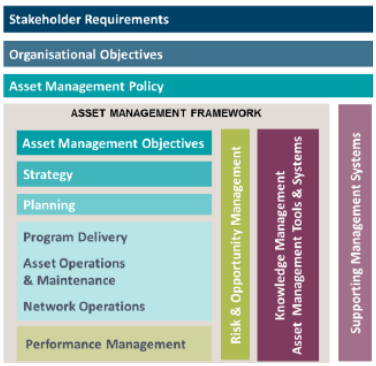
Transmission Substation Structural Steelwork

Design Standard (Technical Specification)



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RESPONSIBILITIES

Western Power's Engineering & Design Function is responsible for this document

CONTACT

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Revision Details

Version	Date	EDM Version	Description
0	August 2019	1	First Issue
1	April 2022	2	Review completed. No updates required.
2	March 2024	3	Standard Online Update

1. Introduction

This Technical Specification outlines the minimum requirements for the construction of structural steelwork for Western Power Transmission Substations. This applies to all steelwork construction required for equipment support structures, landing gantries and substation buildings, including access stairs, ladders, and steel handrails.

1.1. Purpose and Scope

The requirements outlined in this specification are intended to cover the following items associated with the construction of structural steelwork for Western Power Transmission Substations:

- Materials
- Fabrication
- Protective coatings
- Handling, storage, and delivery
- Erection
- Inspection and testing

In all matters, the requirements of this specification are relevant unless otherwise specifically stated elsewhere within the construction SoW of the project or shown on the drawings included in the project deliverables.

This specification applies to both 'Greenfield' and 'Brownfield' sites.

1.2. Acronyms

Acronym	Definition

1.3. Definitions

Terms and definitions used in this document

Term	Definition
ACA	Australian Corrosion Association
ACRS	Australian Certification Authority for Reinforcing and Structural Steels
AINDT	Australian Institute for Non-Destructive Testing
APAS	Australian Paint Approval Scheme
AS	Australian Standard
AS/NZS	Australian/New Zealand Standard
ASTM	American Society for Testing and Materials

Brownfield site	Site with existing or previous electrical assets
EDM	Enterprise Document Management
Greenfield site	New site with no previously installed electrical assets
ISO	International Standards Organization
ITP	Inspection and Test Plan
NATA	National Association of Testing Authorities, Australia
SCA	Steelwork Compliance Australia
SoW	Scope of Work

1.4. References

References which support implementation of this document

Table 1.1 References

Reference No.	Title

2. Supporting Documentation[1]

3. Compliance

3.1. General[2]

All temporary works, shop drawings, materials, plant, equipment, workmanship, fabrication, and installations must comply with the latest revision of the Western Power technical documents such as Standards, Specifications, and relevant Australian Standards relating to the relevant component of the works unless otherwise noted in this specification or advised at the time of Tender.

There should not be any deviation from the provisions of the relevant standards and specifications without obtaining written approval from Western Power.

All work and materials must comply with higher-level Western Power technical documents, such as relevant Network Standards and Functional Specifications.

This Technical Specification should encompass all requirements of the relevant Australian Standards which are current at the time of issue. These relevant Australian Standards are listed in Table 3.1 below. A period

[1] See Western Power Internal Document
[2] See Western Power Internal Document

will be set when the Technical Specification needs to be reviewed. If significant changes occur on an Australian Standard which affects safety, then an out of cycle review can be completed.

Table 3.1: Standards and Guidelines

Standard Number	Standard Title
AS 1101.3	Graphical symbols for general engineering, Part 3: Welding and non-destructive examination
AS 1110.1	ISO Metric Hexagon Bolts and Screws – Product grades A and B, Part 1:Bolts
AS 1112	ISO Metric Hexagon Nuts, Parts 1, and 2
AS/NZS 1163	Cold-formed structural Steel Hollow Sections
AS/NZS 1214	Hot-dip galvanized coatings on threaded fasteners
AS/NZS 1252	High-strength steel fastener assemblies for structural engineering – Bolts, nuts and washers, Parts 1, and 2
AS 1275	Metric Screw threads for fasteners
AS 1397	Continuous hot-dip metallic coated steel sheet and strip - Coatings of zinc and zinc alloyed with aluminium and magnesium
AS/NZS 1554	Structural steel welding (series)
AS/NZS 1594	Hot-rolled steel flat products
AS 1627	Metal finishing - Preparation and pre-treatment of surfaces (series)
AS 1657	Fixed platforms, walkways, stairways and ladders – Design, construction and installation
AS 1674	Safety in welding and allied processes, Parts 1, and 2
AS 2062	Non-destructive testing – Penetrant testing of products and components
AS 2177	Non-destructive testing – Radiography of welded butt joints in metal
AS 2207	Non-destructive testing – Ultrasonic testing of fusion welded joints in carbon and low alloy steels
AS 2312.1	Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings, Part 1: Paint coatings
AS/NZS 2312.2	Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings, Part 2: Hot dip galvanizing
AS 2331.1.3	Methods of test for metallic and related coatings Local thickness tests - Magnetic method
AS 2331.1.4	Methods of test for metallic and related coatings Local thickness tests - Magnetic induction and eddy current methods
AS/NZS 2980	Qualification of welders for fusion welding of steels
AS/NZS 3678	Structural steel – Hot-rolled plates, floorplates, and slabs
AS/NZS 3679.1	Structural steel – Hot-rolled bars and sections
AS/NZS 3679.2	Structural steel – Welded I sections
AS/NZS 3750	Paints for steel structures (series)

Standard Number	Standard Title
AS 3894.1	Site testing of protective coatings non-conductive coatings - Continuity testing - High voltage ('brush') method
AS 3894.2	Site testing of protective coatings non-conductive coatings - Continuity testing - Wet sponge method
AS 3894.3	Site testing of protective coatings - Determination of dry film thickness
AS 3894.9	Site testing of protective coatings - Determination of adhesion
AS 4100	Steel structures
AS 4291	Mechanical properties of fasteners made of carbon steel and alloy steel, Parts 1, and 2
AS/NZS 4600	Cold-formed steel structures
AS/NZS 4680	Hot-dip galvanized (zinc) coating on fabricated ferrous articles
AS/NZS 4855	Welding consumables – Covered electrodes for manual metal arc welding of non-alloy and fine grain steels - Classification
AS/NZS 5131	Structural steelwork – Fabrication and erection
AS/NZS ISO 14171	Welding consumables - Solid wire electrodes, tubular cored electrodes, and electrode/flux combinations for submerged arc welding of non-alloy and fine grain steels - Classification
ISO 2063	Thermal spraying -- Zinc, aluminium and their alloys, Parts 1, and 2
ASTM A123M	Standard specification for zinc (hot-dip galvanized) coatings on iron and steel products
ASTM F959M	Standard specification for compressible-washer-type direct tension Indicators for use with structural fasteners

3.2. Acceptance Criteria

Compliance with the requirements of this specification for materials and construction of structural steelwork shall be based on the minimum requirements and acceptance criteria set out in this specification, construction SoW of the project, construction drawings included in the project deliverables and relevant Australian and international standards listed in Table 3.1.

3.3. Order of Precedence

Where this specification is inconsistent with another document making up the construction SoW of the project, the following order of precedence shall apply to determine which document prevails to the extent of inconsistency, with (a) being the highest precedence and (e) being the lowest:

a) The specific terms and conditions of the construction SoW of the project

b) The 'Policies and Guidelines' of the project

c) Any construction drawings included in the project deliverables

d) Any specific technical requirements stipulated to the project works

e) This Technical Specification

3.4. Documentation and Traceability

Construction of structural steelwork for Western Power Transmission Substations shall comply with the following requirements per AS/NZS 5131 unless otherwise specified, and the contractor shall provide certificate of compliance issued by SCA (Steelwork Compliance Australia) showing compliance with the relevant Construction Category.

- Service category – SC1
- Fabrication category – FC1
- Construction category - CC3
- Traceability – Full
- Treatment grade – P3
- Coating quality level – PC2
- Functional tolerances – Class 2

The list of requirements specific to the nominated construction category and material traceability shall be per AS/NZS 5131.

All required documentation, including quality documentation and material purchasing procedures shall be prepared and maintained for the works covered under the construction SoW of the project and shall be made available to the Western Power representative when requested. Information to be included in each of these documents shall be per AS/NZS 5131 unless otherwise specified.

4. Materials

4.1. General

All materials used in the construction of structural steelwork for Western Power Transmission Substations shall be as shown in the construction drawings.

All materials used shall be new and free from loose scale, slag, rust, and other defects. No steel material with an unidentified strength grade shall be permitted.

All steel materials supplied shall be ACRS certified unless otherwise specified, and a copy of the ACRS certificate shall be provided to the Western Power representative when requested.

Unless otherwise specified, materials used in the construction of structural steelwork for Western Power Transmission Substations shall comply with the requirements specified in Table 4.1 below.

Table 4.1: Structural Steel Materials

Item No	Item	Minimum Technical Requirements
1	Hot rolled sections	Grade 300 to AS/NZS 3679.1
2	Welded sections	Grade 300 to AS/NZS 3679.2
3	Steel plates	Grade 300 to AS/NZS 3678
4	Hollow sections	Grade 350 to AS/NZS 1163
5	Cold formed sections	Minimum Grade 450 formed to AS 1397

Item No	Item	Minimum Technical Requirements
6	Fasteners - Bolts, Nuts and Washers	Property Class 8.8 to AS 4291.1 or Property Grade A to AS 1110.1 (bolts) and AS 1112.1 (nuts). Bolt assembly: Bolt assembly comprising bolts Property Class 8.8, nuts Property Class 8 and hardened washers to AS/NZS 1252.1 Alternative bolt assembly: Bolt assembly comprising bolts Property Class 8.8, nuts Property Class 8 and hardened washers to EN14399-3, System HR.
7	Weld metal (electrodes)	B-E43XX/B-E49XX to AS/NZS 4855 for manual metal arc welding to AS/NZS 1554.1 and AS/NZS 1554.5 B-S430U/B-S490U for submerged arc welding to AS/NZS 1554.1 and AS/NZS 1554.5
8	Grout (for base plates)	Cement based non-shrink grout with a minimum compressive strength of 50MPa at 28days.

4.2. Non Australian Materials

The Contractor shall provide copies of the standard(s) or code(s) with their offer and a table showing all the relevant properties of the applicable Australian standard material and the proposed alternative material for comparison and compliance to AS.

Acceptance of any such alternative material shall be entirely at the discretion of the Western Power representative.

4.3. Certification

The contractor shall submit test reports or certificates of all materials and manufactured components, including items supplied from overseas that are used in the construction of structural steelwork, stating compliance with the specification and applicable Western Power technical documents and or Australian standards together with such details and parameters required to be supplied by those documents and or project quality plan to the Western Power representative for acceptance.

Requirements for test reports or test certificates are provided in the relevant Australian Standards listed in Table 3.1. All such testing shall be carried out by an independent NATA-accredited laboratory approved by the Western Power representative.

5. Fabrication

5.1. General

All structural steelwork for Western Power Transmission substations shall be fabricated as shown on the construction drawings and per the requirements of this specification and AS/NZS 5131.

The steel material grade shall be identifiable at all stages of fabrication.

A detailed work method statement shall be prepared for each fabrication activity and submitted to the Western Power representative for approval before the commencement of the actual works.

All necessary temporary brackets, gussets, and fixings required for handling, transportation, assembly, and erection shall be included in the fabrication.

All fabrication and welding shall be carried out in a fabrication shop approved by the Western Power representative before the application of any protective coating.

All material and workmanship shall be subject to inspection by the Western Power representative, and all necessary access and facilities are to be provided by the contractor at all times.

Due allowance shall be made during fabrication for all discrepancies due to tolerances in material and distortions due to welding, and all precautions shall be taken to minimise these defects and meet the requirements of AS/NZS 5131.

5.2. Shop Drawings

Shop drawings shall be prepared, where required, showing complete information of each assembly, including components, material grade, dimensions, fabrication method, weld details, bolting details, member orientation, surface preparation and temporary connections.

The contractor shall submit copies of the shop drawings for review by the Western Power representative before the commencement of any fabrication works.

5.3. Straightening

All materials shall be straightened by cold pressing and shall be free of any twists before the commencement of any fabrication. Application of any hot process is subject to acceptance by the Western Power representative and to the manufacturer's written recommendations. No hammering is allowed.

5.4. Cutting

Steelwork cutting may be done by sawing, shearing, cropping, machining and thermal cutting (including laser and plasma cutting) as appropriate to the required profile shown on the construction drawings.

Plates thicker than 6mm with edges to be welded shall not be shear cut.

Cut surfaces shall be neat, even, and accurate to the required profile, and any rough burred edges shall be removed off.

All sharp edges and corners shall be rounded and ground smooth to a minimum radius of 2mm. Cut surfaces to be incorporated in a weld shall comply with AS/NZS 1554.1.

5.5. Bending

Steel materials shall be formed or shaped to the required profile shown on the construction drawings. Steel materials shall be bent or pressed to the required shape by either hot or cold processes.

Temperature adopted for hot forming/bending processes shall be per the manufacturer's written recommendations.

5.6. Holing

Holes for bolts in structural connections shall be 2mm larger than the nominal bolt diameter unless specified otherwise. Holes in base plates for anchor bolts shall be 6mm larger than the nominal bolt diameter for bolts

up to and including M24 and 8mm larger than the nominal bolt diameter for bolts over M24. Where not specified, holes for bolts shall be per the requirements of AS/NZS 5131.

Round holes for bolts shall be either machine cut, or drilled full size, or punched full size or sub punched 3mm undersize and reamed to size as appropriate.

Slotted holes shall be either machine cut, or punched in one operation, or formed by drilling two adjacent holes and complete by machine cutting.

Punching holes in material over than 12mm thick shall be restricted to sub punching 3mm undersize followed by reaming to size.

Flame cutting of holes shall not be permitted.

Holes shall be clean and free from burrs and rough edges. Raised edges around the holes shall be milled or ground flush.

After assembly of the fabricated components to be joined, all holes shall be true throughout and aligned to permit the bolts to be positioned without damage to the threaded portion of the bolt.

Venting and draining holes shall be provided in all sealed hollow sections as shown on the construction drawings. Vent/grout holes shall also be provided in the base plates as necessary.

The location and extent of any weld access holes shall be subject to approval by the Western Power representative.

5.7. Connections

All shop connections shall be welded, and field connections shall be bolted unless shown otherwise on the construction drawings.

Site welding shall not be permitted except where shown on the drawings or specifically approved by the Western Power representative.

Bolting shall be per the requirements of Section 5.8 of this specification.

Welding shall be per the requirements of Section 5.9 of this specification.

5.8. Bolting

5.8.1. General

Bolting shall comply with the requirements of the relevant construction drawings, this specification and AS/NZS 5131.

Before the commencement of the bolting works, a detailed work method statement shall be prepared per AS/NZS 5131 and submitted for approval by the Western Power representative.

Where clearances and tightening procedures permit, bolts shall be placed in the same direction within a joint and all similar joints. The head of a bolt shall be exposed or proud in preference to the nut.

Where the full shear capacity of the bolt is to be developed as shown on the drawings, the bolt shall be proportioned, and appropriate washers supplied under the nut to prevent any threaded portion of the bolt from being at the shear plane between the contacting faces of the parts bolted together.

Similarly, where specified on the drawings, bolts subject to tensile loads where nuts are liable to work loose, such as by vibration, shall be effectively locked in position by self-locking nuts or other approved locking devices.

Unless shown otherwise on the drawings, at least one washer shall be used at each bolt and located under the portion to be turned.

Washers shall be fitted to all bolts and shall be tapered where necessary to give the heads and nuts of bolts an even bearing surface.

Steel packer plates or shims shall be a minimum thickness of 2mm where required.

The length of each bolt shall be such that the threaded portion will project through the nut by at least one and a half (1 1/2) full threads and not more than a distance equal to the bolt diameter.

The length of each bolt shall be such that the threaded portion will project through the nut by at least one and half ($1\,^{1}/_{2}$) full threads and not more than a distance equal to the bolt diameter.

Bolts and nuts shall not be welded.

5.8.2. Fasteners

Fasteners (bolts, nuts, and washers) used for structural connections shall comply with the bolt material shown in Table 3.1 unless otherwise specified on the construction drawings.

Bolt assembly for structural connections shall comprise bolts Property Class 8.8, nuts Property Class 8 and hardened washers to AS/NZS 1252.1 unless otherwise specified. Alternative bolt assembly comprising bolts Property Class 8.8, nuts Property Class 8 and hardened washers to EN14399-3, System HR may also be accepted.

Plate washers for long slotted or oversized holes shall be 8mm thick unless specified otherwise. All bolts, nuts and washers shall be hot-dip galvanized to AS 1214.

5.8.3. Bolt Tightening

Installation of fasteners shall only be carried out by qualified, experienced, and competent personnel.

Bolted connections shall be snug-tightened (S) unless specified otherwise and be made per AS/NZS 5131.

Where fully tensioned bearing (TB) type connections are specified on the drawings, bolt tensioning shall be carried out using direct-tension indication (DTI) devices per the procedure set out in AS/NZS 5131.

The preferred DTI devise for Western Power structural steelwork construction is the ‘Squirter DTI Washers’ manufactured by Hobson to ASTM F959M. Installation of the Hobson Squirter DTI washers shall strictly follow the manufacturer’s written instructions. Other approved alternative compressible washer-type indicators shall also be used subject to approval by the Western Power representative.

Bolt tightening and tensioning in the connection should proceed systematically from the most rigid part of the connection towards the free edges.

All fasteners shall be for single use only.

A bolt snug-tightened or tensioned previously shall not be re-used.

Re-tightening bolts that have been fully tightened or re-tensioning bolts that have been fully tensioned shall not be permitted.

5.9. Welding

5.9.1. General

Welding shall comply with the requirements of the relevant construction drawings, this specification and AS/NZS 1554.1.

Welds for structural connections shall be category SP (structural purpose) as defined in AS/NZS 1554.1 unless specified otherwise. GP (general purpose) welds shall be used only where indicated on the construction drawings.

All butt welds shall be full penetration and continuous. Backing strips shall be provided where required, subject to the approval of the Western Power representative. Permanent backing strips are not permitted unless otherwise shown on the construction drawings.

All surfaces to be welded shall be clean and completely free of any coating, scale, dirt, grease, or heavy rust. The items to be welded shall be securely clamped in position during welding to ensure that distortion and residual stresses are kept to a minimum. Whenever distortion is evident, it shall be corrected by the contractor using a method approved by the Western Power representative.

The ends of all hollow structural members are to be sealed with 6 mm thick plates and continuously fillet welded unless otherwise specified. Provision shall be made for venting enclosed members before the galvanizing process. All such vent holes shall be sealed as shown on the construction drawings.

All slag, weld spatter and flux shall be carefully removed using a chipping hammer followed by wire brushing, after each weld run and after the final pass.

Inspection, testing, repair, and rejection of welds shall be per Section 10.4 of this specification.

5.9.2. Weld Materials

Welding electrodes shall be as shown in Table 4.1 unless otherwise specified. All welding electrodes must be kept dry. Re-drying wet electrodes is not permitted.

Welding flux that has become damp shall not be dried, reused or flux fused.

5.9.3. Minimum Fillet Weld Size

The minimum fillet weld size (leg size) shall be as shown in Table 5.1 unless otherwise specified.

Table 5.1: Fillet Weld Size

Item	Thickness, t(mm) of the thinner part joined	Minimum fillet weld (leg) size, w(mm)
1	$t < 6$	$w = t$
2	$6 \geq t \leq 16$	$w = 6$
3	$16 > t \leq 32$	$w = 8$
4	$t > 32$	$w = 10$

5.9.4. Qualification of Welding Procedures

Before commencement of the welding works, a detailed welding plan containing all welding procedures shall be prepared per AS/NZS 5131 and submitted for approval by the Western Power representative.

Welding shall be carried out using qualified procedures complying with the relevant provisions in AS/NZS 5131 and AS/NZS 1554.1. Welds made by procedures that are not prequalified will not be accepted.

5.9.5. Qualification of Welding Personnel

All welders and welding supervisors shall be qualified per AS/NZS 1554.1 unless otherwise specified. The contractor shall submit copies of all certificates and/or qualification records to the Western Power representative for approval before the commencement of the works.

For construction category CC3, welders shall be qualified per AS/NZS 2980 requirements. In addition, identification and traceability of welders are required for CC3 per AS/NZS 5131.

5.10. Splices

All structural members shall be in single length except where splices are shown on the construction drawings. Full contact bearing surfaces in splices shall be produced by machining unless otherwise agreed with the Western Power representative.

5.11. Tolerances

Tolerances for structural steelwork fabrication shall be per AS/NZS 5131 unless specified otherwise. Tolerance Class 2 to AS/NZS 5131 shall be considered for both essential and functional tolerances.

If the actual deviation exceeds the specified permissible value, the deviations shall be corrected such that the actual deviation is within the permissible value. Methods adopted for fixing the actual deviations and the corrected values are subject to acceptance by the Western Power representative.

5.12. Marking

Each fabricated item shall be distinctly marked by stamping the items with letters or numbers before applying protective coatings for identification.

All stamping shall be carried out in a manner that will enable it to be clearly read after galvanizing or painting and that will not affect the strength of the member. The markings shall be located such that they do not become obscured after the erection of the structure.

Smaller members that cannot be stamped on the member may be stamped on a metal tag that shall be securely fastened to the member by steel wire.

All loose pieces, including groups of identical bolts shall be bundled or bagged and clearly marked for identification.

5.13. Assembly Check

Where required, before dispatch to the site, the fit between fabricated members and components shall be checked and documented using either templates, accurate measurements, or trial assembly as appropriate such that the fabrication and erection tolerances are complied with, and a correct fit is achievable at site.

6. Protective Coatings

6.1. General

Protective coatings shall be provided to all structural steelwork as specified on the construction drawings and be carried out only after all fabrication processes have been completed.

Unless specified otherwise, structural steelwork shall be hot-dip galvanized per AS/NZS 4680, and threaded fasteners shall be hot-dip galvanized per AS/NZS 1214.

Zinc-coated cold-formed structural steel members require no further coating other than any repairs to the welded areas.

Before the commencement of any coating works, a detailed work method statement shall be prepared per AS/NZS 5131 and submitted for approval by the Western Power representative. The method statement shall include, but not be limited to, the coating systems, procedures, and coating colour where applicable.

Material traceability consistent with the fabrication methods shall be maintained for each item throughout the surface preparation and protective coating processes.

All material and workmanship shall be inspected by the Western Power representative, and all necessary access and facilities are to be provided by the contractor at all times.

Inspection and testing of protective coatings shall be per Section 10.5 of this specification.

6.2. Protective Coating Types

The following coating types are provided for structural steelwork for Western Power Transmission substations. The actual coating type shall be provided as shown on the construction drawings.

- Hot-dip galvanizing
- Painting
- Duplex system (painting of hot-dip galvanised coatings)

Where both hot-dip galvanizing and painting cannot be provided for practical reasons and/or due to any project-specific constraints, alternative protective coating application by thermal spraying may be considered subject to approval by the Western Power representative. Execution of thermal sprayed metallic coating shall per the requirements of ISO 2063 unless specified otherwise.

6.3. Hot-dip Galvanizing

6.3.1. General

Structural steelwork specified as hot-dip galvanized shall be prepared and coated by a hot-dipping process per AS/NZS 4680. Threaded fasteners shall be hot-dip galvanized per AS/NZS 1214.

Venting and draining holes shall be provided in all sealed hollow sections as shown on the construction drawings. Where not specifically shown, adequate venting and draining holes shall be provided per the requirements of AS/NZS 4680. Every hollow section shall have at least one vent and one drain hole.

Double dipping galvanizing is not permitted unless otherwise specifically approved by the Western Power representative.

6.3.2. Surface Preparation

All dirt, oil, grease, paint, or other contaminants shall be carefully and thoroughly removed from items that are to be galvanized to the requirements of AS/NZS 4680 before the commencement of galvanizing.

All steelwork items that are to be galvanized shall be dry abrasive blast cleaned to class *Sa* $2^{1}/_{2}$ (near white) to AS 1627.4 or by pickling and fluxing as appropriate.

6.3.3. Surface Finish

After galvanizing, the surfaces of the items shall be as continuous, adherent, smooth and evenly distributed as possible and free from any defects that may affect the intended use of the item. Any wet storage staining (white rust) formed shall be removed before the item leaves the galvanizing plant. For temporary identification, either water-soluble marking paints or detachable metal labels shall be used.

If threaded components are galvanised in batches, surplus zinc shall be removed from threads by centrifuging or brushing as appropriate.

6.3.4. Repair after Galvanizing

For galvanized items, the extent of repairable damaged or uncoated areas shall be stated in AS/NZS 4680. Damaged galvanized areas from handling, welding or any other physical damage and uncoated repairable areas shall be repaired by abrasive blast cleaning to class *Sa 2 ½* to AS1627.4 and application of an approved zinc-rich epoxy paint with a minimum dry film thickness of 100µm (mass 710g/m_2 approx.) unless specified otherwise. Blast cleaning shall extend to at least 25mm onto the surrounding sound coating area. The final coating dry film thickness on the repaired/renovated areas shall be at least 30µm more than the specified coating thickness on the drawings.

6.4. Painting

6.4.1. General

Structural steelwork specified as paint-coated shall be prepared and coated per AS 2312.1 and AS/NZS 5131.

Unless specified otherwise, the surface treatment grade of P3 and coating quality level of PC2 shall be considered for painting applications per AS/NZS 5131.

6.4.2. Paint Materials

The type of coating material, coating thickness, and other requirements shall be as shown on the construction drawings.

Unless otherwise specifically approved by the Western Power representative, all materials used in a coating system, including thinners, shall be of one brand name supplied by the same manufacturer and compatible with each other coat.

Paints shall comply with the requirements of AS/NZS 3750 (series) and shall be APAS-approved unless specified otherwise. Where paint materials not certified to APAS are proposed, the contractor shall submit documentary evidence, such as NATA endorsed test certificate or report, for review and acceptance by the Western Power representative before use.

All materials, including cleaning agents, solvents, thinners, primers, curing agents and any other coating materials, shall be clearly labelled to ensure traceability.

All coating materials shall be six months or less old from the date of manufacture unless specifically approved by the Western Power representative.

6.4.3. Surface Preparation

Weld splatters, slag deposits and flux residues shall be removed, and sharp edges prepared before surface preparation to the specified treatment grade to AS/NZS 5131. Surface contaminants such as soluble chloride salts, dirt, loose scale, and other products that may impact the adhesion of the paint coating shall be removed by high-pressure water cleaning. Contaminants such as oil and grease shall be cleaned by using a suitable solvent to AS 1627.1.

All structural steel items that are to be painted shall be dry abrasive blast cleaned to class *Sa 2 ½* (near white) to AS 1627.4. The surface profile achieved shall be typically 40 - 50µm when measured to AS 3894 and shall comply with the requirements of the specified coating application.

All prepared areas shall be cleaned of all residual dust and other loose material before priming by using dry compressed air or brushing. All visible oil or grease remaining on the surface after cleaning shall be completely removed by solvent wiping.

On completion of the surface preparation works, the surfaces to be painted shall be inspected and approved by the Western Power representative before the painting works commence.

6.4.4. Mixing and Application

Application of paint coatings shall be undertaken by qualified, experienced, and competent personnel. The required paint coating thickness shall be as shown on the construction drawings.

Mixing of paints and application of the coatings shall be strictly per the manufacturer's written instructions and to the requirements of AS/NZS 5131.

The manufacturer's Product Data Sheet (PDS) and Safety Data Sheets (SDS) for the coating materials shall be available and provided to the Western Power representative when requested.

It shall be ensured that there is no contamination by wind-borne dust or deterioration in the condition of the surfaces to be primed between preparation and the application of priming paint. Priming shall be carried out as soon as practicable after final cleaning and in any case before tarnishing of the steel surface occurs. After priming, no further coats shall be applied without the Western Power representative's approval before the application of cover coats.

Paint shall not be applied when any of the following conditions exist unless otherwise permitted by the paint manufacturer.

6.4.5. Repair after Painting

Repairs to damaged painted areas from handling, welding or any other physical damage shall be per the paint manufacturer's recommendations.

Assessment of repair requirements, surface preparation and repair methods shall be per AS 2312.1 and AS/NZS 5131 unless otherwise specified.

Where a sound coating adjoins a damaged area, the primer of the repaint system should overlap the sound coating for at least 25mm, and the topcoat should overlap the sound coating for at least 50mm. A further finishing coat should be applied to the whole area if required.

6.5. Duplex Systems

6.5.1. General

Structural steelwork specified as paint-coated to hot-dip galvanized surfaces shall be prepared and coated per AS/NZS 2312.2 and AS/NZS 5131.

Structural steel items specified to receive a duplex coating system shall first be hot-dip galvanized, followed by painting.

6.5.2. Hot-dip Galvanising

Hot-dip galvanizing shall be carried out per the requirements of Section 6.3 of this specification.

6.5.3. Surface Preparation

The preparation and treatment of hot-dip galvanized surfaces before painting shall follow the manufacturer's written instructions.

All galvanized structural steel items that are to be painted shall be degreased and abrasive sweep blast cleaned per the procedure provided in AS/NZS 2312.2. Sweep blasting shall be performed carefully to ensure that no more than 10µm of zinc is removed.

6.5.4. Painting

Painting shall be carried out per the requirements of Section 6.4 of this specification.

Paint coatings shall be applied within 6 hours of sweep blasting unless otherwise specified.

The required paint coating thickness and painting system shall be as shown on the construction drawings. Where not specified, the painting system suitable to meet the requirements shall be determined in consultation with the paint manufacturer. Examples of suitable painting systems for galvanized steel may be found in AS/NZS 2312.2.

7. Handling, Storage and Delivery

Steelwork shall be handled, stacked, and stored by methods and equipment that will not overstress or deform the members and will not damage the painted, galvanized, or other protected surfaces.

Hot-dip galvanized items shall be stored and transported under clean, dry, and well-ventilated conditions. Galvanized items shall not be stored in contact with cardboard or paper products, cinders, ash, clinkers, unseasoned or treated timber or any harmful chemicals. Particular attention shall be paid to conditions of storage, shipment, and transport of galvanized items to avoid the possibility of wet storage stains (white rust) or any chemical attack.

Soft packing shall be used between painted items, and stacking should be avoided.

On delivery to the site, steelwork items shall be unloaded such that all steel items for specific areas of assembly are located in proximity to each other and the final assembled structure. Where possible, all bolts, nuts and washers shall be similarly supplied and delivered to suit convenient erection of the individual structures.

Steelwork received at the site shall be neatly and methodically stockpiled in the storage area and shall be so stacked to prevent any damage through the normal use of the stockpile.

All steelwork shall be suitably supported on hardwood bearers or other suitable non-staining materials such that no steelwork is in contact with the ground or other members. Similar spacers/packers shall be used between members, partly or fully assembled structures that are stacked upon or with each other to protect gussets, stiffeners, stools, and other projections from damage.

Members bent, buckled, or deformed from handling or storing shall be liable to rejection by the Western Power representative and shall be corrected or replaced.

Bolts, nuts, and washers shall be supplied in grit-free containers and stored in watertight premises. Burred, pre-used, damaged, corroded or otherwise unserviceable bolts shall not be used.

8. Erection

8.1. General

All structural steelwork for Western Power Transmission substations shall be erected per the details shown on the construction drawings, construction SoW of the project, requirements of this specification and AS/NZS 5131.

Structural steelwork erection shall be undertaken by qualified, experienced, and competent personnel.

A detailed work method statement and erection sequence methodology shall be prepared and submitted to the Western Power representative for review and approval before the commencement of the actual works. The work method statement shall include a cranage assessment, including a lifting study, a layout showing crane locations, outrigger pads, outrigger loads, soil bearing capacity requirements etc. A risk assessment shall also be undertaken before any erection work commences.

Before erection, all the structural steelwork shall be inspected, and the discovery of any damaged, missing, or incorrectly fabricated items shall be advised to the Western Power representative as early as possible before pre-assembly or erection occurs. Any corrections required to the fabricated structural steelwork, including any members, connections, or coatings, shall be carried out only with prior approval from the Western Power representative.

Before erecting the structural steelwork, the contractor shall ensure the specified minimum thickness of any grout is not compromised by the footing concrete levels. Similarly, ach minimum grout thicknesses shall not compromise the minimum protrusion of the holding down bolt threads above the upper fixing nut. Any occasions where these requirements may be at risk shall be reported to the Western Power representative. See Technical Specification – Transmission Substation Concrete for information on holding down bolt installation.

Temporary bracings and supports shall be erected as required to achieve stability and prevent overstressing of the structural members during erection. Any such bracings and supports shall be left in place as long as required for safety.

The ‘pre-assembly’ of the structural steelwork in sections is preferred to be carried out in a fabrication shop or at ground level on-site to minimise the amount of assembly to be undertaken by personnel working at height.

All material and workmanship shall be subject to inspection by the Western Power representative, and all necessary access and facilities are to be provided by the contractor at all times. Where applicable, the contractor shall give the Western Power representative notice of a minimum of five (5) business days of completion of the structure erection before any portion of the structure that is rendered out of sight after the erection process.

Special consideration shall be given to the site conditions, such as maintaining safe electrical clearances, site limitations, street access, delivery sequence, transport requirements, inclement weather, and overhead obstructions for the entire duration of all works associated with the structural steelwork erection.

Inspection of erection works shall be per Section 10.6 of this specification.

8.2. Assembly and Alignment

Each part of the structure shall be properly aligned as soon as possible after it has been erected before completing the field connections. Steel tapered drifts may only be used to bring parts into position without undue force, not to match misaligned holes, enlarge holes, or to distort the steel members.

Application of force that will damage or distort the members during assembly and/or erection shall not be permitted. The members shall not be over-stressed during the process of erection. Any error in work that prevents proper assembly and fitting of parts shall be reported immediately to the Western Power representative, and approval shall be obtained for the proposed method of correction.

Permanent connections shall be either by bolting or welding, as shown on the construction drawings. Permanent connections shall not be undertaken until the erected steel structure has been correctly aligned, plumbed, and levelled.

The extent of site cutting, drilling and/or welding shall only be as shown on the drawings unless directed or approved by the Western Power representative.

During erection, steel members shall not be cut by grinding, flame cutting, welding, or drilling without prior written approval of the Western Power representative.

Under no circumstances shall holes be made in plates or members for erection purposes.

Alignment of the structure and lack of fit-in connections shall be corrected using packers or shims as required.

Bolting shall be per the requirements of Section 5.8 of this specification. Misaligned holes shall be drilled and reamed to a larger size, and larger bolts shall be fitted. Flame cutting of a bolt hole shall not be permitted.

Welding shall be per the requirements of Section 5.9 of this specification. The areas of surfaces to be site welded shall be cleaned of the coatings for a distance of at least 50mm on each side of the outside lines of the welding.

Grouting shall be provided under base and bearing plates as shown on the construction drawings. Refer to Section 9 of this specification for grouting details.

8.3. Coating Protection

The contractor shall take all necessary precautions to prevent any damage to galvanized or painted surfaces during erection.

Where cutting, drilling, welding, or grinding is carried out during the erection of the structural steelwork, protective measures shall be taken to prevent residue from these activities from damaging any pre-coated steelwork surfaces. If any residue does fall onto coated surfaces, it shall be cleaned up and the surface re-coated if required to the satisfaction of the Western Power representative.

Refer to Sections 6.3.4 and 6.4.5 of this specification for the repair of protective coatings.

8.4. Tolerances

Tolerances for the erection of structural steelwork shall be per AS/NZS 5131 unless specified otherwise. Tolerance, Class 2 to AS/NZS 5131, shall be considered for both essential and functional tolerances.

If the actual deviation exceeds the specified permissible value, the deviations shall be corrected such that the actual deviation is within the permissible value. Methods adopted for the correction of the actual deviations and the corrected values are subject to acceptance by the Western Power representative.

9. Grouting

9.1. General

Where indicated on the construction drawings, grouting shall be provided under base plates and bearing plates.

No grouting work shall commence until the erected steel structure has been correctly aligned, plumbed, and levelled.

Grout thickness shall be a minimum of 25mm unless specified otherwise.

A detailed grouting procedure shall be prepared and submitted to the Western Power representative for approval before the commencement of grouting works.

9.2. Material

Grout material shall be approved cement-based pre-proportioned factory packaged proprietary non-shrink type unless otherwise specified. Other grout types, such as epoxy grouts, shall only be used with prior approval from the Western Power representative.

Grout compressive strength shall be a minimum of 50MPa at 28 days unless specified otherwise.

9.3. Workmanship

The concrete surface under the base plate shall be scabbled back to sound concrete and thoroughly cleaned. The concrete surface shall be free of all laitance, defective concrete, moisture, oil, grease, debris, and any contaminants before the commencement of grouting works. Bolt holes or fixing pockets shall be cleaned of any dirt, loose materials, or debris.

Chemical scabbling or acid etching shall not be used.

Vent/grout holes shall be provided in the base plates as necessary.

Formwork for grouting shall be provided where required. Formwork shall be made from materials of adequate strength and securely anchored to withstand the grout pressure. It shall be adequately watertight to prevent any leakage.

Concrete surfaces that are to be grouted with a cement-based non-shrink grout shall be soaked in water for a minimum period of twelve (12) hours before grouting. Just before grouting, all free water shall be removed from the surfaces, bolt holes and fixing pockets. For epoxy grouts, if used, the surface shall be kept completely dry.

Grout shall be mixed and placed to the required thickness until the space has been filled solid, free of cavities, and cured per the manufacture's written instructions.

10. Inspection and Testing

10.1. General

Inspection shall be undertaken at each stage of structural steelwork construction, including material procurement, fabrication, protective coating, and erection by qualified, experienced, and competent personnel engaged by the contractor per the requirements of AS/NZS 5131.

The contractor shall perform all necessary inspections to ensure that the work complies with the requirements of this specification, the construction SoW of the project, and the applicable standards listed in Table 3.1.

All material and workmanship shall be subject to inspection by the Western Power representative, and all necessary access and facilities shall be provided by the contractor at all times.

Inspection by the Western Power representative shall not relieve the contractor of its own quality assurance/quality control responsibilities.

Unless otherwise specified, all inspection and testing at each stage of steelwork construction shall be undertaken per a documented inspection and test plan (ITP) using documented procedures. All relevant ITPs and quality control procedures to be used during steelwork fabrication and erection shall be submitted to the Western Power representative for prior approval.

The contractor shall give the Western Power representative at least two (2) business day notice for inspections nominated as 'Witness' or 'Hold Point' on the contractor's ITPs, or where the Western Power representative's approval is required for commencement of any stage of the works.

10.2. Material Testing

The contractor shall submit test reports or certificates of all materials as specified in Section 4.3 of this specification.

The Western Power representative reserves the right to request additional material testing. Any such additional testing shall be carried out by an independent NATA-accredited testing laboratory. Where the contractor has carried out additional testing as noted above, all test certificates and reports shall be submitted to the Western Power representative before the tested steel/material is fabricated.

10.3. Inspection of Fabrication

Inspection of steelwork fabrication shall only be undertaken by qualified, experienced, and competent personnel engaged by the contractor. The results of all inspections during fabrication shall be documented and made available to the Western Power representative when requested.

Where the fabricated steelwork has been inspected and approved by the Western Power representative before being delivered to the site, such approval shall not relieve the contractor's responsibility to provide and ensure correct fitting on site.

10.4. Welding Inspection and Testing

10.4.1. General

The extent of testing and inspection of welds shall be as specified in Sections 10.4.2 and 10.4.3 of this specification. Where the testing levels are less than 100%, the Western Power representative shall select the welds to be tested.

All visual inspections of welds shall be undertaken by a qualified welding inspector engaged by the contractor who has not been involved in the supervision of the welded fabrication. Visual inspection also includes random inspection of the weld preparation.

Non-destructive testing shall be undertaken by personnel who are fully qualified for the type of testing to be undertaken. Qualifications shall be to AINDT (Australian Institute for Non-Destructive Testing) or approved equivalent. Copies of the technician's certification shall be submitted to the Western Power representative for approval before any works are undertaken.

10.4.2. Visual Inspection

Visual inspection of all welds shall be carried out per AS/NZS 1554.1, except the extent of visual inspection shall be as follows unless specified otherwise.

- Visual Scanning – 100% of all welds
- Visual Examination – 20% of all welds.

Should any weld fail the visual inspection criteria as defined in AS/NZS 1554.1, the weld shall be rejected, and no further non-destructive testing shall be carried out until the condition of the weld is rectified to the satisfaction of the Western Power representative.

10.4.3. Non-destructive Testing

Non-destructive testing of welds shall be carried out by the contractor using an independent NATA-accredited testing laboratory approved by the Western Power representative.

The non-destructive testing procedures to be used are:

- Radiographic Testing (RT) to AS 2177
- Ultrasonic Testing (UT) to AS 2207
- Magnetic Particle Testing (MT) to AS 1171

The extent of non-destructive testing shall be as follows unless specified otherwise.

- 100% of all full-strength butt weld splices using RT or UT
- All other butt welds - 10% of the welds using RT or UT
- Fillet welds -10% of the welds using MT

Welds required to undergo RT or UT examination shall be nominated by the contractor for review and approval by the Western Power representative before the commencement of weld testing.

All weld non-destructive testing shall be reported, and the results or reports submitted to the Western Power representative within ten (10) business days.

10.4.4. Weld Repair and Rejection

All welds failing to meet the permissible levels of imperfections allowed in the AS/NZS 1554.1 shall be removed or repaired to the satisfaction of the Western Power representative and then re-tested.

The contractor shall prepare a documented procedure for the repair of the defective welds and submit it to the Western Power representative for approval before the commencement of the repair works.

Where a defective weld cannot be satisfactorily repaired, the item will be rejected in its entirety and replaced.

10.5. Inspection of Protective Coatings

10.5.1. General

Inspection of the protective coatings shall only be undertaken by qualified, experienced, and competent personnel with ACA accreditation, or approved equivalent, engaged by the contractor.

The results of all inspections before and after application of the protective coatings shall be documented and made available to the Western Power representative when requested.

Repair of defective protective coatings shall be per Sections 6.3.4 and 6.4.5 of this specification.

10.5.2. Galvanized Coatings

Inspection and testing of galvanized coatings shall be undertaken per the requirements of AS/NZS 4680 and AS/NZS 5131 unless specified otherwise.

Fabricated steelwork shall be inspected before despatch for galvanizing to ensure that the articles are adequately prepared and suitable for galvanizing. Refer to Section 6.3 of this specification for the galvanizing requirements.

Galvanized items shall be inspected for appearance and the coating thickness checked.

The appearance of the completed galvanized coating shall be to the requirements of AS/NZS 4680 and Section 6.3.3 of this specification.

The galvanized coating thickness shall be measured and checked using approved magnetic gauges per AS 2331.1.3 or AS 2331.1.4 as appropriate. The coating mass shall also be checked for compliance.

Where specifically stated elsewhere in the project documents or directed by the Western Power representative, coating adherence shall be tested using a stout knife as detailed in ASTM A123M.

10.5.3. Paint Coatings

Inspection and testing of paint coatings shall be undertaken per the requirements of AS2312.1 and AS/NZS 5131 unless specified otherwise.

Fabricated steelwork shall be inspected before despatch for painting to ensure that the articles are adequately prepared and suitable for the specified paint coating. Refer to Section 6.4 of this specification for the painting requirements.

For each specified coating system, three test reference panels of size 500mm x 500mm x 6mm each shall be prepared by the contractor in accordance with the work method statement, relevant ITPs and the coating manufacturer's specifications and shall be kept available as a quality reference for work in production. For small quantity steelwork, previously produced panels not more than two (2) years old may be used as the agreed standard of workmanship.

- Paint-coated items shall be inspected for appearance and tested for the following unless otherwise specified. Film continuity ('Holiday' testing) to AS 3894.1 or AS 3894.2 or as recommended by the paint manufacturer as agreed.
- Film thickness (Wet and Dry) on each coat to AS 3894.3
- Coating adhesion to AS 3894.9

10.6. Inspection of Erection

Inspection of steelwork erection shall only be undertaken by qualified, experienced, and competent personnel engaged by the contractor. The results of all inspections during erection shall be documented and made available to the Western Power representative when requested.

All material and erection of steelwork shall be subject to inspection by the Western Power representative, and all necessary access and facilities are to be provided by the contractor at all times.

All field bolting and field welding shall be inspected during erection. All field weld slag shall be removed prior to inspection.

No grouting shall take place until the preparation of both the steel and concrete surfaces have been inspected and approved by the Western Power representative.

11. Modification to Existing Structures

Site modifications and repair of existing steel structures shall be carried out where required to the details shown on the construction drawings.

Requirements of Sections 2 to 10 of this specification shall apply equally to any such site modifications and repairs to existing steel structures unless specified otherwise.

Before the commencement of any site modifications and repair works to the existing steel structures, a detailed work method statement shall be prepared per AS/NZS 5131 and submitted for approval by the Western Power representative. The method statement shall also include a methodology for removal, re-installation, and disposal of existing steel structures where applicable.

The extent of site cutting, drilling and/or welding shall only be as shown on the construction drawings unless directed or approved by the Western Power representative.

Holes for bolts shall be drilled. Holing shall be per the requirements of Section 5.8 of this specification.

Bolting shall be per the requirements of Sections 5.8 and 8.2 of this specification.

Existing fasteners that are to be removed to carry out any repair or modification works shall be replaced with new fasteners of the same type and strength unless otherwise specified. Reuse of removed existing fasteners shall not be permitted.

Welding shall be per the requirements of Sections 5.9 and 8.2 of this specification.

Existing surfaces observed with damaged coatings and surfaces affected by repair and modification works shall be cleaned up and the surface re-coated to the satisfaction of the Western Power representative.

Refer to Sections 6.3.4 and 6.4.5 of this specification for repair of protective coatings.

Where indicated on the construction drawings or directed by the Western Power representative, existing steel structures shall be removed and transported to their final destinations as follows.

Table 11.1: Removal of Steelwork

No	Condition	Required Action
1	Existing structure/member to be removed and reinstalled at the same or different location under the same project	Remove and transport to the intended location. Dismantling and re-assembly may be required.

No	Condition	Required Action
2	Existing structure/member to be removed and intended to be kept for future use.	Remove and transport to the designated Western Power store for storage. Dismantling and re-assembly may be required.
3	Existing structure/member to be fully replaced with new structure/member	Remove, transport and dispose-off to designated legal disposal sites. Dismantling and packing may be required.

Handling, storage, and delivery of structural steelwork shall be per the requirements of Section 7 of this specification.

Appendix A: Approval Record and Document Control[3]

[3] See Western Power Internal Document