PIP STS05120
Structural and Miscellaneous Steel Fabrication Specification
PURPOSE AND USE OF PROCESS INDUSTRY PRACTICES

In an effort to minimize the cost of process industry facilities, this Practice has been prepared from the technical requirements in the existing standards of major industrial users, contractors, or standards organizations. By harmonizing these technical requirements into a single set of Practices, administrative, application, and engineering costs to both the purchaser and the manufacturer should be reduced. While this Practice is expected to incorporate the majority of requirements of most users, individual applications may involve requirements that will be appended to and take precedence over this Practice. Determinations concerning fitness for purpose and particular matters or application of the Practice to particular project or engineering situations should not be made solely on information contained in these materials. The use of trade names from time to time should not be viewed as an expression of preference but rather recognized as normal usage in the trade. Other brands having the same specifications are equally correct and may be substituted for those named. All Practices or guidelines are intended to be consistent with applicable laws and regulations including OSHA requirements. To the extent these Practices or guidelines should conflict with OSHA or other applicable laws or regulations, such laws or regulations must be followed. Consult an appropriate professional before applying or acting on any material contained in or suggested by the Practice.

This Practice is subject to revision at any time.

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1. **Scope**

This Practice provides requirements for materials, connections, detailing, fabricating, galvanizing, and delivery of structural and miscellaneous steel. Structural and miscellaneous steel are as defined in ANSI/AISC 303-16 - Code of Standard Practice for Steel Buildings and Bridges.

This Practice does not include requirements that may be applicable for structures that require special seismic detailing.

2. **References**

Applicable parts of the following Practices, industry codes and standards, and government regulations shall be considered an integral part of this Practice. The edition in effect on the date of contract award shall be used, except as otherwise noted. Short titles are used herein where appropriate.

2.1 **Process Industry Practices (PIP)**

- PIP STS05130 - Structural and Miscellaneous Steel Erection Specification

2.2 **Industry Codes and Standards**

- American Institute of Steel Construction (AISC)
  - ANSI/AISC 303-16 - Code of Standard Practice for Steel Buildings and Bridges
  - AISC 325 - Steel Construction Manual
  - AISC 326 - Detailing for Steel Construction
  - ANSI/AISC 360-16 - Specification for Structural Steel Buildings
- ASTM International (ASTM)
  - ASTM A36/A36M - Standard Specification for Carbon Structural Steel
  - ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
  - ASTM A108 - Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished
  - ASTM A143/A143M - Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement
  - ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, and Threaded Rod 60,000 PSI Tensile Strength
• ASTM A384/A384M - Standard Practice for Safeguarding Against Warpage and Distortion during Hot-Dip Galvanizing of Steel Assemblies
• ASTM A385/A385M - Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip)
• ASTM A500/A500M - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
• ASTM A563 - Standard Specification for Carbon and Alloy Steel Nuts
• ASTM A563M - Standard Specification for Carbon and Alloy Steel Nuts (Metric)
• ASTM A572/A572M - Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
• ASTM A759 - Standard Specification for Carbon Steel Crane Rails
• ASTM A780/A780M - Standard Specification for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
• ASTM A786/A786M - Standard Specification for Hot-Rolled Carbon, Low-Alloy, High-Strength Low-Alloy, and Alloy Steel Floor Plates
• ASTM A992/A992M - Standard Specification for Structural Steel Shapes
• ASTM A1011/A1011M - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength
• ASTM B695 - Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel
• ASTM E376 - Standard Practice for Measuring Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Testing Methods
• ASTM F436/F436M - Standard Specification for Hardened Steel Washers Inch and Metric Dimensions
• ASTM F606/F606M - Standard Test Methods for Determining the Mechanical Properties of Externally and Internally Threaded Fasteners, Washers, Direct Tension Indicators, and Rivets
• ASTM F959/F959M - Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners, Inch and Metric Series
• ASTM F1136/1136M - Standard Specification for Zinc/Aluminum Corrosion Protective Coatings for Fasteners
• ASTM F2329/F2329M - Standard Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon and Alloy Steel Bolts, Screws, Washers, Nuts, and Special Threaded Fasteners
• ASTM F3125/F3125M - Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi (830 MPa) and 150 ksi (1040 MPa) Minimum Tensile Strength, Inch and Metric Dimensions

• American Welding Society (AWS)
  • AWS D1.1/D1.1M - Structural Welding Code - Steel
2.3 Government Regulations

Requirements by state or local agencies that have jurisdiction where the structural and miscellaneous steel is to be erected, shall apply.

- US Department of Labor, Occupational Safety and Health Administration (OSHA)
  - OSHA 29 CFR Part 1910
  - OSHA 29 CFR Part 1926

3. Definitions

**contract documents:** Any and all documents, including codes, studies, design documents, specifications, sketches, practices, and data sheets, that purchaser or engineer of record has transmitted or otherwise communicated, either by incorporation or reference, and made part of the legal contract agreement or purchase order between purchaser and fabricator.

**design documents:** The design drawings, or where the parties have agreed in the contract documents to provide digital model(s), the design model. A combination of drawings and digital models also may be provided.

**design drawings:** The graphic and pictorial portions of the contract documents showing the design, location and dimensions of the work. These documents generally include, but are not necessarily limited to, plans, elevations, sections, details, schedules, diagrams and notes.

**design model:** A dimensionally accurate 3D digital model of the structure that conveys the structural steel requirements given in Section 3.1 of ANSI/AISC 303-16 for the building or structure.

**engineer of record:** Purchaser’s authorized representative with overall authority and responsibility for engineering design, quality, and performance of the civil works, structure, foundations, materials, and appurtenances described in contract documents. Engineer of record shall be licensed as defined by laws of the locality in which the work is to be constructed, and be qualified to practice in specialty discipline required for the work described in contract documents. Also known as structural engineer of record in AISC Code of Standard Practice.
erection drawings: Field-installation or member-placement drawings that are prepared by the fabricator to show the location and attachment of the individual structural steel shipping pieces.

fabricator: Party responsible for providing fabricated structural and miscellaneous steel in accordance with contract documents. The term fabricator shall apply also to fabricator’s subcontractor(s) and/or vendor(s).

inspector: Party responsible for verifying quality of all materials, installations, and workmanship furnished by fabricator. Inspector shall be qualified by training and experience and hold certifications or documentation of their qualifications. Unless otherwise specified in contract documents, inspector shall be retained by fabricator.

manufacturer: Party who produces and warrants performance of products, materials, and/or items provided in accordance with contract documents. Products, materials, and/or items are manufactured in a controlled process using standard codes, specifications, tests and possibly include shop drawings to assist in proper application, installation and/or use. The term manufacturer shall apply also to manufacturer’s subcontractor(s) and/or vendor(s).

miscellaneous steel: Steel items other than structural steel that are typically attached to elements of the structural frame including but not limited to stairs, ladders, cages, guards, handrails, toe plate, floor plate, grating, steel decking, steel joists, crane rails and steel items embedded in concrete that are not intended to support structural steel.

owner: Party who owns facility wherein the structural and miscellaneous steel will be used.

professional engineer: An engineer, other than engineer of record licensed as defined by laws of the locality in which the steel is to be erected, and qualified to practice in specialty discipline required for the work described in contract documents.

purchaser: Party who awards contract to fabricator. Purchaser may be owner or owner’s authorized agent.

shop drawings: Drawings of the individual structural steel shipping pieces that are to be produced in the fabrication shop.

structural steel: Elements of the structural frame that are shown and sized in the structural design documents, essential to support the design loads. See ANSI/AISC 303-16, Section 2.1 for a list of items defined as structural steel.

4. Requirements

4.1 Quality Control

4.1.1 Fabricator shall participate in the AISC Certification Program and be designated an AISC Certified Plant, Category BU (formerly known as Category STD).

4.1.2 Fabricator shall be solely responsible for quality control of all materials and workmanship.

4.1.3 Each piece of mill material shall be legibly marked with the heat number, size of section, length and mill identification marks in accordance with
ASTM A6/A6M, plus fabrication mill order number. Alternate material tracking procedures may be used if approved by purchaser.

4.1.4 For material other than ASTM A36/A36M, the appropriate specification number, grade, heat number and fabrication mill order number shall be transferred to the remnant. Alternate material tracking procedures may be used if approved by purchaser.

4.1.5 Mill material with specified minimum yield strength higher than 36 ksi (250 MPa) shall be marked with the color designated in ASTM A6/A6M. Alternate material tracking procedures may be used if approved by purchaser.

4.1.6 A written Material Handling Procedure, Quality Control Program, and Inspection Procedures document shall be provided. This document shall provide details of how compliance with requirements in this Practice and contract documents shall be achieved.

4.1.7 Purchaser has the right to inspect all materials and workmanship and shall have unrestricted entry to fabricator’s shop at all times while work is being performed.

4.1.8 The purchaser may reject improper, inferior, defective, or unsuitable materials and workmanship.

4.1.9 All materials and workmanship rejected shall be repaired or replaced as directed by purchaser.

4.1.10 Bolted connections shall be inspected in accordance with the RCSC Specification for Structural Joints Using High-Strength Bolts.

4.1.11 Welding procedures and individual welders shall be qualified in accordance with requirements of AWS D1.1/D1.1M and when applicable AWS D14.1/D14.1M.

4.1.12 Welding procedures previously qualified for purchaser may be used without requalification. However, purchaser reserves the right to require requalification of any questionable procedure before the start of fabrication.

4.1.13 All welding shall be inspected in accordance with AWS D1.1/D1.1M and when applicable AWS D14.1/D14.1M. Inspectors shall be qualified and certified as AWS Certified Welding Inspectors in accordance with the provisions of AWS D1.1/D1.1M or AWS QC1 or shall be trained by and working under the supervision of an AWS Certified Welding Inspector.

4.1.14 Welding of rigging and under the hook lifting devices shall be inspected in accordance with AWS D14.1. Inspectors shall be qualified and certified as AWS Certified Welding Inspectors in accordance with the provisions of AWS D14.1 or AWS QC1.

4.1.15 Nondestructive testing of welded joints shall be performed in accordance with ANSI/AISC 360-16 Chapter N. ANSI/AISC 360-16 requirements for buildings shall also apply to nonbuilding structures. Unless otherwise specified, structures shall be considered as Risk Category III and groove welds shall be considered as being subject to transversely applied tension loading.

Comment: Chapter N refers to and is consistent with inspection requirements of AWS D1.1/D1.1M. However, AWS
**4.1.16** Certified mill test reports for each heat of structural steel and each lot of high strength bolts shall be available for review by purchaser.

**4.1.17** Purchaser may require a quantity of representative samples of bolt assemblies to be used for testing. Testing in accordance with ASTM F606/F606M shall be at purchaser’s expense.

**4.1.18** Purchaser reserves the right to inspect and reject all galvanized steel in accordance with ASTM A123/A123M and ASTM E376.

### 4.2 Submittals

**4.2.1** The following items shall be submitted to engineer of record for approval. Work shall not proceed without approval:

- a. Checked erection and shop drawings
- b. Checked engineering calculations for each fabricator-designed connection
- c. Quality Control Program and Inspection Procedures
- d. Welding Procedure Specification (WPS)
- e. Procedure Qualification Records (PQR)
- f. Welder(s) qualification records

**4.2.2** Final erection drawings, shop drawings, and field bolt lists shall be sent to the persons responsible for managing construction at their field office before shipment of steel.

**4.2.3** A shipping list (including total weight of release and weight of shipment), a bolt list, and final erection drawings shall accompany the first shipment of each release.

**4.2.4** As a minimum, the following documents shall be submitted to purchaser for record purposes:

- a. Final erection and shop drawings
- b. Records of Quality Control inspection test reports requested by purchaser
- c. Final engineering calculations for each fabricator-designed connection sealed and signed by the responsible Professional Engineer
- d. Records of calibration or recalibration performed on the tools or equipment used during the work, if requested by purchaser
4.2.5 Erection and Shop Drawings

a. Shop drawings and erection drawings shall be prepared in accordance with the AISC documents listed in Section 2.2.

b. Erection drawings shall reference the corresponding design documents; shop drawings shall reference the corresponding erection drawings.

c. Shop drawings shall clearly show the specification and grade of steel to be used.

d. Erection and shop drawings shall be grouped in sets and identified separately for each building, structure, or yard area.

e. Erection drawings shall clearly show the mark number and position for each member. Mark number system shall be agreed upon in advance with purchaser.

f. Erection drawings shall clearly identify pretensioned and slip critical high strength bolted connections.

g. Purchaser’s purchase order number shall be shown on all erection and shop drawings.

h. Shop drawings shall state the welding electrode to be used.

i. Surface preparation and shop applied coatings, including areas to be masked, shall be noted on the shop drawings.

j. A bolt list and list of other fasteners showing the number, grade, size, and length of field bolts and other fasteners for each connection shall be provided. These lists may be shown on either the shop drawings or separate sheets.

k. In the event that drawing revisions are necessary, the shop drawings shall clearly be clouded showing all changes of the latest revisions.

l. Shop drawings and erection drawings shall be prepared using a three-dimensional steel modeling and detailing software system. All miscellaneous steel such as handrail, guards, stairs, and ladders shall be included in the same three-dimensional model as main structural steel and detailed using the same system.

4.3 Performance

4.3.1 All work shall be in accordance with the ANSI/AISC 303-16, ANSI/AISC 360-16, applicable portions of OSHA 29 CFR Part 1910 and Part 1926, and any other applicable federal, state or local regulations.

4.3.2 If local specifications, codes, or standards exist for the materials, section properties, design, and test methods covered by this Practice which yield equivalent quality and performance, they may be substituted only with prior written approval by purchaser.
4.4 Products and Materials

4.4.1 Structural wide flange shapes and WT shapes made from wide flange shapes shall be ASTM A992/A992M, unless otherwise specified in contract documents.

4.4.2 Structural channels, angles, and other shapes shall be ASTM A36/A36M, ASTM A992/A992M, or ASTM A572/A572M Grade 50, as specified in contract documents.

4.4.3 Plates and bars shall be ASTM A36/A36M, or ASTM A572/A572M Grade 50, as specified in contract documents.

4.4.4 Pipe shall be ASTM A53/A53M Type E or S, Grade B or ASTM A106/A106M Grade B.

4.4.5 Structural tubing (hollow structural sections) shall be ASTM A500/A500M Grade C, unless otherwise specified in contract documents.

4.4.6 High strength bolt assemblies, except twist-off type bolt assemblies, shall be as follows:
   a. Bolt - ASTM F3125/F3125M, Grade A325 (Grade A325M), Type 1 or ASTM F3125/F3125M, Grade A490 (Grade A490M), Type 1, as specified in contract documents
   b. Washer - ASTM F436 / ASTM F436M
   c. Direct Tension Indicator (DTI) washers - ASTM F959 / ASTM F959M, if specified in contract documents
   e. Heavy Hex Nut - ASTM A563 / ASTM A563M Grade DH

4.4.7 If twist-off type high strength bolt assemblies are specified in contract documents, they shall be ASTM F3125/F3125M, Grade F1852, Type 1, or Grade F2280, Type 1, as specified in contract documents.

4.4.8 Standard bolt assemblies shall be as follows:
   a. Bolt - ASTM A307 Grade A Heavy Hex
   b. Washer - ASTM F436 / ASTM F436M
   c. Heavy Hex Nut - ASTM A563 / ASTM A563M Grade A

4.4.9 Headed studs shall be ASTM A108 Grade 1010 through 1020, AWS D1.1/D1.1M Section 7, Type B.

4.4.10 Welding filler metal shall be AWS D1.1/D1.1M Section 3.3 (including Table 3.1), low hydrogen, with an electrode strength of 58 ksi (400 MPa) minimum yield strength and 70 ksi (480 MPa) minimum tensile strength. (For example, use E70XX for SMAW, F7XX-EXXX for SAW, ER70S-X for GMAW, and E7XT-X for FCAW.)

4.4.11 Crane rails shall be as follows:
   a. Rails 60 to 84 lb/yard (29.8 to 41.7 kg/m) - ASTM A1
   b. Rails 104 to 175 lb/yard (51.6 to 86.8 kg/m) - ASTM A759
4.4.12 Checkered floor plate shall be ASTM A786/A786M Pattern 4 or 5, commercial quality grade, fabricated from an applicable ASTM material with a minimum yield strength of 36 ksi (250 MPa).

4.4.13 Welded steel bar grating and grating stair treads shall be ASTM A1011/A1011M, Commercial Steel (Type B), galvanized in accordance with ASTM A123/A123M and NAAMM MBG 531. Top surface of bearing bars shall be plain, unless serrated is specified. Grating stair treads shall have abrasive or checkered plate nosing.

4.4.14 Steel deck shall be in accordance with the SDI Design Manual for Composite Decks, Form Decks and Roof Decks.

4.4.15 Steel joists shall be in accordance with SJI Standard Specifications and Load Tables.

4.5 Connections

4.5.1 General

All connections shall be engineer-designed, fabricator-selected, or fabricator-designed as specified in contract documents.

Comment: One of these options will be specified in contract documents for each connection. Connections may be grouped by type and a combination of these options may be specified for the various connection types used in a project.

4.5.2 Engineer-Designed Connections

4.5.2.1 Engineer-designed connections will be fully designed and detailed in design documents, and shall be furnished as shown.

4.5.2.2 Engineer-designed connections shall be only those connections fully detailed in design documents, showing all fastener sizes, arrangement, dimensions, quantities and grades, and all connection material and weld types, sizes, and lengths for each individual member or part to be joined. This information shall be shown on shop drawings.

4.5.2.3 A request to deviate from the specific details of any engineer-designed connection shall be in writing, with written approval of engineer of record. Approval of this submittal constitutes acceptance by engineer of record of design responsibility for the structural adequacy of the changed detail. Such changed details shall also be clearly shown on shop drawings.

4.5.3 Fabricator-Selected Connections

4.5.3.1 Fabricator-selected connections shall be those for which engineer of record has authority and responsibility for the design adequacy and fabricator has authority and responsibility for the detailing.

4.5.3.2 Fabricator-selected connections shall be simple connections (shear only, or negligible bending moment). These connections shall be detailed by selecting standard details from the accepted standards listed in Section 2.2 and shall meet all other requirements in contract documents.
4.5.3.3 The approval by engineer of record of shop drawings detailing fabricator-selected connections constitutes acceptance by engineer of record of design responsibility for the structural adequacy, but not the detailing, of the approved fabricator-selected connections.

4.5.4 Fabricator-Designed Connections

4.5.4.1 Fabricator-designed connections shall be designed and detailed to equal or exceed the required strength shown in design documents or as provided in contract documents.

4.5.4.2 A professional engineer shall design or supervise the design of all fabricator-designed connections and be responsible for the structural adequacy.

4.5.4.3 Fabricator-designed connections shall meet all requirements of contract documents.

4.5.4.4 In all cases, the design shall consider the entire joint (including beams, girders, columns, and bracing) and shall take into account all applicable limit states, including bolt shear, combined bolt tension and shear, prying action, local bending, coped beam capacities, block shear, web buckling, etc.

4.5.4.5 Stiffeners for column webs, column flanges, and for elements of other members involved shall be designed and furnished as required.

4.5.4.6 Checked engineering calculations for each fabricator-designed connection shall be sealed and signed by the responsible professional engineer who designed or supervised the design of the connections.

4.5.4.7 If required by contract documents, all shop drawings containing fabricator-designed connections shall be sealed and signed by the responsible professional engineer.

4.5.4.8 Review of shop drawings detailing fabricator-designed connections and engineering calculation sheets by engineer of record does not relieve fabricator of responsibility for both the structural adequacy and detailing of connections designed by fabricator.

4.5.5 Bolted Connections

4.5.5.1 Design, detailing, and fabrication of bolted connections shall be in accordance with either AISC’s Allowable Strength Design (ASD) or Load and Resistance Factor Design (LRFD) method, as noted in contract documents.

4.5.5.2 Connection design shall be in accordance with the RCSC Specification for Structural Joints Using High-Strength Bolts, AISC 325, and AISC 326.

4.5.5.3 The minimum available strength of all bolted, or mixed bolted and welded, framed beam connections shall be the member end reaction shown in design documents.
4.5.5.4 Unless otherwise specified in design documents, 3/4 inch (M20) diameter $\text{ASTM F3125/F3125M}$, Grade A325 (Grade A325M) high-strength bolts shall be used in all bolted structural connections.

4.5.5.5 $\text{ASTM F3125/F3125M}$, Grade A325 (Grade A325M) bolts larger than 3/4-inch (M20) diameter shall not be used without specific written approval of engineer of record.

4.5.5.6 $\text{ASTM A307}$ bolts, 5/8-inch (16 mm) or smaller diameter shall be permitted for ladder, stair tread, purlin, girt, door frame, and guard and handrail connections.

4.5.5.7 $\text{ASTM A307}$ bolts larger than 5/8-inch (16 mm) shall not be permitted.

4.5.5.8 The minimum number of bolts in a framed beam connection shall be two bolts.

4.5.5.9 High-strength bolted connections shall be bearing type A325-N with threads included in the shear plane.

4.5.5.10 Slip-critical type connections A325-SC shall be used if noted in contract documents.

4.5.5.11 Unless otherwise specified in design documents or permitted by the following paragraphs, all bolt holes shall be standard holes as defined by ANSI/AISC 360-16.

4.5.5.12 For framed beam bearing connections, horizontal short-slotted holes as defined by ANSI/AISC 360-16 may be used in the outstanding leg of clip angles if approved by engineer of record.

4.5.5.13 For framed beam slip-critical connections, oversized or horizontal short-slotted as defined by ANSI/AISC 360-16 holes may be used in the outstanding leg of clip angles if approved by engineer of record.

4.5.5.14 Unless otherwise approved by engineer of record, the long direction of the slot shall be perpendicular to the load direction.

4.5.5.15 Slotted or oversized hole dimensions shall be in accordance with Table J3.3 of the ANSI/AISC 360-16.

4.5.5.16 Hardened washers shall be provided under all bolt heads and/or nuts adjacent to any ply with oversized or slotted holes.

4.5.5.17 For standard holes, a minimum of one hardened washer shall be supplied with each bolt.

4.5.5.18 If used, direct tension indicator washers shall be in accordance with $\text{ASTM F959 / ASTM F959M}$ and shall be installed according to the washer manufacturer’s published specifications.

4.5.5.19 All bolt lengths shall be determined in accordance with the Commentary on RCSC Specification for Structural Joints Using High-Strength Bolts, Table C-2.2.
4.5.5.20 A minimum of 5% extra quantities of each bolt size and length, including nuts and washers, shall be provided for field erection.

4.5.5.21 Mechanically galvanized bolts or nuts shall not be interchanged with hot dipped galvanized nuts or bolts, respectively.

4.5.5.22 All column splices shall be field bolted and shall be in accordance with AISC 326, Appendix C.

4.5.5.23 All nuts for high-strength bolts shall be wax-dipped to reduce torque during installation.

4.5.5.24 Each bolt component shall be clearly marked with the component manufacturer’s identification.

4.5.6 **Welded Connections**

4.5.6.1 Design, detailing, and fabrication of welded connections shall be in accordance with either AISC’s Allowable Strength Design (ASD) or Load and Resistance Factor Design (LRFD) method, as specified in contract documents.

4.5.6.2 Welded connection design shall be in accordance with ANSI/AISC 360, AISC 325, and AISC 326. Welding for monorails, lifting lugs and other below the hook devices required for lifting or rigging shall conform to AWS D14.1/14.1M.

4.5.6.3 The minimum available strength of all welded framed beam connections shall be the member end reaction specified in design documents.

4.5.6.4 Minimum fillet weld size shall be AISC minimum or 3/16 inch (5 mm), whichever is larger, for structural welds.

4.5.6.5 Seal welds shall be 1/8 inch (3 mm) minimum fillet weld.

4.5.6.6 Welds shall be continuous, unless otherwise specified in design documents or approved by engineer of record.

4.5.6.7 Erection clips for field welded connections shall be provided.

4.5.6.8 All run-off bars and extension tabs shall be removed unless otherwise noted.

4.5.7 **Shop and Field Connections**

4.5.7.1 Unless otherwise specified in design documents, all field, galvanized, or coated connections shall be bolted and all shop connections shall be either bolted or welded.

4.5.7.2 To ensure electrical continuity if shop applying non-conductive coatings (i.e., epoxies), all contact surfaces shall be masked unless otherwise noted in contract documents.

4.5.7.3 All locations of no-paint or areas requiring full masking or strip masking shall be noted on the shop drawings.

4.5.7.4 Provide additional bolts or connection devices where required to comply with OSHA 29 CFR Part 1926, Subpart R – Steel Erection.
4.5.8 Bracing Connections

4.5.8.1 Connections for pre-assembled bracing and truss members shall be designed for the required strength specified in design documents, but not less than 50% of the available tensile strength of the member, unless otherwise specified in design documents.

4.5.8.2 The available tensile strength of the member shall be calculated using the gross cross section of the member.

4.5.8.3 A minimum of two bolts per connection shall be provided.

4.5.8.4 All cross bracing shall be bolted at intersections with one bolt minimum for angles and two bolts minimum for tees.

4.5.8.5 All bracing connections, including gusset plates, shall be designed in accordance with the ANSI/AISC 360-16 and AISC 325.

4.5.8.6 All gusset and stiffener plates shall be 3/8 inch (10 mm) minimum thickness.

4.5.8.7 Unless otherwise specified in design documents, all vertical bracing and knee bracing shall have gusset plates on column centerlines.

4.5.8.8 Unless otherwise specified in design documents, the following working points shall be used:
   a. For vertical bracing at the intersection of a column, beam, and brace, the gusset plate shall be connected to both beam and column. The work point shall be the point at which the beam and column centerlines intersect.
   b. For the connection of V-braces to nominal beams 10 inches (250 mm) or smaller, the working point shall be the intersection of the horizontal centerline of the beam and the centerline of the bay.
   c. For the connection of V-braces to nominal beams 12 inches (300 mm) or larger, the working point shall be the intersection of a horizontal line 5 inches (125 mm) below the top flange if the brace is above the beam, or 5 inches (125 mm) above the bottom flange if the brace is below the beam, and the centerline of the bay.

4.5.9 Connections for Concrete Fireproofed Members

4.5.9.1 Connections for members fireproofed with concrete shall be detailed to minimize blockouts in shop applied fireproofing.

4.5.9.2 Gusset plates for vertical or horizontal bracing members and single-plate shear connections for beams shall extend outside fireproofing a sufficient length to make the connection with the fireproofing in place.
4.6 Fabrication

4.6.1 All fabrication shall be in accordance with ANSI/AISC 303-16 and ANSI/AISC 360-16, unless otherwise specified in contract documents, state or local laws, or building codes.

4.6.2 All welding shall be in accordance with AWS D1.1/D1.1M and contract documents.

4.6.3 Shop splices, substitutions of member sizes, or changes in details or dimensions shall not be permitted without written authorization from engineer of record.

4.6.4 All beams, except cantilevers, shall be fabricated with natural mill camber in the up position.

4.6.5 All re-entrant corners shall be shaped, notched-free, to a radius.

4.6.6 If performing shop assembly work, the tolerances shall not exceed those specified in ANSI/AISC 303-16.

4.6.7 All pieces shall be clearly marked with a permanent identifying erection mark number. Method and location of marking shall be proven by past performance to survive galvanizing, shipping, handling, and outdoor storage and be approved by purchaser.

4.6.8 Before surface preparation, all sharp corners, burrs (including bolt hole burrs), weld spatter, slag, weld flux, loose mill scale and other foreign matter shall be removed.

4.6.9 Platforms, stairways, guards, and handrails shall be shop assembled in the largest units suitable for handling and shipping. Ladder cages shall be shop assembled on ladders.

4.6.10 The method for fastening grating shall be as specified in the contract documents. A minimum of two fasteners per panel shall be used at each support, with a minimum of four per panel. The fasteners shall be supplied with 5% extra to cover losses.

4.6.11 Grating/checkered plate openings shown in design documents shall be cut and banded in the shop unless otherwise noted in design documents.

4.6.12 Joints perpendicular to the span of grating and checkered plate flooring shall be permitted only over support members.

4.6.13 Checkered plate shall have 1/2 inch (12 mm) diameter drain holes provided for each 20 square feet (2 square meters) of area, with a minimum of one hole per panel.

4.7 Galvanizing / Corrosion Protective Coating

4.7.1 General

4.7.1.1 Unless otherwise noted in contract documents, all materials, except crane rails and ASTM F3125/F3125M, Grade A490 (Grade A490M) bolts and corresponding nuts and washers, shall be galvanized.
4.7.1.2 Galvanizing of steel shapes, plates, and hardware shall be in accordance with the following ASTM specifications:

a. Steel shapes and plates - ASTM A123/A123M
b. ASTM F3125/F3125M, Grade A325 (Grade A325M) bolts and corresponding nuts and washers - ASTM B695 or ASTM F2329/F2329M
c. ASTM A36/A36M threaded bar or ASTM A307 bolts and corresponding nuts and washers - ASTM B695 or ASTM F2329/F2329M

4.7.1.3 Unless otherwise noted in contract documents, ASTM F3125/F3125M, Grade A490 (Grade A490M) bolts and corresponding nuts and washers shall be coated with Zinc/Aluminum corrosion protective coating in accordance with ASTM F1136/F1136M, Grade 3.

4.7.2 Fabrication

4.7.2.1 It shall be fabricator’s responsibility to safeguard against embrittlement and warpage in accordance with ASTM A143/A143M and ASTM A384/A384M.

4.7.2.2 Fabrication details shall be in accordance with ASTM A385/A385M to allow for the creation of high quality zinc coatings.

4.7.2.3 If practical, cutting, drilling and welding shall be performed before galvanizing.

4.7.2.4 Weld slag shall be removed before galvanizing.

4.7.2.5 The edges of tightly contacting surfaces shall be completely seal welded.

4.7.2.6 Vent holes shall be provided for piping or tubular assemblies as required by ASTM A385/A385M.

4.7.2.7 Potential problems that require a modification in design shall be brought to the attention of purchaser before proceeding.

4.7.3 Galvanizing of Steel Hardware

4.7.3.1 Nuts shall be tapped oversize in accordance with ASTM A563 / ASTM A563M.

4.7.3.2 Nut threads shall be retapped after hot-dip galvanizing to provide proper fit.

4.7.3.3 Direct tension indicators, if used, shall be mechanically galvanized by the indicator manufacturer in accordance with Class 50 of ASTM B695.

4.7.4 Repair

4.7.4.1 Any damage to galvanizing shall be repaired in accordance with ASTM A780/A780M and as described below unless otherwise specified in contract documents.
4.7.4.2 Before repair of damaged galvanized coating, exposed substrate metal shall be cleaned to bright metal and free of all visual rust, oil, or grease. Any nonadhering galvanizing shall be removed to the extent that the surrounding galvanizing is integral and adherent.

4.7.4.3 If surface defects exceed 2% of a member’s area, the defects shall be repaired by redipping the member in the zinc bath.

4.7.4.4 Cold repair using an organic zinc rich coating shall be permitted if the following conditions exist:
   a. Total damaged area is less than 1% of the total coated area of the member being repaired
   b. No single repair is greater than 2 square inches (1300 mm²)
   c. No single repair is greater than 12 inches (300 mm) long.

4.7.4.5 For coating applied for a cold repair, the dry film thickness shall be 2 to 3 mils (0.05 mm to 0.08 mm) and contain a minimum of 65% zinc dust by weight.

4.7.4.6 Hot repairs shall be made in the shop if any of the following conditions exist:
   a. Total damaged area is greater than 1% but less than 2% of the total coated area of the member being repaired
   b. Any single repair is at least 2 square inches (1300 mm²) in area
   c. Any single repair is 12 inches (300 mm) long or more

4.7.4.7 Hot repair shall be made using zinc alloy rod or powder manufactured for the repair of galvanized steel.

4.7.4.8 Flux, heavy ash, or heavy dross inclusions shall be removed by brushing, grinding, or filing as required.

4.7.4.9 Galvanized steel which has been rejected shall be stripped, regalvanized, and submitted again for inspection.

4.7.4.10 Correction of excessive warpage that exceeds ASTM A6/A6M criteria shall be performed by press straightening if possible.

4.7.4.11 The application of localized heating to straighten shall be approved by engineer of record.

4.7.4.12 If galvanized tension control bolts are used, all bare steel surfaces (i.e., bolt ends) shall be repair galvanized in accordance with this section.

4.8 Handling, Shipping, and Delivery

4.8.1 Delivery of steel shall be in the order needed for erection. The delivery sequence for the fabricated steel, unless otherwise noted in contract documents or arranged by purchaser, shall be as follows:
   a. Loose base plates
   b. Steel embedded in concrete
c. Erection bolts

d. First tier columns and framing for all its levels (including stairs, grating, and handrail)

e. Second tier columns and its framing, etc.

4.8.2 All bolts, washers, and nuts shall be packaged and delivered in rigid (not cardboard), weatherproof containers.

4.8.3 Railcars and/or trucks shall be loaded and cribbed so they can be readily unloaded by others.

4.8.4 Railcars and/or trucks shall be loaded in such a manner that continuous drainage is ensured.

4.8.5 All steel and its coatings shall be protected from any damage caused by handling, storage, or shipping before receipt by purchaser.

4.8.6 Adequate protection shall be provided for threads on sag rods and any other threaded components to prevent damage during shipping and handling.

4.8.7 All materials and documentation shall be delivered to the job site in good condition.

4.8.8 All materials and documentation will be inspected by purchaser upon receipt to determine that all items included in the bill of materials have been supplied, to ensure that all documentation has been received, and to check for any damage.

4.8.9 Purchaser reserves the right to reject all damaged or below quality material or documentation.