, studs must comply with the testing requirements of Table ST-SS-S1 9-1.

Table ST-SS-S1 9-1 Testing of studs after welding

Method	Location of studs	Percentage of total length or number
30° hammer bend test in accordance with AS 1554.2 Structural steel welding, Part 2: Stud welding (steel studs to steel)	First of each day's studs welded	First 2 studs welded, or more as required by AS 1554.2 Structural steel welding, Part 2: Stud welding (steel studs to steel)
Visual inspection	All studs welded	100%
Stud weld ring test using a steel 1 kg hammer, swung freely to strike the stud in 2 opposite directions, where:		
a) the tested stud must give a clear ring; and	All studs welded	100%
b) all studs which do not give a clear sound in the ring test must be subjected to the 10° bend test.		
10° bend test in accordance with AS 1554.2 Structural steel welding, Part 2: Stud welding (steel studs to steel)	All members with stud welds	5% of studs on each member (1 in each 20), including studs with missing weld flash, where: a) studs with less than 360° of weld flash must be bent 10° in a direction opposite to the missing portion of the flash; b) if any stud fails, all studs on the member or element must be visually inspected and any stud with less than 360° of weld flash must be tested; and c) studs must not be bent back.

10 Bolted connections

- a) All high strength bolted connections must be assembled and tightened in accordance with the requirements of Queensland Department of Transport and Main Roads Technical Note 62 Assembly and Tensioning of High Strength Bolts and Nuts, Parts 1, 2 and 3 (as applicable).
- b) All holes for bolts must be drilled full size or, where permitted by AS 4100 Steel structures, punched full size. Burnt holes will not be permitted under any circumstances.
- c) After assembly of the parts to be joined, all holes must be true throughout, perpendicular to the face of the member and aligned so as to permit the bolts to be positioned without damage to the threaded portion. The surfaces in contact of parts joined must be free from distortion and all burrs or ridges must be removed.
- d) The length of each bolt must be such that the threaded portion will project through the nut for at least one complete thread and such that the nut will be at least one thread apart from the thread runout. The shanks of bolts must be of sufficient length so that the thread must not project through the shear plane.
- e) At least one washer, but no more than 2 washers, must be placed under the part being rotated in tightening. Taper washers must be used where the part under the bolt head is not perpendicular to the axis of the bolt. Bolts must be positioned so that the taper washers, if required, are able to be fitted under the non-rotating part.

11 Holding down bolts

- a) Where high strength bolts or rods are cast into concrete, the bolts or rods must be firmly held in position by a jig and the rods or bolts must not be welded.
- b) Where a structure is subjected to fatigue loading (including light poles, traffic gantries, major cantilever signs and tall Utility Services poles), levelling nuts must not be used unless explicitly shown on the Design Drawings. Irrespective of the use of levelling nuts, base plates of such structures must be supported on a pad of high strength grout, constructed such that the void beneath the base plate is completely filled with grout.

12 Mock set up

- a) Where the Works or Temporary Works includes beams or structural elements for bridges, the beams or structural elements must be assembled in the form of a mock set-up in the fabrication workshop to the lines and relative levels and with the support conditions that will apply in the completed structure.
- b) On completion of the mock set-up required in section 12a), a **Hold Point** will apply. Final assembly must not occur until the Hold Point has been released.

13 Damage

Any damage to steel work that occurs prior, during or after fabrication will be deemed to be a Non-Conformance and the associated Hold Point set out in PC-QA1 "Quality Management Requirements" or PC-QA2 "Quality Management Requirements for Major Projects" (as applicable) will apply.

14 Hold Points and Witness Points

- a) Table ST-SS-S1 14-1 details the review period or notification period, and type (documentation or construction quality) for each Hold Point referred to in this Master Specification Part.
- b) Table ST-SS-S1 14-2 details the review period or notification period, and type (documentation or construction quality) for each Witness Point referred to in this Master Specification Part.

Table ST-SS-S1 14-1 Hold Points

Section reference	Hold Point	Documentation or construction quality	Review period or notification period
Table ST-SS-S1 7-1	Proposal to reduce magnetic particle examination frequency	Documentation	10 Business Days review
Table ST-SS-S1 7-2	Proposal to reduce the inspection frequency	Documentation	10 Business Days review
7.4e)i)	Submission of splice welding procedure	Documentation	5 Business Days review
7.4e)iii)	Submission of the relevant results from the trial weld	Documentation	5 Business Days review
9.2b)	Evidence of stud welding qualifications	Documentation	2 Business Days review
9.2f)	Submission of shear stud procedure test results	Documentation	7 Business Days review
12b)	Mock set up in workshop of bridge beams and structural elements	Construction quality	48 hours notification

Table ST-SS-S1 14-2 Witness Points

Section reference	Witness Point	Documentation or construction quality	Review period or notification period
7.4e)ii)	Notification of trial weld	Construction quality	48 hours notification
7.6f)	Notification and inspection of steelwork being dispatched for protective coating	Construction quality	24 hours notification
9.2e)	Notification of stud welding procedure test	Construction quality	48 hours notification

15 Verification requirements and records

The Contractor must supply written verification as part of the Quality Management Records that the requirements listed in Table ST-SS-S1 15-1 have been complied with.

Table ST-SS-S1 15-1 Verification records

Section reference	Record to be provided
5.2a)	Evidence of compliance with dimensional tolerances
7.6	Inspection and test results from the testing required by section 7.6