SECTION 1105—FABRICATED STRUCTURAL STEEL

1105.01 GENERAL REQUIREMENTS—

(a) Prequalification. Structural steel fabricators performing work for the Department are required to prequalify according to the AISC Quality Certification Program and obtain approval from the Structural Materials Engineer. Plants and shops must be registered and certified under the AISC program with Simple Steel Bridge Structures or Major Steel Bridges certification and must submit a valid certificate to the Structural Materials Engineer, MTD, 1118 State Street, Harrisburg, Pennsylvania 17120. Annual submission of an endorsed copy of the certificate is required for continued prequalification. New fabricators or certified fabricators wishing to upgrade certification are required to furnish references for which the fabricator has successfully completed fabrication of similar members. If unable to furnish references, the fabricator must satisfactorily produce a sample member before receiving Department approval and listing in Bulletin 15.

Only fabricators having Major Steel Bridges with Certified Fracture Critical certification may fabricate the following:

Fracture critical members and attachments.

Only fabricators having Major Steel Bridges certification may fabricate the following:

Main members, except for rolled beams
Welded floorbeams
Cross frames and diaphragms for curved bridges
Bracing, portals, and stiffening members for arches, trusses, cable-stayed and suspension bridges
Rolled beams with butt welds, or that are heat-curved or heat-cambered.

Fabricators having Major Steel Bridges or Simple Steel Bridge Structures certification may fabricate the following:

Expansion dams
Bridge drainage material
Welded bearings
Rolled beams with bearing stiffeners and diaphragm connection or cover plates
Cross frames and diaphragms for straight bridges*
Inspection walks
Steel grid flooring
Shop-fabricated material for reinforcing existing bridges*
Sign structures
Lateral bracing except for arches, trusses, cable-stayed and suspension bridges*
Lighting poles and anchor bases
Welded sound barrier support
Railings

* Fabricate in a Major Steel Bridges certified shop if welding is required.

AISC certification is not required for the following:

Castings, forgings, and machined parts not welded
Non-metallic bearings
Protective barriers
Protective fence
Material not requiring shop fabrication or shop welding, such as plates and shapes for strengthening existing bridges and manufactured items accepted by certification.

(b) Standard Reference. Section 105.04

(c) Shop Drawings. Section 105.02 and as follows:

Bridge members are generally designed in lengths, depths, and widths that can be transported from the fabrication source to the project. Field splices, if required, are indicated. Do not add or eliminate field splices on the shop drawings for shipping purposes unless approved by the District Executive in writing. If the addition or elimination of field splices is approved, provide a sketch. If required by the District Executive, submit design computations prepared by a Professional Engineer registered in the State according to the Design Manual, Part 4, Structures. The District Executive will not review requests for elimination of field splices unless a notice is included from the TEOD that a hauling permit can be obtained to ship beams exceeding the dimensions shown on the structure drawings.

(d) Erection Drawings. Section 1050.3(c)2.d

(e) Inspection.

1. General. The MTD will supervise shop inspection. Notify the MTD a minimum of 48 hours before the beginning of work so that arrangements can be made for inspection.

The Representative may waive shop inspection and make a complete inspection at a later stage in the construction sequence. Furnish certified mill reports, in duplicate, covering the structural steel used.

2. Facilities for Inspection. Furnish necessary facilities for the inspection of material and workmanship. Furnish an Inspector's Field Office, Type C, as specified in Section 714.5(a), except provide a four-drawer, fire-resistant (D-label) metal file cabinet in place of a two-drawer, fire-resistant (D-label) metal file cabinet. Allow inspectors employed by the Department unrestricted access to work in process and stored material during plant working hours.

3. Plant Inspector's Authority. Plant Inspectors have the authority to reject any material or work not conforming to the requirements of these Specifications. In case of dispute, the Contractor may appeal to the Representative, whose decision will be final.

4. Rejections. Material, workmanship, or finished members accepted by the inspector at the shop may be rejected later if they do not conform to the specifications. Repair or replace rejected material or members.

5. Testing. If directed, furnish test specimens of material, as well as equipment, tools, and labor necessary to prepare the specimens and to make the tests.

6. Mill Orders and Shipping Statements. Furnish copies of mill orders and shipping statements as directed. Show the mass (weights) of the individual members on the statement. Ensure that the fabricator submits a copy of the shipping invoice to the Department's Shop Inspector to be stamped for verification of inspection and acceptance of steel items before shipment. Forward the stamped copy of the shipping invoice with the shipment for the project file. The Shop Inspector will review and accept mill certifications and return them to the fabricator.

(f) Storage of Materials. Section 106.05 and as follows:

Place materials stored aboveground on platforms, skids, or other supports. Place and support materials to avoid overstress, deformation, or damage. Exercise special care for curved members. Keep materials free from dirt, grease, and other foreign materials. Ensure proper drainage and protect materials from corrosion.

(g) QC.

1. General. Establish and maintain a level of QC based on uniform fabrication practices. Do not initiate fabrication without an approved QC process.

2. QC Plan. Shops seeking prequalification must submit a QC Plan to the Chief Structural Materials Engineer, MTD, for review and approval. Develop the plan in accordance with the criteria established in AASHTO-NSBA Steel Bridge Collaboration document S4. 1-2002 "Steel Bridge Fabrication QC/QA Guide Specification" (refer to Publication 135 for an outline of the QC plan criteria). Facilities performing welding that requires non-destructive testing must submit their written practice according to the current version of ASNT- SNT-TC-1A. Pre-qualified shops must submit an updated QC Plan to the Chief Structural Materials Engineer, MTD, if there are any changes in materials, processes, or personnel.

3. QC Personnel. Assign sufficient qualified personnel with structural steel fabrication experience to be

responsible for QC during the fabrication process, storage, and shipment. Do not proceed with fabrication until qualified QC personnel are present and approved by the Department. Provide an AWS Certified Welding Inspector (CWI) on site as the Fabricator's designated QC Representative to oversee all processes of fabrication that involve welding, heat cambering, or straightening of material.

1105.02 MATERIAL—

(a) Structural Steel.

1. General. AASHTO M 160/M 160M (ASTM A 6/A 6M)

2. Carbon Steel. AASHTO M 270/M 270M (ASTM A 709/A 709M), Grade 250 (Grade 36), ASTM A 36.

2.a Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes. ASTM A 500, Grade C.

2.b Hot-Formed Welded and Seamless Carbon Steel Structural Tubing. ASTM A 501

3. High-Strength Low-Alloy Structural Steel for Welding.

3.a High-Strength Low-Alloy, Quenched and Tempered Structural Steel Plate. AASHTO M 270/M 270M (ASTM A 709/A 709M), Grade HPS 485W (Grade HPS 70W).

3.b High-Strength Low-Alloy TMCP Structural Steel Plate. AASHTO M 270/M 270M (ASTM A 709/A 709M), Grade HPS 485W (Grade HPS 70W), up to 50.8 mm (2 inches) thick.

3.c High-Strength Low-Alloy Structural Steel. AASHTO M 270/M 270M (ASTM A 709/A 709M), Grades 345 or 345W (Grades 50 or 50W), ASTM A 572, Grade 345 (Grade 50), of a quality suitable for welding.

3.d High-Strength Low-Alloy Columbium-Vanadium Steel of Structural Quality. AASHTO M 270/M 270M (ASTM 709/A 709M), Grade 345 (Grade 50), ASTM A 572, Grade 345 (Grade 50).

3.e High-Strength Low-Alloy Structural Steel with 345 MPa (50,000 pounds per square inch) Minimum Yield Point to 100 mm (4 inches) Thick. AASHTO M 270/M 270M (ASTM A 709/A 709M), Grade 345W (Grade 50W), ASTM A 588 (Grades A, B, and C only – see Note 1).

Note 1: Plate thicknesses greater than 100 mm (4 inches) are required to conform to the physical properties listed in the specification for plate thicknesses 100 mm (4 inches) and under.

3.f High-Yield Strength, Quenched and Tempered Alloy Steel Plate.

3.f.1 High-Yield Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding. AASHTO M 270/M 270M (ASTM A 709/A 709M), Grades 690 or 690W (Grades 100 or 100W).

3.f.2 High-Strength Alloy Steel Plates, Quenched and Tempered, for Pressure Vessels. ASTM A 517/A 517M. Conforming to the supplementary notch toughness requirements of AASHTO M 244/M 244M.

3.f.3 Quenched and Tempered Alloy Steel Structural Shapes and Seamless Mechanical Tubing. Products conforming to all of the mechanical and chemical requirements of ASTM A 709/A 709M, Grades 690 or 690W (Grades 100 or 100W) steel, except with a maximum tensile strength of 965 MPa (140,000 pounds per square inch) for structural shapes and 1000 MPa (145,000 pounds per square inch) for seamless mechanical tubing, are to be considered as ASTM A 709/A 709M.

4. Supplemental Requirements for Notch Toughness. Provide structural steel conforming to the supplementary notch toughness requirements for the longitudinal Charpy V-notch tests specified for Zone 2 in Table S1 of the applicable AASHTO Materials Specifications. Unless otherwise indicated, the supplemental requirements are mandatory for the following load-carrying member components subject to tensile stress:

- Rolled shapes
- Webs
- Tension flanges of built-up beams
- Beam splice material
- Truss members and gusset plates attached to such truss members.
- Diaphragms, X-frames, bracing, and connecting plates for curved girder bridges or straight girder bridges if the skew is less than 70 degrees.

The requirements are not mandatory for:

- Stiffeners
- Drainage material
- Expansion dams
- Bearings
- Other secondary material
- Diaphragms, X-frames, bracing, and connecting plates for straight girder bridges if the skew is 70 degrees or greater, or unless otherwise indicated as requiring notch toughness.

If directed at a prefabrication meeting, provide samples for Charpy V-Notch testing from steel used in fabricating fracture-critical plates and shapes. Submit the samples to the Structural Materials Engineer, MTD, 1118 State Street, Harrisburg, PA 17120. Obtain the samples from plates delivered to the fabricator.

(b) Bedding Material for Bridge Shoes. Section 1113.03(h)

(c) Bolts, Nuts, and Washers. From a manufacturer listed in Bulletin 15 and as follows, unless otherwise indicated or specified:

1. Bolts for General Application.

- ASTM F 568, Class 4.6
- ASTM A 307, Grade A

1.a Nuts.

- ASTM A 563M, Hex Nut, Style 1
  - M16 to M36, Class 5
- ASTM A 563M, Heavy Hex
  - M42 to M100, Class 5

- ASTM A 536M, Heavy Hex
  - All Diameters, Class A

1.b Washers. ANSI B18.22M

2. Anchor Bolts. AASHTO M 270/M 270M (ASTM A 709/A 709M), Grade 250 (Grade 36), anchor bolts (headed or nonheaded, either straight or bent) and cap screws, hot-dip or mechanically galvanize as specified in Section 1105.02(s).

2.a Nuts. ASTM A 563/A 563M

2.b Washers. ASTM F 436/F 436M

3. Anchor Bolts. ASTM F 1554, Grades 36, 55, 105, anchor bolts (headed or non-headed, either straight or bent) and cap screws (fully threaded shank), hot-dip or mechanically galvanize as specified in Section 1105.02(s).

3.a Nuts. ASTM A 563/A 563M

3.b Washers. ASTM F 436/F 436M

(d) High-Strength Bolts. Use bolts, nuts, and washers mechanically galvanized as specified in Section 1105.02(s), unless otherwise indicated or specified. For AASHTO M 270/M 270M (ASTM A 709/A 709M), Grade 345W (Grade 50W) steel, unpainted, use bolts, nuts, and washers conforming to atmospheric corrosion resistance requirements of AASHTO M 270/M 270M (ASTM A 709/A 709M), Grade 345W (Grade 50W). Use mechanically galvanized bolts, nuts, and washers on painted portions of weathering steel structures.

Provide high-strength, carbon steel bolts; suitable nuts; and plain hardened washers for structural joints from a manufacturer listed in Bulletin 15, and, unless otherwise indicated or specified, conforming to the following requirements:

1. Identifying Marks. Identify bolts manufactured to AASHTO M 164 (ASTM A 325) and nuts manufactured to specifications referenced in AASHTO M 164 (ASTM A 325) by specific markings on the top of the bolt head and on the face of the nut. Identify the bolt strength grade by the symbol "A325," the bolt manufacturer, and the bolt type using head markings. Identify the nut strength grade, the nut manufacturer, and, if Type 3, the nut type using nut markings.

Identify bolts manufactured to AASHTO M 253/M 253M (ASTM A 490/A 490M) and nuts manufactured to specifications referenced in AASHTO M 253/M 253M (ASTM A 490/A 490M) by specific markings on the top of the bolt head and on the face of the nut. Identify the bolt strength grade by the symbol "A490M" ("A490"), the bolt manufacturer, and the bolt type. Identify the nut strength grade, the nut manufacturer, and, if Type 3, the nut type using nut markings.

Identify washer manufacturer and, if Type 3, the washer type using washer markings.

2. Dimensions. Ensure bolt and nut dimensions conform to the requirements for Metric Heavy Hex Structural Bolts (Heavy Hex Structural Bolts) and for Hex Nuts, Heavy, Metric (Hex Nuts, Heavy) given in ANSI Standards B18.2.1 and B18.2.2, respectively.

3. Bolts. AASHTO M 164 (ASTM A 325), except as amended and revised below:

Provide a lot number on the supplier's certification corresponding to that appearing on the shipping package and certification Form CS-4171. Note on the supplier's certification when and where all testing was done, including the rotational capacity tests specified. If galvanized bolts are used, include zinc thickness on the supplier's certification.

Furnish bolts with diameters of 12.7 mm to 25.4 mm (1/2 inch to 1 inch) inclusive, and a hardness of 24 to 33 HRC. Provide black bolts "oily" to the touch when installed.

4. Nuts. AASHTO M 292/M 292M (ASTM A 194/A 194M) or AASHTO M 291 (ASTM A 563), as applicable.

Provide galvanized, heat-treated nuts, Grade 2H, DH, or DH3, and mechanically galvanized nuts as specified in Section 1105.02(s) (AASHTO M 232 or AASHTO M 298).

Provide plain (ungalvanized) nuts, which are Grade 2, C, D, or C3, having a Rockwell Hardness of 89 HRB; or heat-treated, Grade 2H, DH, or DH3.

Lubricate all galvanized nuts. Use a lubricant containing a dye of any color that contrasts with the color of the galvanizing so that a visual check can be made for the lubricant at the time of field installation.

Furnish nuts to be galvanized that are tapped oversize the minimum amount required to allow assembly on the bolt thread in the coated condition. Ensure nuts conform to the requirements of AASHTO M 291 (ASTM A 563) and the rotational capacity test specified.

5. Washers. AASHTO M 293 (ASTM F 436/F 436M), unless otherwise indicated. When indicated, galvanize as specified in Section 1105.02(s) (AASHTO M 232 or AASHTO M 298).

6. Direct Tension Indicator (DTI) Devices. ASTM F 959 and as follows:

Provide Direct Tension Indicator (DTI) devices having a hardness of 38 to 45 HRC. Furnish plain DTI devices for use with plain bolts, and, if galvanized bolts are indicated or specified, provide galvanized DTI devices. Galvanize as specified in Section 1105.02(s) (ASTM B 695).

In addition to the bolt tension tests specified in ASTM F 959, test plain finish DTI devices a second time by applying the compression load until the average gap measures 125 µm (0.005 inch). Ensure that the loading remains within the acceptable range according to Table 3 of ASTM F 959 for the applicable type.

Ship each lot in protective containers marked with the type, lot number, quantity, and total lot size. Include a copy of the certification with each shipment.

Handle and store DTI devices according to the manufacturer's recommendations.

Obtain a minimum of eight samples from each lot according to PTM No. 1 for testing at the MTD. Obtain approval before using DTIs.

7. Testing. Test bolts, nuts, washers, and assemblies as follows:

7.a Bolts. Perform proof load tests according to ASTM F 606/F 606M, Method 1, at the minimum frequency specified in AASHTO M 164 (ASTM A 325), Section 9.2.4.

Perform wedge tests on full size bolts according to ASTM F 606/F 606M, Section 3.5. If bolts are to be galvanized, perform testing after galvanizing. Use the minimum testing frequency specified in AASHTO M 164 (ASTM A 325), Section 9.2.4.

If galvanized bolts are supplied, determine the thickness of zinc coating by taking measurements on the wrench flats or top of bolt head.

7.b Nuts. Perform proof load tests according to ASTM F 606/F 606M, Section 4.2, at the minimum frequency specified in AASHTO M 291 (ASTM A 563), Section 9.3, or AASHTO M 292/M 292M (ASTM A 194/A 194M), Section 7.1.2.1. If nuts are to be galvanized, perform testing after galvanizing, overtapping, and lubricating.

If galvanized nuts are supplied, determine the thickness of zinc coating by taking measurements on the wrench flats.

7.c Washers. If galvanized washers are supplied, perform hardness testing after galvanizing. Remove the galvanized coating before taking hardness measurements.

If galvanized washers are supplied, measure the thickness of zinc coating.

7.d Assemblies. Perform rotational-capacity tests on all black or galvanized bolt, nut, and washer assemblies before shipping. Test galvanized assemblies after galvanizing. Washers are required as part of the test, even if not required as part of the installation procedure. Perform the rotational-capacity test according to AASHTO M 164 (ASTM A 325), except as modified below:

- For long bolts or bolts too short to fit the tension calibrator, test according to PTM No. 427.
- Test each bolt production lot, nut lot, and washer lot in combination as an assembly. If washers are not required as part of the installation procedure, do not include in the lot identification.
- Assign a rotational-capacity lot number to each combination of lots tested.

- Test a minimum of two assemblies per rotational-capacity lot
- Test the bolt, nut, and washer assembly in a Skidmore-Wilhelm Calibrator or an equivalent approved device.

8. Documentation. Report the results of all tests (including zinc coating thickness) on the appropriate test report as required in the applicable AASHTO or ASTM standards and as specified below. Report the location where tests were performed and date of testing. Ensure that the manufacturer or distributor performing tests certifies that the results recorded are accurate.

8.a Mill Test Report (MTR). Furnish a MTR for all mill steel used in manufacturing bolts, nuts, and washers. Indicate where the material was melted and manufactured.

8.b Manufacturer Certified Test Report (MCTR). Provide a MCTR for each item furnished. Ensure that the manufacturer performing the rotational-capacity test include the following on the MCTR:

- The Lot Number of each of the items tested.
- The Rotational-Capacity Lot Number.
- The results of required tests.
- The location where tests were performed and date of testing.
- Certification that the MCTR's for the items conform to this specification and the applicable AASHTO or ASTM standards.
- The location where the bolt, nut, and washer assembly components were manufactured.

8.c Distributor Certified Test Report (DCTR). Ensure that the distributor performing tests furnish a certified test report including the following:

- The MCTR for the various bolt, nut, and washer assembly components.
- The results of all required tests, including the rotational-capacity test if performed by the distributor instead of the manufacturer.
- The location where tests were performed and date of testing.
- The Rotational-Capacity Lot Number.
- Certification that the MCTR's conform to this specification and the applicable AASHTO or ASTM standards.

(e) Welded Stud Shear Connectors.

1. Materials. Provide shear connector studs conforming to AASHTO M 169 (ASTM A 108), cold drawn bars, Grade 1015, 1018, or 1020, either semi-or fully-killed. If flux retaining caps are used, furnish caps of low carbon grade steel suitable for welding and conforming to ASTM A 109/A 109M.

2. Testing. Determine tensile properties of either bar stock after drawing or of finished studs according to the applicable sections of ASTM A 370. Perform tensile tests of finished studs on studs welded to test plates using a test fixture similar to that shown in Figure 7.2 of ANSI/AASHTO/AWS Bridge Welding Code D1.5-2002. If fracture occurs outside of the middle half of the gage length, repeat the test.

The required tensile properties are:

Tensile Strength	415 MPa (60,000 psi) (min.)
Yield Strength*	345 MPa (50,000 psi) (min.)
Elongation	20% in 50 mm (2 inches) (min.)
Reduction of area	50% (min.)

* As determined by a 0.2% offset method.

3. Finish. Provide finished studs of uniform quality and condition, free from injurious laps, fins, seams, cracks, twists, bends, or other injurious defects. Produce finish by cold drawing, cold rolling, or machining.

4. Certification. Provide the manufacturer's certification that the studs, as delivered, conform to the material requirements of this section. Furnish certified copies of in-plant QC test reports to the Representative upon request.

5. Check Samples. If required, provide check samples of studs of each type and size used under the contract. The Representative will select the samples.

(f) Steel Forgings and Steel Shafting.

1. Steel Forgings. Furnish steel forgings conforming to AASHTO M 102 (ASTM A 668/A 668M), Classes C, D, F, or G.

2. Cold-Finished Carbon Steel Shafting. Furnish cold-finished carbon steel shafting conforming to AASHTO M 169 (ASTM A 108), UNS Designations G10160-G10300, inclusive, unless otherwise indicated or specified.

(g) Steel Castings.

1. Mild Steel Castings. Furnish steel castings for use in highway bridge components conforming to AASHTO M 103/M 103M (ASTM A 27/A 27M). Provide steel of Class 485 (Class 70) or Grades 485-250 (Grades 70-36), respectively, unless otherwise indicated or specified.

2. Chromium-Alloy Steel Castings. Furnish chromium, alloy-steel castings conforming to AASHTO M 163/M 163M (ASTM A 743/A 743M), Grade CA-15, unless otherwise indicated or specified.

3. Workmanship and Finish. Furnish castings true to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blow-holes, and other defects in positions affecting the castings' strength and value for the service intended. Provide boldly filleted angles and sharp and perfect arrises.

The Contractor may correct defects not affecting the strength and value of the casting for the service intended if allowed in writing by the Chief Bridge Engineer. The Representative may reject castings containing:

- A blow-hole having a length greater than 25 mm (1 inch), a cross-sectional area greater than 320 mm^2 (1/2 square inch), or a depth greater than 13 mm (1/2 inch).

- A group of holes in a straight line with a total length greater than or equal to 300 mm (1 foot), measured on the surface of the casting, and with an aggregate length greater than 25 mm (1 inch).

4. Testing.

4.a Major Castings. Major castings are those subject to high loading whose failure in service would cause major damage (e.g., bridge bearings or machinery parts in movable bridges). All castings over 450 kg (1,000 pounds) are major castings. Test major castings by radiographing with x-ray or gamma ray apparatus according to ASTM E 186, E 280 or E 446, as applicable, and according to Table A below.

4.b Minor Castings. Minor castings are those whose failure would not lead to failure of main bridge members (e.g., scuppers or gratings). Test minor castings by suspending them and hammering them all over.

4.c Rejection. The Representative may reject castings that contain cracks, flaws, or other defects that appear during or after testing.

(h) Iron Castings.

1. Gray Iron Castings. Furnish gray iron castings conforming to AASHTO M 105 (ASTM A 48), Class No. 207, unless otherwise indicated or specified.

2. Malleable Iron Castings. Furnish malleable iron castings conforming to ASTM A 47/A 47M, Grade 24018, unless otherwise indicated or specified.

3. Ductile Iron Castings. Furnish ductile iron castings conforming to ASTM A 536, Grade 60-40-18, unless otherwise indicated or specified. In addition to the specified test coupons, test specimens from parts integral with the castings, such as risers, for castings having a mass (weight) more than 450 kg (1,000 pounds). Ensure that the required quality is obtained in the castings in the finished condition.

TABLE A
Severity Levels - Radiographically Inspected Castings*

Specification ASTM Designation	Discontinuity Type Designation	Acceptable** Severity Level	Remarks
E 466 up to 50 mm (2 inches)	A	3	
	B	3	
	C-1	3	
	C-2	3	
	C-3	3	
	C-4	3	
	D	-	None Allowed
	E	-	None Allowed
	F	-	None Allowed
	G	-	None Allowed
E 186 50 mm (2 inches) to 115 mm (4 ½ inches)	A	3	
	B	3	
	C-1	2	
	C-2	3	
	C-3	3	
	D	-	None Allowed
	E	-	None Allowed
	F	-	None Allowed
E 280 115 mm (4 1/2 inches) to 300 mm (12 inches)	A	3	
	B	3	
	C-1	2	
	C-2	3	
	C-3	3	
	D	-	None Allowed
	E	-	None Allowed
	F	-	None Allowed

* Radiograph all critical areas, but not less than 25% of each casting, or 25% of all castings, as indicated or as directed.

** If unacceptable defects are found in more than 10% of the radiographs, radiograph 100% of castings until the accumulated rejection level falls to 10% or less. The Contractor may then resume testing 25% of castings.

4. Workmanship and Finish. Furnish iron castings true to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blow holes, and other defects in positions affecting the castings' strength and value for the service intended. Provide boldly filleted angles and sharp and perfect arises.

5. Cleaning. Remove scale and sand from all castings to provide a smooth, clean, and uniform surface.

(i) Bronze Bearing and Expansion Plates. AASHTO M 107 (ASTM B 22), Alloy No. C91100 or C91300, except with a maximum of 2 1/2% lead, unless otherwise indicated or specified.

If indicated, make surfaces permanently self-lubricated. Provide a coefficient of friction of less than 0.10 or as indicated.

(j) Steel Pipe.

1. Pipe and Couplings. ASTM A 53

2. Flanges and Pipe Fittings. ASTM A 338

3. Welded Fittings. ASTM A 234/A 234M

4. Threaded Parts. Apply one coat of primer to all threads immediately before assembly. Wipe clean after assembly.

(k) Low-Alloy Steel Pipe.

1. Pipe and Couplings. Manufactured from low-alloy steel AASHTO M 270/M 270M (ASTM A 709/A 709M), Grade 345 or 345W (Grade 50 or 50W), Type 2 or AASHTO M 270/M 270M (ASTM A 709/A 709M) Grade 345W (Grade 50W), and conforming to either ASTM A 53, or to ASTM A 714, Class 4, Grade V.

2. Flanges and Pipe Fittings. ASTM A 338

3. Welding Fittings. ASTM A 234/A 234M

4. Threaded Parts. Apply one coat of primer to all threads immediately before assembly. Wipe clean after assembly.

(m) Steel Tubing. ASTM A 500 or ASTM A 501

(n) Cast Iron Pipe. ASTM A 74 or ASTM A 377

(p) Sheet Copper. AASHTO M 138/M 183M (ASTM B 152/B 152M), and conforming to the requirements of the Embrittlement Test, Section 12 of AASHTO M 138/M 138M (ASTM B 152/B 152M) and ASTM B 577.
Make lapped joints by soldering or by riveting and soldering.

(q) Sheet Zinc. ASTM B 69, Type II.
Make lapped joints by soldering.

(r) Sheet Lead. Common desilverized lead A, as specified for pig lead, ASTM B 29.

(s) Galvanizing. From a galvanizer listed in Bulletin 15 and as follows:

1. General. If indicated or specified, galvanize materials as specified in the applicable material specifications. If the applicable material specifications do not include galvanizing, galvanize according to ASTM A 53; ASTM B 633; ASTM A 392, Class 2 coating; ASTM B 695 and B 696 (AASHTO M 298 and M 299); ASTM A 123 (AASHTO M 111); or ASTM A 153 (AASHTO M 232), as applicable.
Test for the specified mass (weight) of galvanizing according to ASTM A 90/A 90M (AASHTO T 65).
Comply with ASTM A 143 and ASTM A 385.

2. Repair of Damaged Galvanizing. After erecting galvanized material in place, clean damaged areas and apply two coats of zinc dust—zinc oxide paint, or other acceptable material.

3. Quenching after Galvanizing. Quenching after galvanizing is allowed for the following items:

Non-welded secondary bridge members
Railings
Drainage Scuppers
Downspouts
Inlet grates
Utility brackets
Angle Supports
Embedded plates

Quenching after galvanizing is not allowed for the following items without approval of the Engineer:

Primary bridge members

Welded secondary members
Sign Structures
Traffic and lighting poles
Any member to be painted after galvanizing

Items not listed may not be quenched without approval of the Engineer.

(t) Welding Material. ANSI/AASHTO/AWS D1.5-2002 Bridge Welding Code, modified as specified in Section 1105.03(m)1.

(u) Paint. Section 1060.2

(v) Certification. Section 106.03(b)3

(w) Eyebars. Furnish a weldable grade of steel for eyebars. Acceptable grades include:

- Structural steel for bridges, AASHTO M 270/M 270M (ASTM A 709/A 709M), Grade 250 (Grade 36), ASTM A 36.
- Structural steel for bridges, AASHTO M 270/M 270M (ASTM A 709/A 709M), Grades 345 and 345W (Grades 50 and 50W), ASTM A 572, Grade 345 (Grade 50), ASTM A 588, Grades A, B, and C only.

1105.03 FABRICATION—

(a) Straightening Material and Curving Rolled Beams and Welded Girders. Section 1050.03(c)5 and as follows:

1. Materials. Do not heat straighten or heat curve steels that are manufactured to a specified minimum yield point greater than 345 MPa (50,000 pounds per square inch) without approval.

2. Type of Heating. Curve beams and girders by either continuous or V-type heating, as approved.

2.a Continuous Heating. For the continuous method, heat a strip or intermittent strips along the edge of the top and bottom flange approximately simultaneously depending on flange widths and thicknesses. Use a strip of sufficient width and temperature to obtain the required curvature.

2.b V-type Heating. For the V-type heating, heat the top and bottom flanges in truncated triangular or wedge-shaped areas having their base along the flange edge and spaced at regular intervals along each flange. Use the spacing and temperature necessary to obtain the required curvature and to allow heating to progress along the top and bottom at approximately the same rate. Terminate the apex of the truncated triangular area applied to the inside flange surface just before the junction of the web and the flange is reached. When heating the inside flange surface (the surfaces that intersect the web), do not apply heat directly to the web. If the radius of curvature is 300 000 mm (1,000 feet) or more, extend the apex of the truncated triangular heating pattern applied to the outside flange surface to the juncture of the flange and web. If the radius of curvature is less than 300 000 mm (1,000 feet), extend the apex of the truncated triangular heating pattern applied to the outside flange surface past the web for a distance equal to one-eighth of the flange or 75 mm (3 inches), whichever is less. For the truncated triangular pattern, provide an included angle of approximately 15 to 30 degrees, but do not exceed 250 mm (10 inches) for the base of the triangle. Do not make variations in the patterns prescribed above unless permitted.

For both types of heating, heat the flange edges that will be on the inside of the horizontal curve after cooling. Heat both the inside and outside flange surfaces only if the flange thickness is 32 mm (1 1/4 inches) or greater. Heat the two surfaces concurrently.

3. Temperature. Conduct the heat-curving operation in such a manner that the steel temperature does not exceed 620 °C (1,150F) as measured by temperature indicating crayons or other suitable means. Do not artificially cool the girder until after it naturally cools to 315 °C (600F). Obtain approval for the method of artificial cooling.

4. Position for Heating. Heat-curve the girder with the web in either a vertical or a horizontal position.

If curved in the vertical position, brace or support the girder in such a manner that the tendency of the girder to deflect laterally during the heat-curving process will not cause the girder to overturn.

If curved in the horizontal position, support the girder near its ends and at intermediate points, as necessary, to obtain a uniform curvature. Do not allow the bending stress in the flanges due to the dead weight of the girder to exceed the usual allowable design stress. Maintain intermediate safety catch blocks at the mid-length of the girder within 50 mm (2 inches) of the flanges at all times during the heating process to guard against a sudden sag due to plastic flange buckling.

5. Sequence of Operations. Heat-curve the girder in the fabrication shop before it is painted. Conduct the heat curving operation either before or after all the required welding of transverse intermediate stiffeners is completed. However, unless provisions are made for girder shrinkage, locate and attach connection plates and bearing stiffeners after heat curving. If longitudinal stiffeners are required, heat-curve or oxygen-cut them separately and then weld them to the curved girder. When cover plates are to be attached to rolled beams, attach them before heat curving if the total thickness of one flange and cover plate is less than 65 mm (2 1/2 inches) and the radius of curvature is greater than 300 000 mm (1,000 feet). For other rolled beams with cover plates, heat-curve the beams before the cover plates are attached; either heat-curve or oxygen-cut cover plates separately, then weld them to the curved beam.

6. Camber. Camber girders before heat curving. Obtain camber for rolled beams using approved heat-cambering methods. For plate girders, cut the web to the prescribed camber with suitable allowance for shrinkage due to cutting, welding, and heat-curving. However, if permitted, correct moderate deviations from specified camber by a carefully supervised application of heat. Correct deviations from the specified camber according to Publication 135.

7. Measurement of Curvature and Camber. Measure horizontal curvature and vertical camber after all welding and heating operations are completed and the flanges have cooled to a uniform temperature. Check horizontal curvature with the girder in the vertical position.

(b) Finish. Finish exposed work. Shear, flame cut, and chip carefully and accurately. Make sharp corners and round edges by grinding or other acceptable means.

When AASHTO M 270/M 270M (ASTM A 709/A 709M), Grade 345W (Grade 50W), ASTM A 588, Grades A, B, and C only steel is specified for beams or girders, blast clean only the fascia side of exterior beams or girders in the field according to SSPC-SP6-85, Commercial Blast Cleaning. Blast clean from the top outside (fascia) edge of the top flange to the inside edge of the bottom flange including the bottom of the bottom flange. Blast clean the faying surfaces of splices and connections of all structural elements according to SSPC-SP-1085. Reblast unpainted elements that remain unassembled for a period of 12 months following the initial cleaning.

(c) Bolt Holes.

1. General. Either punch or drill all holes for bolts.

Unless subpunching and reaming are specified in Section 1105.03(d), punch material forming parts of a member composed of not more than five thicknesses of metal 2 mm (1/16 inch) larger than the nominal diameter of the bolts whenever the thickness of the material is not greater than 20 mm (3/4 inch) for structural steel, 16 mm (5/8 inch) for high-strength steel or 12 mm (1/2 inch) for quenched and tempered alloy steel. If there are more than five thicknesses or if any of the main material is thicker than 20 mm (3/4 inch) for structural steel, 16 mm (5/8 inch) for high-strength steel, or 12 mm (1/2 inch) for quenched and tempered alloy steel, either subdrill and ream or drill all holes full size.

When specified, either subpunch (or subdrill if thickness limitation governs) all holes 5 mm (3/16 inch) smaller than the nominal diameter of the bolts and, after assembling, ream to 2 mm (1/16 inch) larger than the nominal diameter of the bolts, or drill all holes full size to 2 mm (1/16 inch) larger than the nominal diameter of the bolts.

When indicated, provide enlarged or slotted holes with high-strength bolts.

2. Punched Holes. Furnish dies with diameters that do not exceed the diameter of the corresponding punch by more than 2 mm (1/16 inch). Ream any holes that must be enlarged to admit the bolts. Cut holes clean without torn or ragged edges.

3. Reamed or Drilled Holes. Furnish reamed or drilled holes perpendicular to the member, cylindrical, and conforming to the size requirements specified in Section 1105.03(c)1. Where practical, direct reamers by mechanical means. Remove burrs on the outside surfaces. Use twist drills, twist reamers, or rotobroach cutters for reaming and drilling. Assemble and securely hold connecting parts while they are being reamed or drilled. Match mark the connecting parts before disassembling.

4. Accuracy of Holes. Furnish holes not more than 1 mm (1/32 inch) larger in diameter than the true decimal equivalent of the nominal diameter. The slightly conical hole that results from punching operations is acceptable. Ensure that the width of slotted holes produced by flame cutting or a combination of drilling and flame cutting or punching and flame cutting are not more than 1 mm (1/32 inch) greater than the nominal width. Grind the flame cut surface smooth.

5. Numerically-Controlled Drilled Field Connections. Instead of reaming sub-sized holes or drilling full-sized holes while assembled, the Contractor may use numerically controlled (N/C) drilling or punching equipment to drill or punch full-sized bolt holes in unassembled pieces, connections, and templates for use with matching sub-sized and reamed holes. The Contractor may use N/C equipment to either drill or punch holes through individual pieces or drill through any combination of pieces held tightly together. Full-size punched holes shall meet the requirements of Section 1105.03(c)2.

If N/C drilling or punching equipment is used, demonstrate the accuracy of the drilling or punching procedure by means of check assemblies as specified in Section 1105.03(g).

6. Holes for Turned Bolts or Other Approved Bearing Type Bolts. Subpunch or subdrill all holes 5 mm (3/16 inch) smaller than the nominal diameter of the bolt for turned bolts or other approved bearing-type bolts. After assembling, either ream, drill to a steel template, or drill from the solid. Provide a driving fit for the finished holes as indicated or as specified in the special provisions.

(d) Preparation of Field Connections. Unless otherwise approved, prepare bolt holes for field connections and field splices as follows:

- Field connections and field splices of main members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders, and rigid frames – subpunch or subdrill and subsequently ream while assembled or drill full size through a steel template while assembled.
- Field splices of rolled beam stringers continuous over floor beams or cross frames – the fabricator may drill full size unassembled to a steel template.
- Floor beams or cross frames – the fabricator may drill full size unassembled to a steel template.
- Floor beam and stringer field end connections – subpunch and ream while assembled or drill full size to a steel template while assembled.
- For any connection, instead of subpunching and reaming, or subdrilling and reaming, the fabricator may drill holes full size with all thicknesses of material assembled in proper position.

When using a steel template, ream and drill full size all field connection holes through the template after the template has been placed in the proper position and angle and firmly bolted into place. Use templates that are exact duplicates for reaming matching members or the opposite faces of a single member. Accurately locate templates used for connections on like parts or members so that the parts or members are duplicates and require no match-marking.

(e) Accuracy of Hole Group.

1. Accuracy Before Reaming. Punch full size, subpunch, or subdrill holes such that after assembling, and before any reaming is done, a cylindrical pin 3 mm (1/8 inch) smaller in diameter than the nominal size of the hole may be entered perpendicularly to the face of the member without drifting in at least 75% of the contiguous holes in the same plane. The Representative will reject pieces that do not conform to this requirement. Also, the Representative may reject any piece that contains at least one hole that will not pass a pin 5 mm (3/16 inch) smaller in diameter than the nominal size of the hole.

2. Accuracy After Reaming. After holes are reamed or drilled, ensure that the offset between adjacent thicknesses of metal is no greater than 1 mm (1/32 inch) for at least 85% of the holes in any contiguous group.

For all steel templates, provide hardened steel bushings in holes accurately dimensioned from the centerlines of the connection as inscribed on the template. Use the centerlines to accurately locate the template from the milled or scribed ends of the members.

(f) Bolting. Clean surfaces of metal in contact before assembling. Assemble, pin, and firmly draw together the parts of a member before drilling, reaming, or bolting. If necessary, dismantle assembled pieces to remove burrs and shavings produced by the operation. Furnish members free from twists, bends, and other deformation.

When assembling, allow enough drifting to bring the parts into position, however, do not allow the drifting to enlarge the holes or distort the metal.

(g) Preassembly of Field Connections.

1. General. As necessary, preassemble field connections of main members of trusses, arches, continuous beams, plate girders, bents, towers and rigid frames before erection to verify the geometry of the completed structure or unit and to verify or prepare field splices.

Submit an appropriate method of preassembly for approval. Provide a method and details of assembly consistent with the erection procedure indicated on the approved erection plans and camber diagrams. At a minimum, provide a preassembly procedure consisting of assembling three contiguous panels accurately adjusted for line and camber. Provide a procedure for progressive assemblies consisting of at least one section or panel of the previous assembly (repositioned if necessary and adequately pinned to ensure accurate alignment) plus two or more sections or panels added at the advancing end. For structures longer than 46 000 mm (150 feet), furnish a procedure for assemblies not less than 46 000 mm (150 feet) long regardless of the length of individual continuous panels or sections. The Contractor may start the sequence of assembly from any location in the structure and proceed in one or both directions provided that the preceding requirements are satisfied.

Use the Progressive Truss and Girder Assembly unless otherwise specified in the proposal.

2. Bolted Connections. For bolted connections, prepare holes as specified in Section 1105.03(c). Where applicable, assemble major components of compression members with milled ends in full bearing, and then ream the sub-sized holes to the specified size.

3. Check Assembly-Numerically Controlled Drilling. When using numerically controlled drilling, furnish a check assembly for each major structural type of each project unless otherwise indicated or specified in the special provisions. Provide check assemblies consisting of at least three contiguous shop sections or, for a truss, all members in at least three contiguous panels but not less than the number of panels associated with three contiguous chord lengths (i.e., length between field splices). Base check assemblies on the proposed order of erection, joints in bearings, special complex points, and similar considerations. Special complex points include the portals of skewed trusses.

Use the first sections of each major structural type to be fabricated as the check assemblies.

Obtain approval for each N/C drilled check assembly before reaming or dismantling the assembly. If a check assembly fails to demonstrate that the required accuracy is being obtained for camber, alignment, accuracy of holes, and fit of milled joints, the Representative may require additional check assemblies. Additional check assemblies will be at no additional cost to the Department.

4. Field Welded Connections. Preassemble field welded connections as specified in Section 1105.03(g)1 and verify the fit of members, including the proper space between abutting flanges.

(h) Match-Marking. Match-mark connecting parts preassembled in the shop to ensure proper fit in the field. Furnish a diagram showing match-marks to the Representative.

(i) Connections Using Unfinished or Turned Bolts.

1. General. When unfinished bolts are specified, furnish unfinished or turned bolts conforming to ASTM A 307, Grade A Bolts. Provide bolts with single self-locking nuts or double nuts unless otherwise indicated or specified in the special provisions. Use beveled washers where bearing faces have a slope of more than 1:20 with respect to a plane normal to the bolt axis.

For bolted connections fabricated with high-strength bolts, assemble connections as specified in Section 1105.03(j).

2. Turned Bolts. Provide turned bolts with an ANSI roughness rating value of 125 for the surface of the body of the bolts. Furnish hexagonal heads and nuts with standard dimensions for bolts of the nominal size specified or the next larger nominal size. Provide thread diameters equal to the body of the bolt or the nominal diameter of the bolt specified. Carefully ream holes for turned bolts with bolts furnished to provide for a light driving fit. Furnish bolts with threads that are entirely outside of the holes. Provide a washer under the nut.

(j) Connections Using High Strength Bolts.

1. General. Provide AASHTO M 164 (ASTM A 325) or equivalent high strength bolts . Furnish bolt holes as specified in Section 1105.03(c). When Turn-of-Nut Tightening Method is used, provide hardened washers as specified in Section 1105.02(d)5, under the element turned in tightening.

2. Bolted Parts. Use steel for all material within the grip of the bolt; do not use compressible material such as gaskets or insulation within the grip. Ensure that bolted steel parts solidly fit together after the bolts are tightened. Bolted steel parts may be coated or uncoated. Do not exceed a slope of 1:20 (20:1) for the surfaces of parts in contact with the bolt head or nut with respect to a plane normal to the bolt axis.

3. Surface Conditions. At the time of assembly, ensure that all joint surfaces, including surfaces adjacent to the bolt head and nut, are free of scale (except tight mill scale), dirt, or other foreign material. Remove burrs that would prevent solid seating of the connected parts.

Paint is allowed on the faying surface in connections except for slip-critical connections as defined in Article 6.13.2.1.1 of the LRFD Specification. Prepare faying surfaces for slip-critical connections according to the following requirements, as applicable:

3.a Non-coated Joints. Exclude paint, including any inadvertent over spray, from the area within the bolt pattern and areas closer than one bolt diameter, but not less than 25 mm (1 inch), from the edge of any hole.

3.b Joints with Painted Faying Surfaces. Blast clean joints specified to have painted faying surfaces. Except as specified in Section 1105.03(j)3.c, coat the joints with a Class A or B paint according to Section 6.13.2.8 of the LRFD Specification.

3.c Coatings with Low Slip Coefficient. If permitted, and provided that the mean slip coefficient is established (tested according to Section 6.13.2.8 of the LRFD Specification) and the allowable slip load per unit area is achieved, the Contractor may use a coating providing a slip coefficient less than 0.33.

3.d Minimum Coating Curing Time. Do not assemble coated joints before the coating has cured for the minimum time used in the qualifying test.

3.e Galvanized Faying Surfaces. Hot-dip galvanize faying surfaces specified to be galvanized according to AASHTO M 111 (ASTM A 123). Subsequently roughen galvanized surfaces by hand wire brushing. Do not roughen using power wire brushes.

3.f Existing Field Surfaces. For connections to existing structures, provide surface conditions according to the contract documents.

(k) Plate Cut Edges.

1. Edge Planing. Plane, mill, grind, or thermal cut to a depth of 5 mm (3/16 inch) the sheared edges of plates more than 16 mm (5/8 inch) thick that carry calculated stress.

2. Oxygen Cutting. Conduct oxygen cutting of structural steel according to the ANSI/AASHTO/AWS Bridge Welding Code D1.5-2002.

3. Visual Inspection and Repair of Plate Cut Edges. Perform visual inspection and repair of plate cut edges according to the ANSI/AASHTO/AWS Bridge Welding Code D1.5-2002.

(l) Not used.

(m) Welding. Conduct welding, welder qualifications, prequalification of weld details, and inspection of welds according to the ANSI/AASHTO/AWS Bridge Welding Code D1.5-2002. Unless otherwise indicated or specified, for tubular structures, conduct welding, welder qualifications, prequalification of weld details, and inspection of welds according to ANSI/AASHTO/AWS D1.1-2002 subject to the following limitations:

- Do not use grade 60 electrodes.
- Use only low-hydrogen electrodes.
- Provide a minimum preheat and interpass temperature of at least 10 ºC (50F).

Do not weld or tack brackets, clips, shipping devices or other material not indicated or specified in the Special Provisions to any member unless shown on the shop drawings and approved.

1. Weld structural steel for highway bridges according to the ANSI/AASHTO/AWS Bridge Welding Code D1.5-2002 with the following modifications:

- Section 1.1.3. Revise completely as follows:
  All references to acceptance or approval will denote acceptance or approval by the Engineer. The term Engineer refers to the Chief Bridge Engineer or the Chief Bridge Engineer's representative; namely, the Chief Structural Materials Engineer.
- Section 1.3.2. Delete this section.
- Section 1.3.6, Welding of Ancillary Products. Delete items (1) and (2).
- Section 2.3.3, Plug and Slot Welds. Delete this section.
- Section 9, Details of Plug and Slot Welds. Delete this section.
- Section 3.5.1.6(2). Panels are designated as unstiffened (no intermediate stiffeners) in any location along the girder where the spacing of stiffeners, including diaphragm connection plates, exceeds 1.5 times the web depth for straight girders and 1.0 times the web depth for curved girders. Web flatness must be checked for conformance in all girder panels by the fabricator, and witnessed by the Department's agency inspector. Flatness variations exceeding the tolerance must be documented. Submit a repair procedure to the chief Structural Materials Engineer for review and approval prior to repair.
- Section 3.5.1.9. Revise completely as follows:
  Bearing stiffeners will be flush and square with the web. Fit of bearing stiffeners as specified in Section 1105.03(u). Flatness and tolerance of side plate after welding as specified in Section 1111.03(c).

- Section 4.1.6. Delete this section.
- Table 4.2, Matching Filler Metal Requirements for WPSs Qualified in Accordance with 5.13. Delete all references to electroslag or electrogas welding.
- Section 4, Part E, Electroslag Welding (ESW) and Electrogas Welding (EGW). Delete this part.
- Section 4, Part F, Plug and Slot Welds. Delete this part.
- Section 5.3, Duration. Add the following:
  Unless directed.
- Section 5.14, Electroslag and Electrogas Welding. Delete this section.
- Table 5.4, Additional PQR Essential Variable Changes Requiring WPS Requalification for Electroslag or Electrogas Welding. Delete this table.
- Section 5.16.4. Delete Item (2).
- Section 5.19.5.2, ESW and EGW Specimens. Delete this section.
- Section 6.7.1. Revise completely as follows:
  Non-destructively test complete penetration groove welds as specified in Section 1105.03(m)8.
- Section 6.7.1.1. Delete this section.
- Section 6.7.1.2(2). Revise completely as follows:
  Twenty-five percent of each joint subject to compression or shear.
- Section 6.7.1.2(2)(d). Delete this section.
- Section 6.7.2.1. Revise the first sentence as follows:
  At least 300 mm (12 inches) will be tested in every 3 m (10-foot) length and 300 mm (12 inches) of such welds less than 3 m (10 feet) in length of each size of weld and type joint in main members including the end connections of such members.
- Section 2.17.6.1. Revise second sentence as follows:
  Connections or splices made with fillet welds will be designed for the average of the calculated stress and the strength of the member, but no less than 75% of the strength of the member.
- Section 12.6 Consumable Requirements – Delete all references to optional supplemental diffusible hydrogen designator H16.

2. Do not weld to flanges in tension areas unless indicated.

3. Show types of steel on shop drawings.

4. Do not weld temporary fabrication and construction details, such as rails for deck finishing equipment, bar supports, or deck-forming devices, to beams, girders, or other main members, unless permitted. Identify locations of such welds on the shop drawings.

5. Do not use electroslag or electrogas welding.

6. Do not use the gas metal arc welding (GMAW) process for main load-carrying members, including rolled shapes, web-to-web welds, web-to-flange welds, flange-to-flange welds, and stiffener and connection plate welds to flanges or webs, truss members, or gusset plates. The Contractor may use the GMAW process for welding drainage material, expansion dams, X-frames, diaphragms, bearings, bracing, and other secondary material, unless otherwise indicated.

The Contractor may use the gas shielded flux cored arc welding (FCAW) process for shop application only of stiffener and connection plate welds to flanges and webs, gusset plates, drainage material, expansion dams, X-frames, diaphragms, bearings, bracing, other main load-carrying members or secondary material, unless otherwise indicated. Do not use FCAW on primary member welds, including girders, trusses and fracture critical members (e.g., web splicing, flange splicing, or web-to-flange weld), unless otherwise indicated.

7. Do not use plug welds to repair misplaced holes.

8. Non-destructively test all groove welds in main members according to the ANSI/AASHTO/AWS Bridge Welding Code D1.5-2002. Unless otherwise indicated or specified, use radiographic testing on butt joints. Use radiographic or ultrasonic testing for corner or "T" joints. Use magnetic particle testing according to ANSI/AASHTO/AWS D1.5-2002, Section 6.7.2.

9. All welding consumables (electrodes and electrode/flux combinations) used for welding of fracture critical members will conform to the diffusible hydrogen requirements of the AWS filler metal specifications optional supplemental designator H4 or H8 only.

10. Perform weld repairs according to specified welding code and Department approved procedure(s). Do not repair individual locations more than three times without written permission of the Engineer. Following the third unsuccessful attempt, submit a proposed repair procedure for review.

11. Do not repair any individual area on welded pole to base connections for luminaire supports, traffic signal supports, and sign structure supports more than one time without written permission of the Engineer.

(n) Weld Repairs and Geometric Corrections using Applied Heat. For non-fracture critical members only, refer to Publication 135 for pre-approved base metal repair procedures and heat correction procedures. The fabricator may use the pre-approved procedures after the Department's inspector has verified that the discontinuity to be repaired is covered by the specific procedure. Any repairs performed are subject to inspection by the Department's inspector.

(o) Not used.

(p) Oxyfuel Gas Cutting and Plasma Arc Cutting. Cut steel and weld metal using oxyfuel gas, air plasma arc, or oxygen plasma arc processes. Conduct cutting for all processes according to the ANSI/AASHTO/AWS Bridge Welding Code D1.5-2002 with the modifications specified in Section 1105.03(m)1. Air plasma arc cutting and oxygen plasma arc cutting may be used for AASHTO M 270/M 270M (ASTM A 709/A 709M), Grades 250, 345, 345W, and 485W (Grades 36, 50, 50W, and HPS 70W) and for stainless steels. Do not cut materials thicker than 16 mm (5/8 inch) with air plasma arc cutting. Do not cut materials thicker than 25 mm (1 inch) with oxygen plasma arc cutting. Do not apply water to the base metal during any cutting process except as otherwise indicated. Do not cut fracture critical members with either air plasma arc cutting or oxygen plasma arc cutting.

(q) Facing of Bearing Surfaces. Ensure that the surface finishes of bearing and base plates and other bearing surfaces in contact with each other or concrete conform to the ANSI surface roughness requirements defined in ANSI/ASME B46.1 and listed below:

- Steel slabs — ANSI 50 µm (2 mils)
- Heavy plates in contact with shoes to be welded — ANSI 25 µm (1 mil)
- Milled ends of compression members, milled or — ANSI 12.5 µm (0.5 mil)

ground ends of stiffeners and fillers	
• Bridge rollers and rockers	ANSI 6.3 µm (0.25 mil)
• Pins and pin holes	ANSI 3.2 µm (0.13 mil)
• Sliding bearing	ANSI 3.2 µm (0.13 mil)
• Sliding bearings—Stainless Steel to Polytetrafluoroethylene (PTFE)	ANSI 0.20 µm (0.008 mil)

Fabricate bearing surfaces according to the following additional requirements:

- Machine sliding bearings having a surface roughness of 1.6 µm (0.063 mil) or rougher so the lay of the cut is parallel to the direction of movement.
- Provide machined surfaces plane and true, conforming to the indicated dimensions.
- For surfaces designed to be flat, machine surfaces to within 0.25 mm (0.01 inch) of flatness. Determine flatness as specified in Section 1111.03(c).
- Maintain uniform and even contact when assembling adjacent bearing surfaces. Unless a closer tolerance is indicated or specified, do not exceed a gap of 1.0 mm (0.040 inch) between bearing surfaces. Machine all sliding surfaces of base plates.
- Do not machine any surfaces of fabricated members until all fabrication and welding of the assembly or subassembly is complete. Machine heat-treated components after completion of heat treating.

(r) Abutting Joints. Mill or saw-cut abutting joints in compression members of trusses and columns to obtain a square joint and uniform bearing. Do not allow the opening at other joints not required to be faced to exceed 10 mm (3/8 inch).

(s) Plates: Direction of Rolling. Fabrication of Members. Unless otherwise indicated, cut and fabricate steel plates for main members and splice plates for flanges and main tension members (not secondary members) so that the primary direction of rolling is parallel to the direction of the main tensile and compressive stresses.

Unless otherwise indicated or specified, fabricate I-shaped beams and girders so that when erected and under their own weight, the webs are within the allowable tolerance of vertical. Provide flanges normal to the web, unless otherwise indicated.

(t) Bent Plates.

1. General. Fabricate bent, unwelded, load-carrying, rolled-steel plates from the stock plates so that the bend lines will be at right angles to the direction of rolling. If permitted, cold-bent ribs for orthotropic-deck bridges may be bent with bend lines in the direction of rolling.

Before bending, round the corners of the plate where bending is to occur to a radius of 2 mm (1/8 inch).

2. Cold Bending. Cold bend such that no cracking of the plate occurs. Provide minimum bend radii, measured to the concave face of the metal, according to the following table:

Thickness in mm (inches) (t)	Up to 12 (1/2)	Over 12 (1/2) to 25 (1)	Over 25 (1) to 38 (1 1/2)	Over 38 (1 1/2) to 65 (2 1/2)	Over 65 (2 1/2) to 100 (4)
Bend radii for all grades of structural steel in this specification	2t	2 1/2t	3t	3 1/2t	4t

Provide allowance for springback of Grades 690 and 690W (Grades 100 and 100W) steels of about three times that for Grade 250 (Grade 36) steel. For break press forming, provide a lower die span of at least 16 times the plate thickness. Multiple hits are advisable.

3. Hot Bending. If a radius shorter than the minimum specified for cold bending is necessary, hot bend the plates at a temperature not less than 430 °C (800F) and not greater than 650 °C (1,200F). If Grades 690 and 690W (Grades 100 and 100W) steel plates are heated to a temperature greater than 610 °C (1,100F), requench and temper them according to the producing mill's practice.

(u) Fit of Stiffeners. Ensure that at least 75% of the bearing area of end bearing stiffeners for girders and stiffeners intended as supports for concentrated loads have full bearing on the flanges that they transmit load to or receive load from. The gap between the bearing stiffener and the flange may not exceed 0.8 mm (1/32 inch). Mill or grind the ends of bearing stiffeners to achieve the required bearing on the flanges. For weldable steel in compression areas of flanges, weld stiffeners as indicated or specified.

Provide a tight fit against the compression flange for intermediate stiffeners not intended to support concentrated loads unless otherwise indicated or specified.

(v) Eyebars. Flame cut pin holes at least 50 mm (2 inches) smaller in diameter than the finished pin diameter. Securely fasten together all eyebars that are to be placed side by side in the structure in the order that they will be placed on the pin and bore both ends while clamped. Pack and match-mark eyebars for shipment and erection. Stamp all identifying marks on the edge of one head of each member with steel stencils after fabrication is completed so that the marks are visible when the bars are nested in place on the structure. Provide low stress type steel die stamps.

Furnish eyebars straight and free from twists. Accurately locate pin holes on the centerline of the bar. Limit inclination of any bar to the plane of the truss to 1 mm per 200 mm (1/16 inch to a foot).

Simultaneously cut the edge of eyebars that lie between the transverse centerline of their pin holes with two mechanically operated torches abreast of each other and guided by a substantial template. Prevent distortion of the plates.

(w) Annealing and Stress Relieving. Anneal (full annealing) and normalize structural members indicated according to ASTM A 941. Finish machining, boring, and straightening structural members subsequent to heat treatment. Maintain the temperature uniformly throughout the furnace during heating and cooling so that the temperatures of any two points on the member differ by no more than 55 °C (100F) at any one time.

Do not anneal or normalize members consisting of Grades 690 and 690W (Grades 100 and 100W) or Grade 485W (Grade 70W) steel. Stress relieve these members only if permitted. Do not allow the holding temperatures for stress relieving Grades 690 and 690W (Grades 100 and 100W) and Grade 485W (Grade 70W) steels to exceed 610 °C and 580 °C (1,100F and 1,050F), respectively.

Furnish a record of each furnace charge identifying the pieces in the charge and showing the temperature and schedule actually used. Provide proper instruments, including recording pyrometers, to determine the temperatures of members in the furnace at any time. Submit the records of the treatment operation for approval.

When indicated or specified, stress relieve members such as bridge shoes, pedestals, or other parts that are built up by welding sections of plate together according to Section 4.4 of the ANSI/AASHTO/AWS Bridge Welding Code D1.5-2002.

(x) Pins and Rollers. Turn pins and rollers to the dimensions indicated and ensure that they are straight, smooth, and free from flaws. Forge and anneal pins and rollers more than 225 mm (9 inches) in diameter. Either forge and anneal or use cold-finished, carbon-steel shafting for pins and rollers 225 mm (9 inches) or less in diameter.

In pins larger than 225 mm (9 inches) in diameter, bore a hole not less than 50 mm (2 inches) in diameter full length along the axis of the pin after the forging has cooled to a temperature below the critical range and before annealing. Bore the hole under suitable conditions to prevent damage by cooling too rapidly.

(y) Boring Pin Holes. Bore pin holes true to the specified diameter, smooth and straight, at right angles with the axis of the member and parallel with each other unless otherwise indicated or specified. Produce the final surface by a finishing cut.

Do not allow the diameter of the pin hole to exceed that of the pin by more than 0.50 mm (1/50 inch) for pins 125 mm (5 inches) or less in diameter, or by more than 0.75 mm (1/32 inch) for pins larger than 125 mm (5 inches) in diameter. Do not allow the distance outside to outside of end holes in tension members and inside to inside of end holes in compression members to vary more than 0.75 mm (1/32 inch) from that indicated or specified. Bore pin holes in built-up members after the member has been assembled.

(z) Threads for Bolts and Pins. Provide threads for all bolts and pins for structural steel construction conforming to Unified Standard Series UNC ANSI B1.1, Class 2A for external threads and Class 2B for internal threads, except furnish pin ends having a diameter of 34.9 mm (1 3/8 inches) or threaded more than six threads to 25 mm (1 inch).

(aa) Full Size Tests. When full size tests of fabricated structural members or eyebars are indicated or specified, provide suitable facilities, material, supervision, and labor necessary for making and recording the required tests.

(bb) Marking and Shipping. Paint or mark each member with an erection mark for identification. Furnish an erection diagram to the Representative indicating the location of the erection marks on each member, so that the marks can be located in the field.

Furnish copies of material orders, shipping statements, and erection diagrams to the Representative. Show the masses (weights) of the individual members on the statements. Mark the masses (weights) of members with a mass (weight) greater than 2700 kg (3 tons) on the members. Load structural members on trucks or cars in such a manner that they may be transported and unloaded at their destination without being excessively stressed, deformed, or otherwise damaged.

Pack bolts of one length and diameter and loose nuts or washers of each size separately. Ship pins, small parts and packages of bolts, washers, and nuts in boxes, crates, kegs, or barrels, but do not allow the gross mass (weight) of any package to exceed 135 kg (300 pounds). Plainly display a list and description of contents on the outside of each shipping container.

(cc) Painting. Section 1060.3 and as follows:

Include the manufacturer of the complete self-curing inorganic zinc system consisting of the primer, intermediate tie, and finish coats on the shipping papers.

(dd) Identification of Steel During Fabrication. Use a system of assembly-marking individual pieces and issuing cutting instructions to the shop (generally by cross-referencing the assembly-marks indicated on the shop drawings with the corresponding item covered on the mill purchase order) that maintains the identity of the original piece.

Only furnish steel from stock material that can be identified by heat number and mill test report.

During fabrication, up to the point of assembling members, clearly and legibly show the grade designation on each piece of steel other than Grade 250 (Grade 36) steel. Either write the grade designation on the piece or use the identification color code shown in Table B.

TABLE B
Identification Color Codes

Grade Metric (English)	Color Code
345 (50)	Green & Yellow
345W (50W)	Blue & Yellow
485W (70W)	Blue & Orange
690 (100)	Red
690W (100W)	Red & Orange

Except for Grade 250 (Grade 36) steel, establish an individual color code for steels not covered in Table B or included in AASHTO M 160/M 160M (ASTM A 6/A 6M). Provide the color code to the Representative.

Die stamp or firmly attach a substantial tag to identify the grade designation of those pieces of steel, other than Grade 250 (Grade 36) steel, that before being assembled into members will be subjected to fabricating operations such as blast cleaning, galvanizing, heating for forming, or painting that might obliterate paint color code markings. Furnish low stress-type steel die stamps.

If requested by the Representative, furnish an affidavit certifying that the identification of the steel was maintained according to this specification throughout the fabrication operation.

(ee) Welded Connections. Ensure that surfaces and edges to be welded are smooth, uniform, clean, and free of defects that would adversely affect the quality of the weld. Prepare edges according to the ANSI/AASHTO/AWS Bridge Welding Code D1.5-2002.

(ff) Numerically-Controlled Drilled Field Connections. Section 1105.03(c)5

(gg) Facing of Bolted Surfaces. ASTM A 6/A 6M, and as follows:

- Provide surfaces plane and true, within the specified tolerances.
- Variations for surfaces designed to be flat: Conforming to ASTM A 6/A 6M, Tables A1.13, A1.14, and A1.15, unless otherwise indicated or specified.
- Complete all welded attachments to bolted surfaces before machining surfaces to required tolerances.
- Grind only on surfaces less than 50 mm (2 inches) wide, unless otherwise permitted.
- Use milling or other acceptable procedures to correct plate flatness to within the specified tolerances
- Provide plate thickness as indicated.
- Identify each plate and the methods used to correct plate flatness to the specified tolerances.
- Replace rejected plates at no additional cost to the Department.

(hh) Determination of Surface Flatness.

Furnish surfaces having flatness as determined by the following method:

- Place a precision straightedge that is a minimum of 150 mm (6 inches) longer than the surface to be measured in contact with and as parallel as possible to the surface. The straightedge may be located in any position on the surface being evaluated and not necessarily at 90 degrees to the edge.
- Attempt to insert a feeler gage having the required tolerance under the straightedge.
- Flatness is acceptable if the feeler gage does not pass between the straightedge and the surface.