503.14	Epoxy-Coated Reinforcing Steel, Fabricated and Delivered	Kilogram [Pound]
503.15	Epoxy-Coated Reinforcing Steel, Placing	Kilogram [Pound]
503.16	Welded Steel Wire Fabric, Complete in place	Kilogram [Pound]
503.17	Mechanical/Welded Splice	Each

SECTION 504 - STRUCTURAL STEEL

504.01 Description This work shall consist of detailing, fabricating and erecting structural steel bridges, ancillary bridge products and other steel structures.

504.02 Materials Materials shall meet the requirements of the following Sections of Division 700-Materials:

Structural Steel	713.01
Heavy-Hex Structural Bolts, Washers, Nuts and DTI's	713.02
Pre-formed Pads	713.03
Bronze or Copper-Alloy Bearing and Expansion Plates	713.04
Cold-Finished Carbon Steel Shafting	713.05
Castings	713.06

Note: The Department maintains a list of pre approved welding consumables that may be used without furnishing Certificates of Conformance from the electrode/consumable manufacturer.

504.03 Drawings The Contractor shall prepare shop detail, erection and other necessary working drawings in accordance with Section 105.7 - Working Drawings. Weld and nondestructive examination symbols shall be shown on the shop drawings. Welding Procedure Specifications (WPSs) shall be considered part of the shop drawing submittal. The drawings will be reviewed and approved in accordance with the applicable requirements of Section 105.7 and the AASHTO/NSBA Shop Detail Drawing Review/Approval Guidelines, G1.1.

504.04 Facility Requirements Steel shall be fabricated in a facility holding a current AISC or MDOT shop certification as follows:

Type of Product	Type of Certification Required[1,2,3,4,]
Continuous and Complex Bridge Structures, HPS 485W (HPS 70W), HPS 345W (HPS 50W)	AISC Cbr
Unspliced Rolled Beam Bridges, Steel for Bridge Repair and Rehabilitation	AISC Cbr or Sbr
Ancillary Products, Non-vehicular Bridges, Structural Supports, High Mast Poles, Light Poles and Other Steel Products	AISC Cbr or Sbr or Cbd or Sbd or MDOT

[1] Application of protective coatings requires a “P” endorsement or SSPC QP3 Certification.

[2] Fracture Critical fabrication requires an “F” endorsement.

[3] All materials fabricated in a non-certified shop will be rejected.

[4] Work shall not be subcontracted to a non-certified facility without the approval of the Fabrication Engineer.

504.05 Notice of Beginning Work The Contractor shall give the Fabrication Engineer a minimum of two weeks notice before the beginning of work. No work shall be performed before the Fabrication Engineer has been notified. Before beginning work, a pre-fabrication meeting may be held at the discretion of the Fabrication Engineer or, if requested, by the Contractor.

The Contractor shall advise the Fabrication Engineer of the production schedule and any changes to it. If the Contractor suspends work on a project, the Fabrication Engineer will require 48 hours notice prior to the resumption of work.

504.06 Inspection Quality Control (Q.C.) is the responsibility of the Contractor. The Quality Control Inspector (Q.C.I.) shall inspect all aspects of the work and shall supervise all nondestructive examination (NDE). The Q.C.I. shall record measurements and test results in a clear and legible manner. The Q.C.I. shall reject materials and workmanship that do not meet contract requirements. The Contractor may perform NDE in addition to the minimum required. The results of all measurements and testing shall be made available to the Quality Assurance Inspector (Q.A.I.).

Quality Assurance (Q.A.) is the prerogative of the Fabrication Engineer. The Q.A.I. will ensure that the Q.C. Department

is performing properly, verify documentation, periodically inspect workmanship and witness NDE. Q.A. testing deemed necessary by the Fabrication Engineer in addition to the minimum testing requirements shall be scheduled to minimize interference with the production schedule.

504.07 Inspector's Authority The Q.A.I. will have the authority to reject material or workmanship that does not meet the contract requirements. The acceptance of material or workmanship by the Q.A.I. will not prevent subsequent rejection, if found unacceptable.

504.08 Rejections Rejected material and workmanship shall be corrected or replaced by the Contractor.

504.09 Facilities for Inspection The Contractor shall provide a private office at the fabrication plant for inspection personnel authorized by the Department. The office shall have an area not less than 9.3 m² [100 ft^2] and shall be in close proximity to the work. The office shall be climate controlled to maintain the temperature between 18° C [65° F] and 30° C [85° F], lighted and have the exit(s) closed by a door(s) equipped with a lock and 2 keys which shall be furnished to the Inspector(s). The office shall be equipped with a desk or table having a minimum size of 1200 by 760 mm [48 in by 30 in], 2 chairs, a telephone, telephone answering machine, line data port, plan rack and 2-drawer letter size file cabinet with a lock and 2 keys which shall be furnished to the Inspector(s).

The facilities and all furnishings shall remain the property of the Contractor upon completion of the work. Payment for the facilities, heating, lighting, telephone installation, basic monthly telephone charges and all furnishings shall be incidental to the contract.

504.10 Mill Orders and Mill Test Reports The Contractor shall provide a copy of the material mill orders. The Contractor shall provide Certified Mill Test Reports (CMTRs) for all material. The CMTRs shall include chemical and mechanical properties as well as the results of CVN testing, when required. CMTRs shall originate from the producer of the steel. The CMTRs shall be provided prior to the beginning of fabrication.

504.11 Material Identification and Control Structural steel plates and shapes shall be marked as specified in AASHTO M 160M/M 160(ASTM A 6/A 6M). Material from stock shall only be used if it can be positively identified, properly documented and the direction of rolling can be determined, when necessary.

Material shall be stored above the ground and shall be kept free from dirt, grease and other foreign material. Steel shall be

protected from significant corrosion.

Fasteners shall be organized and stored by size and production lot to facilitate sampling. Fasteners shall be stored in a protected environment that preserves the fastener lubricant.

504.12 Protective Coatings Paint, metallizing and fusion-bonded coatings shall be applied in accordance with Section 506 and/or the plans as applicable.

Galvanizing shall be done in accordance with AASHTO M 111 (ASTM A 123). Steel shall be abrasive blast cleaned to SSPC SP-6/NACE No. 3 before galvanizing. Fasteners shall be galvanized in accordance with AASHTO M 232 (ASTM A 153) or AASHTO M 298 Class 50 (ASTM B 695 Class 50). Galvanized nuts shall be lubricated with a water-soluble lubricant containing a dye that contrasts with the color of the galvanizing.

504.13 Unpainted Steel Products fabricated from weathering steel shall remain in the bare, unpainted condition, unless otherwise noted on the plans. All surfaces shall be cleaned to a minimum SSPC SP-6/NACE No. 3, Commercial Blast Cleaning.

HIGHWAY BRIDGE FABRICATION

504.14 Materials for Bridges Bridge steel shall meet the requirements of AASHTO M 270M/M 270 (ASTM A 709/A 709M). The grade of steel shall be designated on the plans.

504.15 Design Bridge design, detail and load requirements shall conform to Division 1, Design, of the AASHTO LRFD Bridge Design Specifications, applicable Interim Specifications, and these Specifications.

504.16 Fabrication Fabrication shall be in accordance with the *ANSI/AASHTO/AWS D1.5 Bridge Welding Code* (the D1.5 Code), as modified herein, and these Specifications.

Material shall be handled in a manner that prevents nicks, gouges or other damage from chains, wire ropes or other handling devices during all phases of fabrication.

504.17 Nondestructive Examination Nondestructive examination shall be performed in accordance with the D1.5 Code.

The Q.A.I will witness all nondestructive examination. The Contractor shall give the Q.A.I. twenty-four hours notice to facilitate the Q.A.I.'s presence. Nondestructive examination shall be documented on the appropriate forms from Annex III of the D1.5 Code or an equivalent form prepared by the user.

504.18 Plates for Fabricated Members Plates subject to calculated stress, including splice plates, shall be cut so that the direction of rolling is parallel to the primary stresses. The direction of primary stresses for web material is parallel to the flanges unless otherwise shown. Heat numbers shall be transferred to all primary bridge material and maintained until it is incorporated in a piece-marked member.

Ends of flange plates that are to be butt-welded shall be scanned for laminations by ultrasonic straight beam testing (UT) in accordance with ASTM A 898/A 898M as modified herein. The plate shall be scanned a distance of 300 mm [12 in] from the ends prior to welding.

The acceptance standard shall be Level I. Repairs to laminations within 300 mm [12 in] of butt welds shall have the prior approval of the Fabrication Engineer.

504.19 Correcting Materials Steel may be corrected by any method that does not damage the material. If heating of the steel is required, it shall be done in accordance with a written procedure approved by the Fabrication Engineer.

Following corrective work, the steel shall be carefully inspected using nondestructive examination (NDE) methods acceptable to the Fabrication Engineer. The presence of cracks or fractures shall be cause for rejection of the material.

For general use, a Contractor may submit a procedure for correcting camber or sweep by heating for pre-qualification by the Fabrication Engineer.

504.20 Base Metal Repairs Base metal repairs that require welding shall not be made without the approval of the Fabrication Engineer.

504.21 Thermal Cutting Steel shall be thermal cut with automatic equipment or with a mechanical guide. The rate of travel of the cutting equipment shall be adjusted to prevent hardening the steel. Freehand cutting is not allowed.

504.22 Edge Hardness Thermal cut edges of cover plates, flange plates and splice material other than ASTM A 36/A 36M

shall have an average hardness not exceeding Rockwell C30 and no individual reading shall exceed Rockwell C35. Hardness shall be measured at approximately mid-thickness of the plate and the spacing of the measurements shall be at both ends, quarter points and midpoint unless additional testing is required by the Q.A.I. One measurement shall consist of the average of three readings taken at each location. Hardness readings and locations shall be documented by the Q.C.I.

Excessive hardness shall be removed by the application of heat, by grinding or machining. Heating shall be done only with the approval of the Fabrication Engineer.

504.23 Edge Planing Sheared edges of plates greater than 16 mm [• in] thick for use as flanges, cover plates, bearing stiffeners and splice material shall be planed to a depth of 5 mm [3/16 in].

504.24 Bent Plates Cold-bent, rolled steel plates shall conform to the following:

(a) The bend line will be at right angles to the direction of rolling.
(b) The radius of bends shall be such that no cracking of the plate occurs. Minimum radii, measured to the concave face of the metal, are shown in the following table:

AASHTO (ASTM)	Metric Units [U.S. Customary] Plate Thickness in Millimeters [Inches]		
	t≤25 [1 in]	25[1 in]<t≤50[2 in]	50 [2 in]<t
M 270M (A 709M) Grade 250 (Gr. 36) M 270M (A 709M) Grade 345 (Gr. 50) M 270M (A 709M) Grade 345W (Gr. 50W) M 270M (A 709M) Grade HPS70W M 183M (A 36M) M 223M (A 572M) M 222M (A 588M)	2.5 t	3.5 t	4 t

(c) If a smaller radius is required, the plates shall be bent hot at a temperature not greater than 595° C [1100° F]. Before bending, the edges of the plates shall be rounded to a radius of 2 mm [$^{1}/_{16}$ in] through that portion of the plate where the bending occurs.

504.25 Die Stamping Die stamping of primary members (including splice material, diaphragms and cross frames on curved bridges) shall be done only with the approval of the Fabrication Engineer. Secondary members may be die stamped with the piece mark. Die stamping shall be limited to no-stress locations. Die stamping shall be done with blunt nose, low-stress dies.

504.26 Camber and Curvature If camber or curvature is required for stringers or girders, the camber or curvature will be specified on the plans. The allowable tolerances for the camber and curvature of stringers and girders shall be as specified in the D1.5 Code. Specified camber or curvature shall be measured and documented using the same ordinates shown on the plans.

When no camber or curvature is specified, variations in straightness of rolled shapes, with and without cover plates, shall not exceed the tolerances of AASHTO M 160M/M 160(ASTM A 6/A 6M).

504.27 Heat Cambering and Curving Structural members may be brought to the required camber and/or curvature by the application of heat. Steel with a specified minimum yield greater than 345 MPa [50,000 psi] and High Performance Steel shall not be heat-curved or heat-cambered without the approval of the Fabrication Engineer..

A heat cambering/curving procedure shall be submitted to the Fabrication Engineer for approval before beginning the work. The procedure shall include:

1.The proposed heating pattern, showing location and distribution of heated areas, the size and shape of heated areas and sequencing of heating.
2. Method of support of the member.
3. Minimum and maximum temperature.
4. Method of heating (gas, gas flow, nozzle size, etc.)
5. Method and rate of cooling.

Steel shall be blast cleaned to SSPC SP-6/NACE No. 3 prior to heating. Both flanges and webs shall be heated with a minimum of two torches (one torch on either side of the member). Restraining or jacking the member before or during heating shall be done only with the approval of the Fabrication Engineer. The Contractor shall submit calculations showing that the nominal bending stress in the member does not exceed 0.60 F_y if restraint or jacking is proposed.

The target temperature shall be 595º C [1100º F]. Steel heated in excess of 675°C [1250° F] will be subject to rejection. The temperature of the steel shall be measured using temperature indicating crayons applied to the heated area approximately 10-15 seconds after the torch is removed. Alternate methods of measuring the temperature may be used with the approval of the Fabrication Engineer.

For camber, the heated area of the web shall be a “V” with a 10-15 degree included angle extending full web depth less 50 mm [2 in]. The heated area of the flange shall be rectangular and centered over the base of the triangle. Web heating shall begin at the apex of the triangle and proceed toward the base using the ½ lap technique. Flange heating shall begin immediately after completion of the web. Backtracking is not allowed.

Curving may be performed by a combination of line heats applied to the edge of both flanges simultaneously using an automatic track torch(es) and "V" heats, or by "V" heats alone. If the Contractor elects to use line heating, the steel shall be allowed to cool to ambient temperature before the beginning of "V" heats. When using "V" heats, the heated area shall have an included angle of 15-30 degrees and a height 65% the flange width. The Contractor shall apply heat to adjacent areas on both flanges and both sides of the flanges simultaneously.

Following the application of heat, the steel shall be allowed to cool in still air to below 315ºC [600ºF] after which compressed air may be used. Quenching will not be allowed.

All cambering and curving, including corrections, shall be carried out in the presence of the Q.A.I. Heating a structural member without the Q.A.I. present shall be cause for rejection. Camber and sweep shall be measured for acceptance after the steel has reached ambient temperature.

Areas of suspected cracking shall be tested by an NDE method satisfactory to the Fabrication Engineer. The cost of NDE examination required by the Fabrication Engineer after heat curving or cambering shall be incidental to the contract.

504.28 Welding AASHTO M 270M/M 270 (ASTM A 709/A 709M),Gr. 250, Gr. 345, Gr. 345W Weld Procedure Specifications (WPSs) for groove welds and multiple-pass fillet welds shall be qualified by Procedure Qualification Testing in accordance with the D1.5 Code. The electrical parameters shall be within the consumable manufacturer’s published recommendations.

Each side of complete joint penetration welds, once begun, shall be welded to completion without interruption or a delay

between passes except as necessary to maintain interpass temperature requirements. When backgouging is required, the groove and 75 mm [3 in] on either side of the groove shall be preheated to 51° C [125° F] immediately before the resumption of welding.

Single-pass fillet welds may be qualified by a Fillet Weld Soundness Test performed in accordance with the D1.5 Code as modified herein. The "T" test shall be performed by welding the smallest fillet weld to be used in production on one side and the largest fillet weld used in production on the other side of the "T". The test specimens shall be macroetch tested in accordance with the requirements of Section 5 of the D1.5 Code. Acceptance and re-testing, if required, shall be in accordance with Section 5 of the D1.5 Code.

The minimum heat input for single-pass fillet welds during testing and production shall be 1.4 kilojoules/mm [35 kilojoules/in].

504.29 Welding AASHTO M 270M/M 270 (ASTM A 709/A 709M) HPS 345W (HPS 50W) and HPS 485W (HPS 70W) Steel Consumables shall be handled and stored in accordance with Subsections 12.6.5, and 12.6.6 of the D1.5 Code.

Filler metals for joining HPS 345W (HPS 50W) to HPS 345W (HPS 50W) or Grade 345W (Grade 50W) base metal shall meet the requirements of Table 4.1 or Table 4.2 of the D1.5 Code for Grade 345W (Grade 50W) steel.

Filler metals for welding HPS 485W (HPS 70W) base metal shall meet the following requirements:

Unless otherwise specified on the Plans, filler metals for fillet welds joining HPS 485W (HPS 70W) to HPS 485W (HPS 70W), HPS 345W (HPS 50W) or Grade 345W (Grade 50W) shall meet the matching filler metal requirements of Table 4.1 of the D1.5 Code for Grade 345W (Grade 50W) steel (H8 maximum).

Single-pass fillet welds joining HPS 485W (HPS 70W) to HPS 345W (HPS 50W) or Grade 345W (Grade 50W) steel shall meet the requirements of Section 4.1.5 of the D1.5 Code.

Single-pass fillet welds need not meet the requirements for exposed bare application.

Filler metals for multiple-pass fillet welds joining HPS 485W (HPS 70W) to either HPS 485W (HPS 70W), HPS 345W (HPS 50W) or Grade 345W shall meet the requirements of Table 4.3 of the D1.5 Code for Grade 345W (Grade

50W) steel (H8 maximum).

Filler metals for groove welds joining HPS 485W (HPS 70W) to HPS 345W (HPS 50W) or Grade 345W (Grade 50W) shall meet the matching filler metal requirements for Grade 345W (Grade 50W) steel (H8 maximum) as listed in Table 4.1 of the D1.5 Code.

Matching filler metal for HPS 485W (HPS 70W) shall meet the following requirements:

(a) AWS Classification F9A4-EXXX-X with the optional supplemental diffusible hydrogen designator of H2 or H4 and a minimum of 1% Nickel. In addition to the Procedure Qualification Test, diffusible hydrogen (H_d) tests shall be performed on the weld metal. The deposited weld metal shall have a diffusible hydrogen level of 4mL/100g [0.0048 gal/lb] or less. H_d shall be prepared at the fabrication facility and tested in accordance with AWS A4.3.

(b) Matching SMAW electrodes shall meet the requirements of E9018RHZ and have an optional diffusible hydrogen designator of H2, H4, or H8. Undermatching SMAW electrodes shall meet the requirements of undermatching filler metals form Tables 4.1 or 4.3 of the D1.5 Code as applicable.

(c) As an alternative, HPS 485W (HPS 70W) base metal may be welded by the SAW process using the consumables and reduced preheat temperatures specified in Appendix A of the *AASHTO Guide Specification for Highway Bridge Fabrication with HPS70W Steel,* September, 2000.

Procedure Qualification Tests for HPS 345W (HPS 50W) shall be performed in accordance with Section 5 of the D1.5 Code except that the backing bar may be Grade 345W (0.025 S max.) or HPS 345W (HPS 50W).

Weld Procedure Specifications for butt welds and multiple-pass fillet welds joining HPS 345W (HPS 50W) to HPS 345W (HPS 50W) shall be written based on the results of approved Procedure Qualification Tests performed on HPS 345W (HPS 50W) base metal.

Weld Procedure Specifications for single-pass fillet welds joining HPS 345W (HPS 50W) to HPS 345W (HPS 50W) or Grade 345W (grade 50) may be written based upon an approved Procedure Qualification Test performed on Grade 345W

(Grade 50W) base metal.

Procedure Qualification Tests for HPS 485W (HPS 70W) shall be performed in accordance with Section 5 of the D1.5 Code except that the backing bar may be Grade 345W (0.025 S max.) or HPS 485W (HPS 70W). The heat input range developed by testing shall be between 1.6 kJ/mm and 3.5 kJ/mm [40 kJ/in and 90 kJ/in].

SAW and SMAW processes are approved for welding HPS 485W (HPS 70W). FCAW and GMAW processes shall be subject to approval by the Fabrication Engineer.

The results of a Procedure Qualification Test performed with HPS 485W (HPS 70W) and matching filler metal shall meet or exceed the Base Metal Requirements of AASHTO M 270M/M 270 (ASTM A 709/A 709M) for HPS 485W (HPS 70W) Steel.

Weld Procedure Specifications for fillet welds on HPS 485W (HPS 70W) using under-matched filler metals shall be written based upon an approved Procedure Qualification Test performed on HPS 345W (HPS 50W) or Grade 345W (Grade 50W) test plates.

Weld tabs for butt joints joining HPS 485W (HPS 70W) shall meet the requirements of Section 3.12 of the D1.5 Code except that the minimum length shall be 150 mm [6 in].

When welding HPS 485W (HPS 70W) steel to HPS 485W (HPS 70W) steel, preheat and interpass temperatures shall meet the requirements of Table 4.4 of the D1.5 Code for Grade 485W (Grade 70W) base metal. When welding HPS 485W (HPS 70W) steel to HPS 345W (HPS 50W) or Gr. 345W steel, the minimum preheat temperature shall meet the requirements of Table 4.4 of the D1.5 Code for the applicable grade and thickness of the base metals.

Nondestructive Examination of HPS 485W (HPS 70W) steel shall be performed in accordance with Section 6 as modified herein. Inspectors and NDT Technicians shall be qualified in accordance with Section 12 of the D1.5 Code. Fillet weld repairs shall be inspected in accordance with Subsection 12.16.2.3 of the D1.5 Code. Cooling time prior the inspection shall be in accordance with Subsection 12.16.4 of the D1.5 Code.

504.30 Welded Fabrication A copy of an approved Welding Procedure Specification (WPS) for the joint being welded shall be displayed at each welding station. Only WPSs bearing the approval stamp of the Maine Department of

Transportation shall be used.

Flange plate and web plate butt joints, web to flange welds, stiffener and connection plate to web welds, and cover plate to flange welds shall be made using an automatic or semi-automatic weld process.

Repairs to welds shall be made with the same process used for the original welds, except that repairs less than 300 mm [12 in] in length may be made with a different process using an approved WPS.

Runoff tabs shall be removed and butt welds shall be ground smooth prior to nondestructive examination. Butt welds joining plates of equal thickness shall be ground flush with the base metal. Butt welds joining plates of unequal thickness shall be ground at a slope of 1:2.5. Butt joints joining plates of unequal width shall have a smooth transition with a minimum 600 mm [24 in] radius. Grinding marks shall be parallel to the direction of the primary stresses.

Weld metal deposited without an approved WPS or outside the parameters of an approved WPS shall be removed and rewelded as directed by the Fabrication Engineer.

504.31 Shop Assembly Abutting members shall be placed in their exact relative field position for erection and shall be assembled with the associated filler and splice material. The Q.C.I. shall record all measurements necessary to demonstrate that the shop assembly meets the requirements of the plans and Specifications. The Q.A.I. shall be given the opportunity to verify the measurements prior to disassembly.

504.32 Tolerances Dimensional tolerances for welded plate girders shall be as described in the D1.5 Code. Dimensional tolerances for rolled shapes shall be as described in AASHTO M 160 M/M 160 (ASTM A6/A 6M).

Layout and fit-up tolerances for plate girders and rolled stringers shall be as described in the D1.5 Code. The tolerance for the length of any primary bridge member shall be ±6 mm [¼ in]. The bearing- to-bearing tolerance shall be ±3 mm [• in]. Abutting joints at field splices shall have an opening of 6 mm [¼ in] ± 3 mm [• in].

504.33 Match marking Drill assembled or ream assembled parts shall be match marked prior to disassembly. The match marks shall be preserved through field erection.

504.34 Holes for High Strength Bolts Holes for connections may be sub-punched and reamed, sub-drilled and reamed, or

drilled full-size with all the splice material assembled in final position. Holes that are reamed shall be sub-punched or sub-drilled 5 mm [3/16 in] smaller than the nominal diameter of the bolts. After assembly, the splices shall be reamed 2 mm [$^1/_{16}$ in] larger than the nominal bolt diameter. The Contractor may drill holes full size in each piece separately, provided that after drilling, all connections are fully assembled, duplicating the final position of the stringers or girders, to demonstrate the accuracy of the holes. Splice plates that have been drilled full size may be used as one-time templates to drill webs and flanges. The plates shall remain with the splice. Plates damaged while being used as a template shall be replaced.

Holes for cross frames, diaphragms and associated connection plates may be punched when the thickness of the plate is not greater than 20 mm [9/16 in] for AASHTO M 270M/M 270 (ASTM A 709/A 709M, Grade 250) steel and 16 mm [• in] for AASHTO M 270M/M 270 (ASTM A 709/A 709M, Grade 345 and Grade 345W). The diameter of the die shall not exceed the diameter of the punch by more than 2 mm [$^1/_{16}$ in]. Holes shall be clean cut, without torn or ragged edges. When the material is thicker than the above limits, punching is not allowed.

Holes shall be cylindrical and perpendicular to the member. Burrs caused by drilling or reaming shall be removed from all parts.

Oversize or short-slotted holes may be used in connections other than splices of primary members and end connections of floor beams. Hardened washers shall be used over oversize and slotted holes.

Thermal cut holes in bearing plate material shall be produced using an automatic or mechanically guided process. The surface roughness shall not exceed ANSI 25µm [1000 µin].

504.35 Accuracy of Holes After assembling all parts of a connection containing sub-punched or sub-drilled holes, it shall be possible to enter a pin 3 mm [• in], smaller in diameter than the nominal size of the hole in at least 75 percent of the contiguous holes in the array. When assembled, all holes in a connection shall be able to pass a pin 5 mm [3/16 in] smaller in diameter than the nominal size of the sub-punched or sub-drilled holes. Pins shall be entered perpendicular to the face of the member and no drifting will be allowed. Failure to comply with either of the above criteria shall be cause for rejection of the splice material.

Following the completion of the drilling or reaming of all holes in a contiguous group, with all plies of a connection in

their proper position for assembly, all holes shall accept a pin 0.8 mm [1/32 in] smaller in diameter than the nominal hole size.

No finished hole shall be located more than 3 mm [• in] from its theoretical location. The repair of mislocated holes shall be subject to the approval of the Fabrication Engineer.

The minimum edge distances for holes shall be as shown below:

Fastener Size-mm[in]	Sheared/Flame Cut Edges-mm[in]	Rolled or Gas Cut Edges-mm[in]
16 [•]	30 [1 •]	22 [7/8]
20 [¾]	32 [1 ¼]	25 [1]
22 [7/8]	40 [1 ½]	30 [1 •]
24 [1]	45 [1 ¾]	32 [1 ¼]

After the splices have been disassembled, all faying surfaces shall be solvent cleaned in accordance with SSPC-SP 1.

Bolted connections shall be considered slip-critical unless otherwise specified. Contact surfaces within slip-critical joints shall be blast cleaned to SSPC SP-6/NACE No. 3, Commercial Blast unless otherwise specified.

504.36 Shop Bolts Shop bolts shall be installed and tensioned in accordance with this Specification. As an alternative, Tension Control (TC) bolts meeting the requirements of ASTM F 1852 may be used with the approval of the Fabrication Engineer.

504.37 Bearings Bearings, base plates and other contact surfaces shall be finished to the following tolerances:

Surface Roughness Requirements-Metric [U.S. Customary]

Steel slabs	50 µm [ANSI 2000 micro-inches]
Bearing sole plates	25 µm [ANSI 1000 micro-inches]

Milled ends to compression members, milled or ground ends of stiffeners or rockers	10 µm [ANSI 500 micro inches]
Bridge rockers and rollers	5 µm [ANSI 250 micro-inches]
Sliding bearings	3 µm [ANSI 125 micro-inches]
Pins and pin holes	3 µm [ANSI 125 micro-inches]

Bearing mating surfaces (including steel to steel, or steel to bronze and steel to elastomeric material) shall have a minimum of 90% contact area. Flatness (the permissible variation from a true plane) shall be a maximum 1 mm [1/32 in].

504.38 Marking and Delivery Each member shall be marked for identification. Erection marks, match marks and piece marks shall be placed where they will not be exposed in the finished structure.

The Contractor shall furnish the Fabrication Engineer copies of shipping documents and erection diagrams.

Bolts of one length and diameter, along with the required number of nuts and washers shall be packed together in heavy-duty waterproof containers. Each container shall have a list and description of the contained material, including the identifying shipping lot number and Rotational-Capacity lot number, in a waterproof envelope, firmly attached to the outside of the container.

504.39 Handling and Storing Materials Material shall be placed and supported above the ground. They shall be kept clean and properly drained. Fabricated members shall be supported in a manner that will prevent injury due to excessive deflection or torsion. Care shall be exercised to prevent gouges, scratches and other damage. Chains and wire rope slings shall not be used in direct contact with fabricated members when being lifted or transported. Steel members shall be loaded, transported and unloaded at their destination without damage.

BRIDGE STEEL ERECTION

504.40 Plans If fabrication and erection of the superstructure are done under separate contracts, the Department will furnish detailed plans for the bridge or bridges to the Contractor.

504.41 Methods and Equipment The Contractor shall submit to the Fabrication Engineer plans for any false work and/or for modifications to an existing structure necessitated by construction loading. The false work and/or modifications shall be designed, constructed and maintained for the loads placed upon it. False work calculations and design shall be stamped by a Professional Fabrication Engineer. The approval of the Fabrication Engineer shall not relieve the Contractor of the responsibility for the safety of the method, equipment or from carrying out the work in accordance with the plans and Specifications. No work shall be done without the Fabrication Engineer's approval.

504.42 Bearings, Expansion Devices, and Anchorages Bearings shall be installed in accordance with Section 523 - Bearings.

504.43 Assembling Steel The steel shall be assembled as shown on the plans. Surfaces in permanent contact shall be cleaned before assembly. Drift pins shall be used in both the webs and flanges of connections to assure alignment of all holes. A minimum of eight drift pins shall be used in each flange and web connection. No less than 50% of the bolts in each contiguous group shall be installed and snugged before the member is released from the crane. Drift pins shall not be removed until bolts have been installed and snugged in the remaining holes.

504.44 Connections Using High Strength Bolts The Contractor shall provide all necessary torque and power wrenches, calibration equipment, feeler gauges and labor required for the testing, calibration, installation and inspection of high strength bolts. A tension measuring device (Skidmore-Wilhelm or approved equal) and torque wrench, both of which have been calibrated within 12 months and are in good condition, shall be provided by the Contractor. Both the tension measuring device and the torque wrench shall remain at the job site during steel erection.

Each torque wrench shall have a maximum capacity approximately 100% greater than the anticipated job torque. Torque wrenches shall be equipped with a dial face gauge and a memory pointer that remains at the applied torque reading. Torque wrenches shall be graduated in increments not to exceed two percent of the maximum capacity of the wrench and shall be readable to one percent of the maximum capacity.

If Direct Tension Indicators (DTI's) are used, a Technical Representative from the DTI manufacturer or supplier shall be present during initial testing of the DTI's.

504.45 Bolts, Nuts, Washers and Direct Tension Indicators Bolts, nuts and washers shall be furnished by one supplier and, when practicable, shall be from one manufacturer. DTI's shall be supplied from one manufacturer and, when practicable,

from one production lot.

The manufacturer or supplier shall perform a Rotational Capacity Test (RCT) in accordance with AASHTO M 164M/M 164 (ASTM A 325/ A 325M) for each combination of bolts, nuts and washers supplied. Each combination shall be assigned a unique Rotational Capacity (R-C) lot number. The Contractor shall provide the results of the RCT to the Fabrication Engineer before installation of the fasteners.

Fasteners shall be protected from dirt and moisture. Only as many fasteners as anticipated to be installed during a work shift shall be taken from protected storage. Fasteners not used shall be returned to protected storage at the end of the workday. Fasteners that have become rusted or dirty shall be cleaned and lubricated prior to installation with a lubricant recommended by the bolt supplier or manufacturer. Tension Control (TC) fasteners shall only be re-lubricated by the manufacturer.

Surfaces in contact with the bolt head and nut shall not have a slope more than 1 to 20 with respect to a plane normal to the bolt axis. Where an outer face of the bolted parts has a slope of more than 1 to 20 with respect to a plane normal to the bolt axis, a hardened beveled washer shall be used. Bolted parts shall fit solidly together when assembled. When assembled, all joint surfaces shall be free of mill scale, dirt, burrs, or other material that would prevent solid seating of the parts.
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Bolts shall be installed with a hardened washer under the element turned in tightening. Hardened washers are required over slotted and oversize holes. Washers must completely cover holes.

Fasteners shall be tightened within 48 hours of installation. All fasteners in a connection shall be tightened to at least 105% of the Minimum Bolt Tension values in Table 1.

When DTI’s are used, the installation of DTI’s under the turned element of the fastener assembly shall be done only with the approval of the Fabrication Engineer.

504.46 Test Specimens The Fabrication Engineer will select four specimens of each lot, length and diameter bolt along with the associated nuts, washers and DTI’s for testing by the Department. The cost of the specimens shall be incidental to the appropriate contract items. Test specimens shall be available to the Department a minimum of three weeks prior to beginning steel erection. Fasteners that have been installed and later found unacceptable shall be replaced at the Contractor’s expense.

504.47 Verification The Contractor shall perform a Rotational Capacity Test (RCT) for each lot, length, and diameter bolt assembly at the job site immediately prior to installation. If DTI's are used, the Contractor shall perform a DTI Verification Test for each production lot immediately prior to installation. The Fabrication Engineer will witness and document both the RCT and DTI Verification Test.

504.48 Rotational Capacity Test The test shall be conducted using a tension measuring device (Skidmore-Wilhelm or equivalent) and a torque wrench. Two randomly selected fastener assemblies of each length and diameter from each R-C lot shall be tested.

The fastener assemblies shall be tested in the following manner:

1. Bring the fastener to a snug-tight condition in the tension-measuring device (approximately ten percent of the Installation Tension from Table 1 below). Mark the socket with reference to a point on the tensioning device in such a way that nut rotation can be measured.

Table 1
Minimum Installation Tension Requirements and Turn Test Tension-Metric [U.S. Customary]

Bolt Diameter, mm	16 [•]	20 [¾]	22 [7/8]	24 [1]	27 [1 •]	30 [1 ¼]	36 [1 •]
Installation Tension-kN [kips]	85 [19]	125 [28]	175 [39]	227 [51]	249 [56]	316 [71]	378 [85]
Turn Test Tension-kN [kips]	98 [22]	142 [32]	200 [45]	262 [59]	285 [64]	365 [82]	436 [98]

2. From snug tight, bring the fastener assembly to the Minimum Required Installation Tension specified in Table 1 using the torque wrench.

3. At a point after the required Minimum Installation Tension has been achieved, one reading of tension and torque shall be recorded. The readings should be taken with the nut in rotation and as close as possible to the Minimum Installation Tension.

4. Further tighten the fastener assembly to the total rotation (from snug-tight) specified in Table 1A below:

Table 1A

Bolt length up to and including 4 diameters	2/3 turn (240 degrees)
Bolt length over 4 diameters up to and including 8 diameters	1 turn (360 degrees)
Bolt length over 8 diameters	1 1/3 turns (480 degrees)

5. The tension at the specified rotation above shall be equal to or greater than the Turn Test Tension (see Table 1). Record the tension.

6. Upon completion of steps 1 through 5:

(a.) The torque measured in step 3. to produce the measured tension shall not exceed the value obtained by the following equation:

METRIC

Torque ≤340 PD Where:
Torque = Measured Torque (N.mm)
P = Measured Bolt Tension (N)
D = Nominal Bolt Diameter (mm)

U.S. CUSTOMARY

Torque ≤ 0.25*PD* Where:
Torque = Measured Torque (ft.-lbs.)
P = Measured Bolt Tension (lbs.)
D = Nominal Bolt Diameter (feet)

(b) If the torque measured in step 3 exceeds the torque calculated in step 6, all fasteners from the lot represented shall be re-lubricated and retested.

7. Bolts that are too short to be assembled in the tension-measuring device shall be tested in a steel joint. Mark the turned element relative to the steel joint in such a manner that fastener rotation can be measured. Use the torque wrench

to bring the fastener assembly from a snug-tight condition to 1/3 turn. Record the torque required to reach that rotation while the turned element is in motion. The torque thus determined shall not exceed the maximum torque requirement using the formula in step 6., assuming *P* to be equal to the appropriate Turn Test Tension from Table 1. Further tighten the fastener assembly to 2/3 turn from the initial mark. Assemblies that fail before 2/3 rotation either by stripping or fracture fail the test.

8. Disassemble each fastener assembly and run the nut down the full length of the threads excluding the grip length. If evidence is found of torsional failure, shear failure or stripping of the threads, the assembly shall be deemed to have failed the test. Slight necking in the grip length is not considered a failure.

9. Bolts used for the Rotational Capacity Test shall be discarded.

504.49 DTI Verification Test When Direct Tension Indicators are used, a DTI Verification Test shall be performed at the job site. The Verification Test shall be performed for each production lot of DTIs in combination with each R-C lot of fasteners. The test shall be performed in two steps:

1. a) Use three randomly selected fastener assemblies from each R-C lot and for each position of the DTI with respect to the turned element.

b) Install the bolt, nut, hardened washer, and DTI in a tension-measuring device in such a manner that the DTI is available for inspection by feeler gauge after tensioning. Use flat inserts instead of the normal bolt head restraints so that both nut and bolt are capable of rotating.

c) Using two wrenches, one to restrain the unturned element of the bolt assembly, tighten the assembly to the Bolt Tension listed in Table 2. If an impact wrench is used, tighten to approximately 2/3 the required tension and use a manual wrench to attain the required tension.

TABLE 2-Metric [U.S. Customary]

AASHTO M 164M/m 164 (ASTM A 325/ A 325M)							
Bolt Dia.-mm [in.]	16[•]	20[¾]	22[7/8]	24 [1]	27[1 •]	30[1 ¼]	36[1 ½]

Bolt Tension-kN [kips]	89 [20]	129 [29]	182 [41]	240 [54]	262 [59]	334 [75]	480 [108]

d) Determine and record the number of spaces between the protrusions on the DTI that a 0.13 mm [0.005 in] thickness gage is refused.

e) The number of spaces in which the 0.13 mm [0.005 in] gage is refused shall not exceed the number given in Table 4. If the number of refusals exceeds the number in Table 4, the DTI fails the Verification Test.

TABLE 3-Metric [U.S. Customary]

AASHTO M 164M/m 164 (ASTM A 325/ A 325M)							
Bolt Dia.-mm [in.]	16 [•]	20 [¾]	22 [7/8]	24[1]	27[1 •]	30[1 ¼]	36[1 ½]
Number of Gaps	4	5	5	6	6	7	8

Verification Criteria*						
Number of spaces in DTI	4	5	6	7	8	9
Max. Number of gaps in which gage is refused	1	2	2	3	3	3

TABLE 4

*If the test is a coated DTI, the maximum number of spaces the gage is refused is the number of spaces on the DTI minus one.

2. a]The bolt shall be further tightened to the smallest gap to be allowed in the work. Normally, this is defined as all gaps refusing a 0.13 mm [0.005in] gage and at least one visible gap remaining. Record the tension. The tension shall not exceed the applicable tension from Table 5.

TABLE 5 -Metric [U.S. Customary]

AASHTO M 164M/m 164 (ASTM A 325/ A 325M)							
Bolt Dia.-mm [in.]	16 [•]	20[¾]	22[7/8]	24[1]	27[1 •]	30[1 ¼]	36[1 ½]

Bolt Tension -kN [kips]	120 [27]	178 [40]	245 [55]	325 [73]	356 [80]	454 [102]	658 [148]

TABLE 6-Metric and U.S. Customary

Inspection Criteria*					
Number of gaps in DTI	4	5	6	7	8
Minimum number of gaps gage is refused	2	3	3	4	4

*The gage shall be refused in all gaps when a coated DTI is used under the turned element.

b) Remove the bolt from the tension measuring device and turn the nut on the threads of the bolt by hand. If the nut can be run the length of the threads, excluding the thread runout and the tension does not exceed the allowable tension from Table 5, the DTI lot is acceptable. If the nut is unable to run the thread length at the smallest gap condition (defined in a) above), the test shall be performed again using a larger minimum acceptance gap.

c) If the number of gage refusals is less than the minimum number from Table 6 when the tension is equal to or greater than the applicable bolt tension from Table 5, the DTI lot shall be rejected.

Bolts too short to fit in the tension-measuring device shall be tested by tightening to the minimum gap in step 2. a) and checked in accordance with step 2. b). The DTI used with the short bolt should be verified using a longer bolt in the tension-measuring device.

504.50 Calibration, Installation and Tensioning of High Strength bolts The Contractor shall select one of the methods listed herein for installing and tensioning high strength bolts. Standard torque determined by the use of tables or formulas that attempt to relate torque to tension are not acceptable.

The Fabrication Engineer will observe the calibration and testing procedures to confirm that the selected installation procedure is properly used and that the specified tensions are attained as a minimum. The installation of fasteners in the work will be monitored by the Fabrication Engineer to verify that the selected procedure is routinely being used in an acceptable manner.

Regardless of the procedure used, care shall be taken to assure that all fasteners are brought to a snug tight condition before final tensioning. Snug tight is defined as all plies in a connection being in contact with approximately 10% of the final bolt tension applied to all fasteners.

High Strength bolts shall be installed and tensioned by: (1) the Calibrated Wrench method, (2) the Turn of Nut method, (3) with Direct Tension Indicators or (4) Alternative Design Fasteners.

504.51 Installation A Hardened washer shall be installed under the turned element. Fastener assemblies shall be installed in all holes in a contiguous group, except for holes containing drift pins, and shall be brought to a snug tight condition, progressing systematically from the most severely restrained location in a connection to the free edges. Drift pins shall not be removed until enough bolts have been tightened to prevent slippage in the joint. Tightening shall progress systematically from the most rigid part of the joint to the free edges.

504.52 Tightening Tightening of fasteners shall be done by one of the following:

1. The Calibrated Wrench Method Adjustable pneumatic wrenches, adjustable hydraulic wrenches or calibrated torque wrenches may be used. Each wrench used shall be calibrated.

The Calibrated Wrench method for tensioning bolts shall be calibrated at least once each shift for fastener assemblies of each diameter, length, and R-C lot being installed.

Three fastener assemblies (bolt, nut and washer) for each diameter and length shall be randomly selected for wrench calibration.

Install each of the three fastener assemblies in the tension-measuring device and install enough washers so at least three but no more than five threads are showing. A hardened washer shall be under the turned element. Snug the bolt using the same procedure to be used during installation.

When the calibrated wrench is an adjustable pneumatic wrench or an adjustable hydraulic wrench, the wrench shall be set so that each of the three assemblies shall be tightened from snug to less than 105% of the Minimum Bolt Tension specified in Table 1.

When a manual torque wrench is used, the torque required to tension each of the three bolts to 105% of the Minimum Bolt Tension specified in Table 1 shall be recorded. The job installation torque shall be the average of the three recorded torque values. The torque shall be measured with turned element in rotation.

When bolts are too short to fit in the tension measuring device, the wrenches shall be calibrated using DTI's. The DTI's must first be calibrated as described in Section 504.49.

Following the snug tightening operation, calibrated wrenches shall be operated until the wrench cuts out at the setting established by calibration or manual torque wrenches shall be used to bring the bolt assembly to the job installation torque as a minimum. Torque shall be measured with the turned element in rotation. The wrench shall be returned to "touch up" previously tightened fasteners that may have relaxed because of subsequent tightening.

2. The "Turn of Nut" Method The Turn of Nut method shall be calibrated once, prior to fastener installation, for each diameter and length bolt of each R-C lot.

Select a random sample of three fastener assemblies of each diameter, length and R-C lot. Install each assembly in a tension-measuring device, using the snugging procedure to be used in the work. Mark the nut or socket to a reference point on the tension-measuring device and further tighten the bolt to the required rotation in Table 6. The bolt tension shall be a minimum of 105% of the Minimum Bolt Tension from Table 1.

All bolts shall be installed in a connection (except for holes with drift pins) and brought to a snug tight condition. This may be attained by a few impacts of an impact gun or the full effort of a man using an ordinary spud wrench.

Following the snugging operation, all bolts shall be tightened by the applicable amount of rotation. The unturned element shall be held by a wrench to prevent rotation during tightening.

TABLE 6

Nut Rotation from Snug Tight [1,2,3]

Disposition of Outer Faces of Bolted Parts

Bolt Length Measured from Underside of head to extreme of point	Both Faces Normal to Axis 3	One Face Normal to Bolt Axis and Other Face Sloped Not More Than 1:20 (bevel washer not used) 3	Both Faces Sloped Not More Than 1:20 from Normal to Axis (bevel washer not used) 3
Up to and including 4 diameters	1/3 turn	½ turn	2/3 turn
Over 4 diameters but not exceeding 8 diameters	½ turn	2/3 turn	5/6 turn
Over 8 diameters but not exceeding 12 diameters 2	2/3 turn	5/6 turn	1 turn

1 Nut rotation is relative to bolt, regardless of the element (nut of bolt) being turned. For bolts installed by ½ turn and less, the tolerance shall be plus or minus 30 degrees; for bolts installed by 2/3 turn and more, the tolerance shall be plus or minus 45 degrees.

2 No research work has been performed by the Research Council on Riveted and Bolted Structural Joints to establish the turn-of-nut procedure when bolt lengths exceed 12 diameters, therefore, the required rotation must be determined by actual tests in a suitable tension measuring device simulating the actual condition.

3 The tolerances in footnote 1 may be exceeded if calibration in an approved tension measuring device shows that the specified minimum tension cannot be obtained or is exceeded when using the specified turns.

3. Tensioning Fastener Assemblies with DTI's Fasteners using DTI's shall be tightened so that a 0.13 mm (0.005 in) feeler gage is refused in at least the number of gaps shown in Table 7 and the minimum acceptance gap remains. Tightening beyond crushing the DTI shall be cause for rejection of the fastener assembly.

TABLE 7

Inspection Criteria for DTI's*						
Number of gaps in DTI	4	5	6	7	8	9

Min. number of gap refusals	2	3	3	4	4	5

4. Alternate Design Fasteners Alternate design fasteners designed to indicate bolt tension indirectly or tension bolts automatically may be used only with the prior approval of the Fabrication Engineer. Alternate design fasteners shall meet the chemical and mechanical requirements of AASHTO M 164M / M 164 (ASTM A 325/ A 325M) and shall have the same body diameter and not less than the same bearing area under the head and nut as a heavy hex fastener.

The Contractor shall provide a detailed written installation procedure from the fastener manufacturer to the Fabrication Engineer for approval before beginning bolt installation. The Fabrication Engineer may modify or place restrictions on the installation procedure before approval.

Before installation, three fastener assemblies of each diameter, length, and lot shall be calibrated in a tension measuring device. Each fastener shall achieve a minimum of 105% of the Minimum Bolt Tension from Table 1 when installed and tensioned in accordance with the approved installation procedure. If any of the three fasteners fails to achieve 105% of the Minimum Bolt Tension, a retest of five fastener assemblies from the same lot may be performed. If any of the five fastener assemblies fails to achieve 105% of the Minimum Bolt Tension, the lot shall be rejected. The Fabrication Engineer may require re-calibration of the fasteners if the condition of the fasteners has significantly changed.

Alternate design fasteners shall be tensioned immediately after installation. Alternate design fasteners shall be installed and snugged in accordance with the approved installation procedure. After all fasteners in a connection have been properly snugged, the fasteners shall be brought to final tension starting at the most rigid part of the joint and working systematically toward the free edges. After all other bolts in a connection have been properly tensioned, the drift pins shall be removed and fasteners shall be installed in the remaining holes.

Alternate design fasteners are extremely dependent on proper lubrication and thread condition. Fasteners shall be handled and stored in accordance with the manufacturer’s recommendations. Fasteners that have been improperly handled or stored shall be rejected.

504.53 Inspection For joints not using DTI’s or alternate design fasteners that indicate proper tensioning, inspection of all completed joints shall be done within 24 hours following completion of each joint.

The following inspection procedure shall be used:

1. The contractor, in the presence of the Fabrication Engineer shall use a calibrated torque wrench as an inspection tool.

2. At least once each day, a representative sample of five bolts from each diameter, length and R-C lot used in the work shall be tightened in the tension measuring device to the Minimum Bolt Tension specified in Table 1. There shall be a washer under the turned element of each bolt. The job inspection torque shall be the average of three values after rejecting the high and low values.

3. Bolts represented by the sample in the preceding paragraph which have been tightened in the structure shall be inspected by applying, in the tightening direction, the inspection wrench and the job inspection torque to a minimum of 10% of the bolts, but not less than two bolts, selected at random, in each connection. If any nut or bolt is turned more than five degrees (approximately one inch at a twelve inch radius) by the application of the job inspection torque, all bolts in the connection shall be tested. Alternatively, the Contractor or Erector may re-tighten all the bolts in the connection before the specified inspection.

4. For joints using DTI's, inspection will consist of verifying that the DTI has the minimum number of refusals required from Table 7 and the minimum gap allowed in the work (from the DTI Verification Test) remains in at least one space.

5. At the Fabrication Engineer's option, if the Fabrication Engineer witnesses the snugging and final tensioning of fasteners in a joint using the "Turn of Nut" method and finds it acceptable, no further inspection will be required.

504.54 Reuse of Bolts Only black AASHTO M164M/M164 (ASTM A325/A325M) bolts may be reused. There shall be no excessive elongation of the bolt in the threaded area. If the nut can be installed by hand for the full thread length, no excessive elongation is evident. Fastener assemblies that are found to be deformed due to improper installation or tightening shall be rejected and replaced at the Contractor's expense.

504.55 Field Welding Welders shall have in their possession a valid certification, for the process and position required, from the American Welding Society or other organization acceptable to the Fabrication Engineer.

A written Weld Procedure Specification (WPS) for each joint shall be submitted to the Fabrication Engineer for approval. The WPS shall be provided to the welder and Inspector before beginning welding.

Field welding and nondestructive examination of field welds shall conform to the requirements of the D 1.5 Code.

504.56 Misfits The correction of misfits involving reaming will be considered a legitimate part of steel erection. Errors in shop fabrication or deformation from handling and transportation which prevents the proper assembling and fit-up of parts by the use of drift pins or by reaming (not to exceed 10% of the holes in a contiguous array) shall be reported immediately to the Fabrication Engineer. The contractor shall provide a written proposal for correction to the Fabrication Engineer.

ANCILLARY BRIDGE PRODUCTS and SUPPORT STRUCTURES

504.57 Ancillary Bridge Products Ancillary bridge products are defined in Section 713.01. The fabrication of ancillary bridge products shall be in accordance with the D1.5 Code as applicable to ancillary bridge products and this Specification.

504.58 Support Structures Support structures shall be welded in accordance with the *AWS D1.1 Structural Welding Code* (the D1.1 Code). Support structures shall include, but not be limited to, pedestrian bridges, high mast poles, sign supports, light and signal poles, dual purpose poles, strain poles, cantilever and butterfly support structures.

504.59 Materials Materials for ancillary bridge products will be specified in the Contract documents. When AASHTO M 270M/M 270 (ASTM A 709/A 709M) steel is specified for ancillary bridge products, equivalent ASTM grades of steel may be substituted. Materials for support structures shall be as specified in the Contract documents. CMTRs shall be provided for all steel products.

504.60 Holes for Base Plates Holes in base plates may be drilled or thermal cut at the Contractor's option. If thermal cut, the roughness shall not exceed the allowable tolerances in the D 1.1 Code. Deviation from specified dimension for thermal cut holes shall not exceed 2 mm [$^{1}/_{16}$ in] in any direction.

504.61 Bolted Connections Holes for bolted connections shall meet the requirements of Sections 504.34 and 504.35. High strength bolts shall be installed, tensioned and inspected in accordance with Sections 504.50 through 504.54.

504.62 Anchor Bolts Anchor bolts shall be as shown on the Plans, Standard Details or Specifications.

504.63 Support Structures Weld Procedure Specifications, welders and welding operators shall be qualified in accordance with the D1.1 Code.

Circumferential shop splices for poles shall be full penetration, butt welds. Welded longitudinal seams shall have 100 percent penetration for 150 mm [6 in] on either side of a shop splice, and for the splice length plus 150 mm [6 in] at the field splice end(s) of a shaft section. The remainder of the seam weld shall have a minimum effective weld throat of 60 percent of the wall thickness. Pole to base welds may be complete joint penetration welds or socket-type joints with two fillet welds. When complete joint penetration welds are used, the backing bar shall be removed after welding.

Before erection, the assembled shaft or structure shall not exhibit a sweep in excess of 0.2 percent of the nominal pole height or length, as measured with the pole or structure in a horizontal position.

Shafts or structures that do not conform to the sweep requirements shall be corrected with a method approved by the Fabrication Engineer.

504.64 Non Destructive Testing-Ancillary Bridge Products and Support Structures Unless otherwise specified, nondestructive testing shall be as follows:

1. Twenty five percent of each production lot shall be examined using Magnetic Particle (MT) inspection. The operator shall be qualified in accordance with the AWS D 1.1 Structural Welding Code. If any welds examined require a welded repair, an additional twenty five percent of the original lot number will be examined using MT. If any welds in the second twenty five percent require a welded repair, all welds in that production lot shall be tested using MT.

2. For the purposes of this Specification, a production lot shall be defined as a day's production of small parts (e.g. post to base welds), each discrete segment of complex structures (e.g. overhead sign supports, mast arm poles, etc.) or other grouping or unit not to exceed one week's production.

3. One hundred percent of all circumferential welds and the full penetration sections of the longitudinal seam welds shall be inspected by radiographic examination (RT). Ten percent of the partial penetration sections of the longitudinal seam welds shall be inspected by the magnetic particle method (MT). Ultrasonic testing may be used on material over 8

mm [5/16 in] thick with the approval of the Fabrication Engineer. Fillet and partial penetration welds connecting the upright to the horizontal members of cantilever or butterfly type sign support structures shall be one hundred percent tested by the magnetic particle method (MT).

4. Nondestructive testing shall be performed in the presence of the Fabrication Engineer.

504.65 Basis of Payment Structural steel will be paid for at the contract lump sum price for the respective contract items.

Payment will be made under:

	Pay Item	Pay Unit
504.70	Structural steel fabricated and delivered,	Lump Sum
504.701	Structural steel fabricated and delivered, rolled	Lump Sum
504.702	Structural steel fabricated and delivered, welded	Lump Sum
504.71	Structural steel erection	Lump Sum

SECTION 505 - STUD WELDED SHEAR CONNECTORS, ANCHORS, & FASTENERS

505.01 Description This work consists of furnishing and installing steel stud welded shear connectors, concrete anchors threaded fasteners in accordance with the ANSI/AASHTO/AWS D1.5 Bridge Welding Code (D1.5) and these Specifications.

505.02 Materials Materials shall meet the requirements of Section 711.06 - Stud Welded Shear Connectors, Anchors, and Fasteners. The Contractor shall provide the stud manufacturer’s certification that the studs meet the material requirements prior to beginning welding.

505.03 Quality of Work The studs shall be free from rust, scale, oil, and other contaminants that would adversely affect the welding operation.

Weld locations shall be free of scale, rust, oil and other deleterious material. The Contractor may clean the weld locations by any method that results in satisfactory welds.