

3301 REINFORCEMENT BARS

3301.1 SCOPE

Provide deformed and plain reinforcing steel for use as reinforcement in concrete construction.

3301.2 REQUIREMENTS

Provide reinforcement bars, other than wire, meeting the requirements of the following AASHTO specifications for the size, type and grade as shown on the plans or as required by the contract:

Table 3301-1 AASHTO Specifications Per Bar Type	
Reinforcement Bars	AASHTO Specification Requirement
Billet steel bars	AASHTO M 31
Rail steel bars	AASHTO M 322 M/AASHTO M 322
Axle steel bars	AASHTO M 322 M/AASHTO M 322

If the plans or specifications do not specify the type or grade of reinforcement bars, provide Grade 60 [Grade 420] of any type except as modified by the following:

- (1) Provide deformed billet steel reinforcement bars for use in a concrete bridges, including precast units, box culverts, and retaining walls.
- (2) Provide deformed reinforcement bars of any type or grade for use in all other concrete structures, and
- (3) If required or allowed by the contract, weld bars meeting the requirements of ASTM A 706 and having a yield point of at least 60,000 psi [414 MPa].

If required in the plans, provide epoxy coated reinforcement bars meeting the requirements of AASHTO M 284. Apply the coating in a fusion bonded epoxy coating plant certified by the CRSI.

Ensure the plant's quality control office maintains documentation required by CRSI certification, including test data and measurements taken at times and locations as directed by the Materials Engineer.

Fabricate, store, and place reinforcement in accordance 2472, "Metal Reinforcement."

3301.3 SAMPLING AND TESTING

If the Engineer or the Materials Engineer determines that the fusion bonded epoxy coating plant is not following approved coating procedures, correct the process and

repair or replace the unacceptable material as directed by the Engineer, in conjunction with the Materials Engineer.

3302 DOWEL BARS

3302.1 SCOPE

Provide dowel bars for use in portland cement concrete pavements and other concrete applications as shown on the plans.

3302.2 REQUIREMENTS

Provide Grade 40 or Grade 60 steel dowel bars meeting the requirements of AASHTO M 31. Provide an epoxy coating meeting the requirements of AASHTO M 254. Epoxy coat the ends of the dowel bars as required by the manufacturer. Apply epoxy coating in a fusion bonded epoxy coating plant certified by the CRSI or another organization approved by the Engineer, in conjunction with the Materials Engineer. Use alternate dowel bar materials as required by the contract.

Ensure the manufacturer's plant quality control office maintains documentation containing the data required by certification, including test data and measurements taken at times and locations as required by the CRSI, the Engineer in conjunction with the Materials Engineer, or both.

Store and protect dowel bars as specified in 2472, "Metal Reinforcement."

The Contractor may perform shearing if the epoxy coating is not damaged and subject to permissible deformation. The Engineer will ensure dowel bars do not contain deformations greater than the true shape by 0.04 in [1 mm] in diameter or thickness, or extend greater than 0.40 in [10 mm] from the dowel end.

3302.3 SAMPLING AND TESTING

Sample and test dowel bars meeting the requirements of the Schedule of Materials Control.

3303 STEEL FABRIC

3303.1 SCOPE

Provide steel fabric for use as concrete reinforcement.

3303.2 REQUIREMENTS

Provide steel fabric for concrete reinforcement meeting the requirements of AASHTO M 55 or AASHTO M 221 for plain or deformed wire, except the Contractor may use oversized wire. If the Contractor uses oversize wire, the maximum and minimum diameter requirements will not apply. Provide flat sheets or rolls of fabric.

3303.3 SAMPLING AND TESTING

Sample and test the steel fabric meeting the requirement of the Schedule of Materials Control.

3305 SPIRAL REINFORCEMENT

3305.1 SCOPE

Provide steel wire for use as spiral cage reinforcement for round columns.

3305.2 REQUIREMENTS

Provide cold drawn steel wire to fabricate spiral cage reinforcement for round columns meeting the requirements of AASHTO M 32 for the size shown on the plans. Alternatively, the Contractor may use plain or deformed Grade 60 billet steel bars in accordance with 3301, "Reinforcement Bars."

When required to splice spiral reinforcement by welding, perform welding in accordance with the requirements of ANSI/AWS D1.4, "Structural Welding Code - Reinforcing Steel."

3305.2 SAMPLING AND TESTING

Sample and test according to the requirements of 3301, "Reinforcement Bars."

3306 LOW-CARBON STRUCTURAL STEEL

3306.1 SCOPE

Provide carbon steel shapes, plates, bars, sheets, and strips.

3306.2 REQUIREMENTS

Provide low-carbon structural steel meeting the requirements of ASTM, the tensile requirements in, and 3308, "General Requirements for Structural Steel."

Provide steel shapes, plates, and bars meeting the requirements of ASTM A 709/A 709M, for Grade 36 [250].

Provide steel sheets and strips meeting the requirements of ASTM A1011/A 1011M Grade 36 [250], Type 2.

3306.3 SAMPLING AND TESTING

Perform tensile tests for all sizes of shapes and bars in accordance with the Schedule for Materials Control.

3308 GENERAL REQUIREMENTS FOR STRUCTURAL STEEL

3308.1 SCOPE

Provide steel for structural applications referenced in 2471, "Structural Metals."

3308.2 REQUIREMENTS

A General

Provide steel for structural applications meeting the requirements of ASTM A 6/A 6M and the following:

B Quality

Submit a Nonconformance Report (NCR) to the Engineer for review and approval before performing any weld repairs of the base metal.

Correct injurious defects (e.g. pipes, seams, unapproved repairs, laminations, cracks, segregations) and perform necessary testing to determine the extent of the defects or confirm the adequacy of repairs, as required by the Engineer, at no additional cost to the Department.

The Engineer will reject plates or rolled beams with defects that reduce the thickness of the material in any given section by greater than 30 percent.

3308.3 SAMPLING AND TESTING

A Tensile Test

Take tensile specimens for rolled beams from the mid-thickness of the flange and oriented longitudinally to the rolling direction. Note the location and orientation of tensile specimens on the mill test report.

B Impact Tests

Perform impact tests for structural steel provided for use in major structural components as defined in 2471.3.A.1.b, "Major Structural Components," or the contract. The Department will not require impact testing for minor structural components unless otherwise required by the contract

Ensure that impact tested structural steel meets the requirements of ASTM A 709/A 709M for zone 3 welded material.

3309 HIGH-STRENGTH LOW-ALLOY STRUCTURAL STEEL

3309.1 SCOPE

Provide high-strength, low-alloy structural steel shapes, plates, bars, sheets, and strips.

3309.2 REQUIREMENTS

Provide high-strength, low-alloy shapes, plates, and bars meeting the requirements of ASTM A 709/A 709M, for Grade 50W [345W], and 3308, "General Requirements for Structural Steel."

Provide high-strength, low-alloy sheet and strip meeting the requirements of ASTM A 606, for Type 4 hot rolled material and 3308, "General Requirements for Structural Steel," except ensure the yield strength is at least 50,000 psi [345 MPa].

If the contract does not specify the type of steel, provide any material type listed on the Approved/Qualified Products List. For unpainted structures, provide all steel material of the same type.

3309.3 SAMPLING AND TESTING — (BLANK)

3310 HIGH-STRENGTH LOW-ALLOY COLUMBIUM-VANADIUM STEEL

3310.1 SCOPE

Provide high-strength, low alloy columbium-vanadium steel shapes, plates, bars, sheets, and strips.

3310.2 REQUIREMENTS

Provide shapes, plates, and bars for high-strength, low-alloy columbium-vanadium steel meeting the requirements of ASTM A 709/A 709M, for Grade 50 [345], and 3308, "General Requirements for Structural Steel."

Provide sheet and strip for high-strength, low-alloy columbium-vanadium steel meeting the requirements of ASTM A 1011/A 1011M, for Grade 50 [340] Class 1, and 3308, "General Requirements for Structural Steel."

3310.3 SAMPLING AND TESTING — (BLANK)

3312 STAINLESS STEEL

3312.1 SCOPE

Provide stainless steel plates, sheet, and strip.

3312.2 REQUIREMENTS

Provide stainless steel plates, sheet, and strip meeting the requirements of ASTM A 240 for Type 302 or Type 304.

For the finish, use a No. 4 polish, except on sheet and strip used in bearing and modular expansion joint assemblies, use a No. 8 polish.

Provide stainless steel bars meeting the requirements of ASTM A 276 for Type 302 or Type 304, Condition A (annealed). Provide pin stock in accordance with the requirements for Type IV in 3314, "Cold-Finished Bar Steel."

For free machining applications such as bolt stock, provide stainless steel meeting the requirements of ASTM A 582/A 582M Type 303, Condition A, cold finished, unless otherwise required by the contract. Provide bolt stock in accordance with 3391.2.E, "Stainless Steel Bolts."

De-scale and clean stainless steel surfaces in accordance with ASTM A 380.

If welding, use stainless steel with a carbon content no greater than 0.03 percent.

3312.3 SAMPLING AND TESTING — (BLANK)

3313 HOT ROLLED BAR STEEL

3313.1 SCOPE

Provide rounds, squares, hexagons, or flats for hot rolled bar steel of the following types, as required by the contract:

3313.2 REQUIREMENTS

A Type I — Carbon Bar Steel

Provide carbon bar steel with the following characteristics:

- (1) A minimum yield strength of 45,000 psi [310 MPa],
- (2) A minimum ultimate strength of 60,000 psi [420 MPa], and
- (3) A minimum elongation of 20 percent in 2 in [50 mm].

Use ASTM A 400, "Practice for Steel Bars, Selection Guide, Composition, and Mechanical Properties," to select the material specifications and grade in accordance with the section and mechanical properties. Procure steel in accordance with the relevant procurement specifications.

B Type II — Alloy Bar Steel

Provide alloy bar steel with the following characteristics:

- (1) A minimum yield strength of 55,000 psi [380 MPa],
- (2) A minimum ultimate strength of 85,000 psi [585 MPa], and
- (3) A minimum elongation of 15 percent in 2 in [50 mm].

Use ASTM A 400, "Practice for Steel Bars, Selection Guide, Composition, and Mechanical Properties," to select the material specifications and grade in accordance with the section and mechanical properties. Procure steel in accordance with the relevant procurement specifications.

C Type III — Heat-Treated Alloy Bar Steel (Round)

Provide heat-treated alloy bar (round) steel in accordance with ASTM A 434, with mechanical properties meeting the requirements for Class BC.

D Type IV — Corrosion Resisting Cold Finished Rounds

Provide cold-finished, hot-rolled stainless steel bars for bridge pins, finished to size in a fabrication shop. Manufacture bars for bridge pins from a base material that is annealed and hot-finished free machining, Type 303, as specified in ASTM A 582. After turning, ensure the size does not exceed a pin diameter of 5½ in [140 mm].

3313.2 SAMPLING AND TESTING — (BLANK)

3314 COLD-FINISHED BAR STEEL

3314.1 SCOPE

Provide rounds, squares, hexagons, or flats as required by the contract.

3314.2 REQUIREMENTS

A Type I — Carbon Bar Steel

Provide cold-finished carbon bar steel meeting the requirements of ASTM A 108 for Grade C 1035, and the following strength requirements, unless the contract requires otherwise:

- (1) For rounds with a diameter no greater than 2⅞ in [73 mm] and hexagons and squares with a maximum dimension across flats no greater than 3 in [75 mm]:
 - (1.1) A minimum yield strength of 60,000 psi [415 MPa],
 - (1.2) A minimum ultimate strength of 70,000 psi [485 MPa], and
 - (1.3) A minimum elongation of 10 percent in 2 in [50 mm].
- (2) For rounds with a diameter greater than 2⅞ in [73 mm] and flats, hexagons, and squares with a maximum dimension across flats greater than 3 in [75 mm]:
 - (2.1) A minimum yield strength of 45,000 psi [310 MPa],
 - (2.2) A minimum ultimate strength of 60,000 psi [415 MPa], and
 - (2.3) A minimum elongation of 20 percent in 2 in [50 mm].

B Type II — Alloy Bar Steel

Provide cold-finished alloy bar steel meeting the requirements of ASTM A 331 for the corresponding annealed and cold-finished Grade AISI A 4140 or Grade

AISI A 4142 and the following strength requirements, unless the contract requires otherwise:

- (1) For rounds with a diameter no greater than $2^{15}/_{16}$ in [74 mm] and hexagons and squares with a maximum dimension across the flats no greater than 3 in [75 mm]:
 - (1.1) A minimum yield strength of 75,000 psi [520 MPa],
 - (1.2) A minimum ultimate strength of 95,000 psi [655 MPa], and
 - (1.3) A minimum elongation of 10 percent in 2 in [50 mm].
- (2) For rounds with a diameter greater than $2^{15}/_{16}$ in [74 mm] and hexagons, squares, and flats with a maximum dimension across the flats greater than 3 in [75 mm]:
 - (2.1) A minimum yield strength of 55,000 psi [380 MPa],
 - (2.2) A minimum ultimate strength of 85,000 psi [585 MPa], and
 - (2.3) A minimum elongation of 15 percent in 2 in [50 mm].

C Type III — Pre-Heat Treated Alloy Bar Steel (Rounds)

Provide cold-finished pre-heat treated alloy bar steel with the following characteristics:

- (1) Base material meeting the requirements of ASTM A 331 for corresponding Grade AISI A 4140 or Grade AISI A 4142.
- (2) Stock that is pre-heat treated by quenching and tempering to meet the physical properties specified in Table 3313-1, and is in a machinable condition.

D Type IV — Corrosion Resisting Cold Finished Rounds

Provide cold-finished stainless steel rounds for use as bridge pins meeting the requirements of ASTM A 276 for Type 316, annealed and center-less ground. Ensure the pin diameter does not exceed $4\frac{1}{2}$ in [115 mm].

3314.3 SAMPLING AND TESTING — (BLANK)

3315 STEEL FORGINGS

3315.1 SCOPE

Provide material for steel forgings.

3315.2 REQUIREMENTS

A Material Requirements

Provide material for steel forgings meeting the requirements for one of the three types of steel specified in this section, as required by the contract. If the contract does not specify a steel type, provide Type I.

A.1 Type I — Carbon Steel Forgings

Provide carbon steel forgings meeting the requirements of ASTM A 668/A 668M for Class D forged from blooms, billets, bars, or slabs meeting the requirements of ASTM A 711 for Grade C 1035 or Grade C 1040.

A.2 Type II — Alloy Steel Forgings

Provide alloy steel forgings, for sizes no greater than 9 in [225 mm] thick or in diameter, meeting the requirements of ASTM A 668/A 668M for Class G.

Provide alloy steel forgings, for sizes greater than 9 in [225 mm] thick or in diameter, meeting the requirements of ASTM A 668/A 668M for Class H.

Provide alloy steel forgings made from alloy steel blooms, billets, bars, or slabs meeting the requirements of ASTM A 711 for Grade A 4140, Grade A 4142, or Grade A 4145.

A.3 Type III — Corrosion Resisting Steel Forgings

Provide corrosion resisting steel forgings made from billets or bars primarily produced for re-forging in accordance with ASTM A 314 for Type 316.

Provide steel forgings meeting the physical and chemical requirements for hot-rolled materials as specified in ASTM A 276. Provide Type 316 material that is fully annealed to develop maximum corrosion resisting properties. Workmanship, appearance, and finish must conform to ASTM A 484.

B Machine Finishing

Machine steel forgings after the annealing process is complete. Finish forgings in accordance with 2471, "Structural Metals."

Unless otherwise shown on the plans or required by the contract, bore a 2 in [50 mm] round hole longitudinally through the center of each type of forged steel pin roller measuring over 9 in [225 mm] in diameter.

3315.3 SAMPLING AND TESTING

Ensure the supplier performs the following physical and chemical tests required by the ASTM Specifications for Type I, Type II, and Type III material:

- (1) Perform magnetic particle tests on Type I forgings in accordance with ASTM E 709.
- (2) Perform magnetic particle tests on Type II forgings in accordance with ASTM A 275/A 275M.
- (3) Perform ultrasonic tests on Type III forgings in accordance with ASTM A 388/A 388M.

Ensure the supplier performs magnetic particle testing after machining operations are complete. The Engineer will reject material with serious defects such as bursts, cracks, pipes, internal cracks and flakes, or laminations.

Submit to the Engineer certified test reports for physical, chemical, magnetic particle, and ultrasonic tests from the supplier.

3316 HIGH PERFORMANCE STEEL (345 MPA Y.S.)

3316.1 SCOPE

Provide high-strength, low-alloy structural steel shapes, plates, and bars to enhance atmospheric corrosion resistance, weldability, and mechanical properties.

3316.2 REQUIREMENTS

Provide material for high-performance steel meeting the requirements of ASTM A 709/A 709M, Grade HPS 50W (HPS 345W), and 3308, "General Requirements for Structural Steel." Provide Grade HPS 50W (HPS 345W) high-performance steel with a minimum specified yield strength of 50 ksi [345 MPa].

3316.3 SAMPLING AND TESTING — (BLANK)

3317 HIGH PERFORMANCE STEEL (485 MPA Y.S.)

3317.1 SCOPE

Provide high-strength, low-alloy structural steel shapes, plates, and bars, to enhance atmospheric corrosion resistance, weldability, and mechanical properties.

3317.2 REQUIREMENTS

Provide materials for high-performance steel meeting the requirements of ASTM A 709/A 709M, Grade HPS 70W [HPS 485W], and 3308, "General Requirements for Structural Steel." Provide high-performance steel Grade HPS 70W [HPS 485W] with a minimum specified yield strength of 70 ksi [485 MPa].

3317.3 SAMPLING AND TESTING — (BLANK)

3321 GRAY IRON CASTINGS

3321.1 SCOPE

Provide gray iron castings for drainage or structural use. The castings are classified according to tensile strength, but the Department will make provisions for acceptance of drainage castings and other ornamental or non-stress bearing castings on the basis of flexural tests.

3321.2 REQUIREMENTS

Provide gray iron castings meeting the requirements of AASHTO M 105 for the class required by the contract. Obtain the castings from foundries, approved by the Materials Engineer, in accordance with these specifications.

A Class Designation

If the contract does not specify a strength class, provide castings in accordance with the following:

- (1) Provide Class 40C, or better, for stress bearing castings such as bridge rockers, bolsters, and sliding shoes; or
- (2) Provide Class 35B, or better, for bridge rail posts, light standard bases, drainage and manhole castings, and other castings subject to vehicle impact or vehicle loading.

B Special Requirements

Provide drainage castings of metal with a Brinell Hardness Number from 190 to 265.

Provide round casting assemblies with lid-to-frame surfaces machine-milled to provide true bearing around the entire circumference.

C Foundry Control

Before beginning casting, the manufacturer and the Engineer will establish, in conference, a control procedure for correlating casting operations, arranging for foundry inspection, and establishing an approved identification system. Unless the Engineer otherwise agrees, the manufacturer will identify castings as follows:

- (1) With a mark correlating the casting with test bars using a system of heat numbers or a calendar date and tap number, using numerals no greater than $\frac{1}{2}$ in [13 mm];
- (2) With a mark indicating the source of manufacture, using a symbol no greater than $1\frac{1}{2}$ in [38 mm] in the largest dimension or a letter no greater than $\frac{3}{4}$ in [19 mm] high and 2 in [50 mm] long;
- (3) With the Department's type or style number shown on the plans, in the size and location indicated.

Form these identification marks on castings of sufficient size during manufacture. If the casting size is insufficient for the marks, use stamped metal tags wired to the castings for markings not formed in the castings. Place identification marks, subject to approval by the Engineer, where they will not interfere with assembly of parts and will not be removed during machine finishing operations. Ensure the manufacturer does not place its name on castings except as specified above.

D Casting Details

Provide castings meeting the dimensions shown on the plans. Provide draft by increasing the net dimensions. Provide castings within a tolerance of $\frac{1}{8}$ in [3 mm] for the overall general dimensions. Limit the tolerance in dimensions of grates and covers for drainage casting assemblies, and the openings into which they fit, to $\frac{1}{16}$ in [1.5 mm]. In no case is the metal thickness to be less than $\frac{1}{16}$ in [1.5 mm] less than the thickness shown on the plans.

Provide castings with a density of at least 95 percent of the theoretical density of that type, based on 442 lb/cu. ft [7080 kg/cu. m], cast to the exact dimensions shown on the plans.

Pour castings in closed molds with gating, feeders, risers, and sprues. Ensure castings completely fill the molds. Do not remove castings from the molds until properly cooled. Do not chill the castings.

Boldly fillet castings on the inside and re-entrant corners. Round the outside corners and edges to a radius of at least $\frac{1}{8}$ in [3 mm]. For bridge bearings, use a $\frac{1}{2}$ in [13 mm] fillet except where the fillet may interfere with assembly.

E Workmanship and Finish

Remove attachments of gates, risers, and sprues from the castings and grind remaining extensions flush to the casting surface. The Engineer will reject castings damaged through careless removal of attachments. Do not repair by welding.

Fabricate castings free of sponginess, cracks, blow holes, warping, sand inclusions, cold shuts, chilled iron shrinks, and other defects that affect the strength and value of the casting for the purpose intended. Ensure the contact surfaces between different castings in an assembly provide a firm, even bearing, without rattling or rocking.

Clean castings of foundry sand, rust, scale, and other deleterious material.

3321.3 SAMPLING AND TESTING

Ensure the manufacturer casts the required number of test bars, as stated below, and machine finishes tension test specimens to the dimensions required in the Schedule for Materials Control. Unless otherwise approved by the Engineer, the manufacturer will deliver test specimens to the Materials Laboratory for testing.

Cast three test bars for each heat or tap. If adding alloys in the ladle, cast three test bars for each ladle. For continuous furnace pouring, cast two test bars at the beginning and two test bars at the end of cast.

For bridge bearing castings, cast at least one test bar for each casting. Pour castings and test bars in the presence of the Engineer, unless the test bars are cast as an integral part of the bearing castings.

Identify each test bar separately and to the corresponding castings using symbols, letters, or numbers cast on the test bar and casting.

If properly identifying castings and corresponding test bars is not possible, the Engineer may require test specimens to be cut from selected castings that are representative of a lot, and perform tests on those samples.

3322 CARBON STEEL CASTINGS

3322.1 SCOPE

Provide mild to medium strength carbon steel castings for general applications requiring a tensile strength of no more than 70,000 psi [485 MPa].

3322.2 REQUIREMENTS

Provide carbon steel castings meeting the requirements of ASTM A 27M for the grade required by the contract and this section.

A Grade Designations

If the contract does not specify a strength grade, provide castings in accordance with the requirements for ASTM A 27 Grade 70-36 [485-250].

Supply castings in a normalized or normalized and tempered condition.

B Casting Details

Provide casting patterns that will produce a finished casting with the dimensions and details shown on the plans. Provide draft by increasing the net dimensions without reducing the metal thickness as required by the contract.

Boldly fillet sharp angles. Provide fillets of a size that does not reduce the clearance required by the contract. Round external corners on castings, except ornamental types, to a radius of $\frac{3}{16}$ in [5 mm].

Make allowance for shrinkage and provide enough material on surfaces requiring a finish to produce castings of the specified size and shape after the completion of finishing operations as shown on the plans.

The Engineer will not allow split cores between unfinished surfaces of restricted clearance. Provide face cores of one piece, unless castings require machine finishing. Provide chaplets spaced, and in numbers to prevent the chaplets from impairing the strength of the casting. Provide chaplets that are completely fused.

Fabricate castings using methods that will ensure corners, arises, and edges are completely filled. For castings with one machine surface, cast with the machine surface down. Do not use metal from different melts in the same casting.

Do not withdraw castings from the mold until properly cooled. Do not quench castings to speed up cooling.

C Workmanship and Finish

The Engineer will reject castings with structural defects in a casting, including blow hole shrink pipes, sand hole cracks, checks, slag inclusions, cold shuts, unfilled arises, warped surfaces, or deformation from core or flask movement. Do not repair castings with minor defects until the Engineer provides permission and approves the repair method.

Grind extensions, high spots, and rough edges resulting from pouring connections, smooth and flush with the casting surface. Clean castings of foundry

sand, rust, scale, and other deleterious material before painting, galvanizing, or metalizing as required by the contract.

Clean, paint, galvanize and metalize castings in accordance with 2471, "Structural Metals."

3322.3 SAMPLING AND TESTING

If the Engineer suspects the soundness of a casting, the Engineer has the right to subject castings to radiographic or magnetic particle inspection, at no additional cost to the Department.

A Test Specimens

Attach test coupons using the preferred method of a keel block, but do not make attachments that may structurally weaken the casting.

Cast two test coupons integrally for each casting greater than 750 lb [340 kg]. Provide two test coupons for each casting heat less than 750 lb [340 kg], and cast the test coupons as ribs, integrally and below a special block no less than 6 in × 6 in × 2 in [150 mm × 150 mm × 50 mm].

B Foundry Control

Identify castings with embossed markings, indicating the heat from which the casting was poured, together with the bridge and piece numbers. Die mark the same information on the representative test coupons.

Mark test coupons and castings for each heat. Do not remove coupons until after the castings are heat-treated. The Engineer will reject castings without proper identification unless the inspector can identify corresponding test coupons by matching fractures.

3323 ALLOY STEEL CASTINGS

3323.1 SCOPE

Provide alloy steel castings meeting the requirements of ASTM A 743, for Grade CA-15 and this section.

3323.2 REQUIREMENTS

Provide alloy steel castings meeting the requirements of ASTM A 743, for Grade CA-15 and this section.

Provide castings in a normalized or normalized and tempered condition. Ensure that the reduction of area is at least 30 percent.

3323.3 SAMPLING AND TESTING

Provide test specimens, foundry control, casting details, workmanship and finish, and inspection and testing in accordance with 3322.2.B, "Casting Details," 3322.2.C, "Workmanship and Finish," 3322.3.A, "Test Specimens," and 3322.3.B, "Foundry Control," except cast two test coupons integrally with each casting regardless of mass.

3324 MALLEABLE IRON CASTINGS

3324.1 SCOPE

Provide malleable iron castings.

3324.2 REQUIREMENTS

Provide malleable iron castings meeting the requirements of ASTM A 47M for the grade required by the contract and this section.

For galvanized castings, heat treat to meet the requirements for the specified grade. Galvanize in accordance with ASTM A 153.

3324.3 SAMPLING AND TESTING — (BLANK)

3325 WROUGHT BRONZE PLATES

3325.1 SCOPE

Provide wrought bronze plates.

3325.2 REQUIREMENTS

Provide wrought bronze plates that are cold-finished and meet the requirements of ASTM B 100 for Alloy C51000 or Alloy C65500, or ASTM B 169 for Alloy C61400.

For plates fabricated in accordance with ASTM B 169, meet the following hardness requirements:

<p style="text-align: center;">Table 3325-1 Wrought Bronze Plates</p>

Plate Thickness <i>in [mm]</i>	Hardness	
	Brinell	Rockwell by Conversion
$\geq \frac{5}{16} - \frac{1}{2}$ [8 – 13]	≥ 128	$\geq B73$
$\geq \frac{1}{2} - 2$ [13 – 50]	≥ 121	$\geq B70$

3325.3 SAMPLING AND TESTING — (BLANK)

3327 BRONZE CASTINGS — TYPE 1

3327.1 SCOPE

Provide Type 1 bronze castings for nameplates and other castings.

3327.2 REQUIREMENTS

Provide Type 1 bronze castings meeting the requirements of ASTM B 584, Alloy C83600.

Use this low-strength copper alloy for nameplates and other castings with light detail allowing lightly filleted corners and a natural patina.

3327.3 SAMPLING AND TESTING — (BLANK)

3328 BRONZE CASTINGS — TYPE 2

3328.1 SCOPE

Provide Type 2 bronze castings for bridge bearing plates, medium pressure bearing sleeves, and bright ornamental castings and other items having light details.

3328.2 REQUIREMENTS

Provide Type 2 bronze castings meeting the requirements of ASTM B 148, Alloy C95300 or ASTM B 584, Alloy C86500, subject to the following:

- (1) Modify the chemical composition of Alloy C86500 to allow a maximum manganese content of 3.5 percent; and

- (2) Unless the plans specify one alloy, the Contractor may use either of the two alloys designated in this section.

Use Type 2 bronze castings for bridge bearing plates, medium pressure bearing sleeves, bright ornamental castings, and other items with light detail allowing medium filleted corners and slightly rounded arises and a medium bright finish.

3328.3 SAMPLING AND TESTING — (BLANK)

3329 LUBRICATED BRONZE BEARING PLATES AND BUSHINGS

3329.1 SCOPE

Provide aluminum bronze bearing plates and manganese bronze bushings.

3329.2 REQUIREMENTS

Provide aluminum bronze bearing plates meeting the requirements of ASTM B 148, Alloy C95400 or Alloy C95500; or ASTM B 169/B 169M, Alloy C61400, Temper M20. Provide manganese bronze bushings meeting the requirements of ASTM B 584, Alloy C86200 or Alloy C86300. Provide bearing plates and bushings from standard production.

Provide bronze bearing plates and bushings with recesses completely filled with lubricating compound. Form recesses by trepanning, drilling, or the shell molding process, as shown on the plans, but at least $\frac{3}{16}$ in [5 mm] deep. Ensure recesses have straight sides without grooves, and do not intersect the edges of the parent plate or bushing. Provide plates with recesses that are uniformly spaced in a geometric pattern over the area of the bearing, with adjacent rows overlapping in the direction of motion.

Provide lubricating compound consisting of graphite, metallic substances, and a lubricant binder to form a dense, non-plastic, lubricating insert, capable of withstanding spalling and atmospheric elements. Do not use shellac or other gummy materials as the lubricant binder. Ensure the top surface of the bearing insert is flush with or slightly above the surface of the bearing plate or bushing.

For both bearing plates and bushings, provide a lubricated area that comprises 25 percent to 30 percent of the total area. If the plate or bushing manufacturer uses a bearing insert in the shape of a hollow cylinder, ensure the net lubricated area is at least 20 percent of the total area of the plate or bushing.

If the plans do not indicate which surfaces to lubricate, provide inserts for surfaces that have provisions for movement other than flexural.

Provide bearing plates and bushings with contact surfaces with at least a 125 μin [3.175 μm] finish.

Provide bearing plates that are true to detail, flat surfaces truly flat and curved surfaces curved true to the radius with an allowable working tolerance of 0.02 in [500 μm] between male and female fittings. Provide a minimum net section of $\frac{1}{2}$ in [13 mm] for the bronze.

Provide bushings with a wall thickness of at least $\frac{3}{8}$ in [10 mm]. Provide the machine allowances for the I.D. and O.D. operating fit of bushings recommended by the manufacturer unless otherwise shown on the plans.

Ensure the bronze and steel portions of bearing plates and bushings are assembled in the fabricating shop and match-marked or bonded together and shipped as a unit.

3329.3 SAMPLING AND TESTING — (BLANK)

3331 SHEET BRASS

3331.1 SCOPE

Provide sheet brass.

3331.2 REQUIREMENTS

Provide sheet brass meeting the requirements of ASTM B 36/B 36M, Alloy C26000 or Alloy C26800, in H02, H03, or H04 temper.

3331.3 SAMPLING AND TESTING — (BLANK)

3332 SHEET COPPER

3332.1 SCOPE

Provide sheet copper.

3332.2 REQUIREMENTS

Provide sheet copper meeting the requirements of ASTM B 152/B 152M for any type of copper with a total copper and silver content at least 99.9 percent, and the following:

- (1) Provide a light cold-rolled temper;
- (2) The Engineer will waive the requirements for resistivity and embrittlement tests; and
- (3) Ensure the copper sheet withstands the bend test by cold-bending the sheet through an angle of 180° flat upon itself without fractures on the outside of the bend portion.

3332.3 SAMPLING AND TESTING — (BLANK)

3335 SHEET LEAD

3335.1 SCOPE

Provide sheet lead prepared from pig lead.

3335.2 REQUIREMENTS

Provide sheet lead prepared from pig lead meeting the requirements of ASTM B 29. Provide sheets with a thickness within a tolerance of 5 percent of the thickness required by the contract.

3335.3 SAMPLING AND TESTING — (BLANK)

3336 WROUGHT AND EXTRUDED ALUMINUM

3336.1 SCOPE

Provide aluminum alloy for specified applications.

3336.2 REQUIREMENTS

Provide aluminum alloy products meeting relevant requirements of the ASTM specifications listed in this section. Provide the alloy and temper for a specified application as required by the contract.

Provide sheet and plate products meeting the requirements of ASTM B 209/B 209M (B 209) for Alloy 1100, Alclad 2024, Alclad 3003, Alclad 5083, Alclad 5154, Alclad 5456, or Alclad 6061.

Provide standard structural shapes, rolled or extruded, meeting the requirements of ASTM B 308/B 308M for Alloy 6061-T6.

Provide pipe and tube products meeting the following requirements:

- (1) Drawn, seamless tube in accordance with ASTM B 210/B 210M for Alloy 6061 or Alloy 6063;
- (2) Seamless pipe and seamless extruded tube in accordance with ASTM B 241/B 241M for Alloy 6061 or Alloy 6063; and
- (3) Extruded structural pipe in accordance with ASTM B 429 for Alloy 6061 or Alloy 6063. Provide sand castings meeting the requirements of ASTM B 26/B 26M for Alloy SG70A [356.0] or Alloy S5B [443.0]. Provide permanent mold castings meeting the requirements of ASTM B 108 for Alloy SG70A [9356.0], Alloy SG70B [A356.0], Alloy S5B [443.0], or Alloy S7A [A444.0].

Provide other miscellaneous aluminum products as shown on the plans or the special provisions.

3336.3 SAMPLING AND TESTING — (BLANK)

3340 STAINLESS STEEL CLAD PLATE

3340.1 SCOPE

Provide stainless steel clad plate.

3340.2 REQUIREMENTS

Provide stainless steel clad plate meeting the requirements of ASTM A 264 and this section.

Provide Type 316L stainless steel cladding. Unless the contract requires otherwise, provide a plate clad on one side with a nominal thickness of 10 percent, at least 9 percent of the total plate thickness, or no greater than ½ in [13 mm] of cladding.

Provide cladding and base metal with a shear strength of at least 20,000 psi [140 MPa] when tested in accordance with ASTM A 264.

Provide the clad surface of the plate with a sand blasted and pickled finish or a blast cleaned and pickled finish.

Provide the plate in a heat-treated condition. Perform heat treatment so cladding develops maximum corrosion-resistant properties.

3340.3 SAMPLING AND TESTING — (BLANK)

3348 SEVEN-WIRE STRAND FOR PRESTRESSED CONCRETE

3348.1 SCOPE

Provide one of two grades of seven-wire, uncoated, stress-relieved steel strand for pretensioned and posttensioned prestressed concrete construction.

3348.2 REQUIREMENTS

Provide steel strands meeting the requirements of ASTM A 416, Grade 250 [1725] with an ultimate tensile strength of 250,000 psi [1,725 MPa], and ASTM A 416, Grade 270 [1860], with an ultimate tensile strength of 270,000 psi [1,860 MPa], based on the nominal area of the strand.

3348.3 SAMPLING AND TESTING

Submit two copies of the mill certificate, two copies of the stress-strain curve representing the lot, and steel strand samples to the Engineer. Provide mill certifications with bond strength test results representative of the current year's production, showing that the manufacturing process produces strand with a bond strength of at least 36,000 psi [248 MPa] at a measured free-end slip no greater than $\frac{3}{32}$ in [2.4 mm]. Ensure an accredited, independent testing laboratory performs or certifies bond strength tests. Perform bond strength tests on an embedment length of 18 in [457 mm] in accordance with standard test procedures on file in the Department's Office of Materials.

3351 SHEET STEEL PRODUCTS

3351.1 SCOPE

Fabricate galvanized sheet steel products for erosion control or other uses, including open metal flumes or gutters, culvert headwalls or aprons, anti-seepage diaphragms, erosion dams, and cribbing.

3351.2 REQUIREMENTS

The term, "metal unit" refers to the products specified in this section.

A Materials

Provide galvanized steel in the fabrication of metal units meeting the requirements of ASTM A 929/A 929M, except as modified for different coating classes.

If the plans or specifications specify a galvanized coating requirement other than 2 oz per sq. ft [610 g per sq. m] of sheet, provide galvanized coating in accordance with ASTM A 653/A 653M instead of ASTM A 929/A 929M.

Provide the steel thickness shown on the plans.

Galvanize or sherardize rivets consisting of the same base metal as used for the sheets. Unless the contract requires otherwise, provide bolts, nuts, and washers of commercial grade and galvanized in accordance with ASTM A 153/A 153M. Provide other unspecified steel shapes, plates, bars, and rods made of steel meeting the requirements of 3306, "Low-Carbon Structural Steel," and galvanized in accordance with ASTM A 123/A 123M.

B Fabrication

Provide units fabricated to the shape and dimensions shown on the plans. Avoid cracking or breaking the spelter coating on galvanized sheets.

Ensure fabricated units of the same nominal size and type are interchangeable. Do not drill, punch, or drift to correct defects in manufacture. Ensure the centers of rivets or bolt holes are at least twice the diameter of the holes from the edge of the metal. Locate slots, holes, and lugs for accurate field assembly as shown on the plans.

Drive rivets cold, and ensure the plates are drawn tightly together throughout the entire lap. Provide rivets with full hemispherical heads or heads of a form acceptable to the Engineer. Drive rivets without bending and completely fill the hole with driven rivets.

3351.3 SAMPLING AND TESTING 3226.3

3352 SIGNS, DELINEATORS, AND MARKERS

3352.1 SCOPE

Provide fabricated traffic signs, delineators, and markers consisting of sign panels complete with border, legend, route markers and legend components as individual items.

The Department defines the term “Legend” as all letters, numerals, and symbols that convey the message on signs.

3352.2 REQUIREMENTS

Use traffic signs, delineators, and markers as specified in the MN MUTCD and in accordance with this section.

A Materials

Fabricate signs, delineators, and markers in the colors meeting the FHWA Color Tolerance Charts unless otherwise specified in this section. If using color tolerance charts, determine color compliance by visual comparison with the appropriate chart.

A.1 Base Material for Sign Panels, Delineators and Markers

Use sign base material with no warps or twists and flat so the finished sign, delineator, or marker will lay flat against the post or mounting structure.

A.1.a Sheet Aluminum

Provide sheet aluminum for sign panels, delineators, and markers meeting the requirements of ASTM B 209M for Alloy 5052-H38 or Alloy 6061-T6.

Provide sheet aluminum thickness for single section sign panels, delineators, markers, panel sections of multiple section signs, and sign panels type overlay in accordance with the following:

Table 3352-1	
Sheet Aluminum Thickness	
Length of Longest Side, in [mm]	Thickness, in [μm]
≤ 18 [≤ 460]	0.063 ± 0.004 [1600 \pm 100]
> 18 [460] – 30 [760]	0.080 ± 0.005 [2030 \pm 130]
> 30 [> 760]	0.100 ± 0.005 [2540 \pm 130]
Overlays	0.040 ± 0.004 [1020 \pm 100]

A.1.b Extruded Aluminum, Bolted Type

Provide extruded aluminum panels meeting the requirements of ASTM B 221M for Alloy 6063-T6 and in accordance with the following sizes and weights:

- (1) 12 in [300 mm] wide and at least 2.53 lb per ft [3,765 g per m] of length, and
- (2) 6 in [150 mm] wide and at least 1.02 lb per ft [1,518 g per m] of length.

Use aluminum alloy hardware, as recommended by the manufacturer, or stainless steel hardware to assemble the panel sections and to attach to the supports, except use nylon insert stainless steel locknuts meeting the requirements of ASTM F594, Type 304 for the nuts for post clip bolts.

A.2 Retroreflective Sheeting

Provide retroreflective sheeting on the Approved/Qualified Products List for signs, barricades, reboundable drums, cones, and other traffic control devices as specified in this section. Refer to ASTM D 4956-09, including the supplementary requirement S2, and this section for the classification of retroreflective sheeting. Some standard sheeting types have been modified to reflect Mn/DOT requirements.

A.2.a Sign Sheeting Type III

Provide Sign Sheeting Type III MC for traffic cones and Sign Sheeting Type III MT for tubular markers and yellow cylinder style delineators meeting the performance requirements and impact resistance of ASTM D 4956-09, Type III. Additionally, test the impact resistance of the material at 32 °F [0 °C] and 72 °F [22 °C].

A.2.b Sign Sheeting Type V

Provide Sign Sheeting Type V for cylinder style delineators and tubular markers meeting the performance requirements and impact resistance of ASTM D 4956-09, Type V. Additionally, test the impact resistance of the material at 32 °F [0 °C] and at 72 °F [22 °C].

A.2.c Sign Sheeting Type VI

Provide Sign Sheeting Type VI for temporary roll-up signs meeting the requirements of ASTM D 4956-09, Type VI fluorescent material.

A.2.d Sign Sheeting Type VIII

For reboundable plastic drums, weighted channelizers, and white cylinder style delineators, provide white Sign Sheeting Type VIII meeting the performance requirements and impact resistance of ASTM D 4956-09, Type VIII and provide orange Sign Sheeting Type VIII meeting the performance requirements and impact resistance of ASTM D 4956-09, Type VIII fluorescent material. Additionally, test the impact resistance of the material at 32 °F [0 °C] and at 72 °F [22 °C].

A.2.e Sign Sheeting Type IX

Provide Sign Sheeting Type IX for highway signing, markers, and delineators meeting the performance requirements of ASTM D 4956-09, Type IX. Provide yellow-green and yellow Sign Sheeting Type IX meeting the performance requirements of ASTM D 4956-09, Type IX fluorescent material.

Provide orange Sign Sheeting Type IX FO for rigid substrate construction signs, delineators, and markers meeting the performance requirements of ASTM D 4956-09, Type IX fluorescent material.

A.2.f Sign Sheeting Type XI

Provide Sign Sheeting Type XI for highway signing, markers, and delineators meeting the performance requirements of ASTM D 4956-09, Type XI. Provide yellow-green and yellow Sign Sheeting Type XI meeting the performance requirements of ASTM D 4956-09, Type XI fluorescent material.

Provide orange Sign Sheeting Type XI FO for rigid substrate construction signs, delineators, and markers meeting the performance requirements of ASTM D 4956-09, Type XI fluorescent material.

Provide Sign Sheeting Type XI B for work zone barricade sheeting meeting the performance requirements of ASTM D 4956-09, Type XI.

A.3 Warranty Requirements

Ensure the reflective sheeting manufacturer provides the following warranties to the Department:

Table 3352-2 Reflective Sheeting Manufacturer Warranties	
Material	Warranty

Table 3352-2	
Reflective Sheeting Manufacturer Warranties	
Material	Warranty
Prismatic sign sheeting for permanent signs and white cylinder style delineators (non-fluorescent)	12 years total. The first 7 years covers 100 percent full replacement of all material and labor costs associated with fabricating and installing the sign or device. The final 5 years covers 100 percent of sheeting replacement.
Fluorescent prismatic sign sheeting for permanent signs	10 years total. The first 7 years covers 100 percent full replacement of all material and labor costs associated with fabricating and installing the sign or device. The final 3 years covers 100 percent of sheeting replacement.
Encapsulated lens sign sheeting for permanent signs and yellow cylinder style delineators	10 years total. The first 7 years covers 100 percent full replacement of all material and labor costs associated with fabricating and installing the sign or device. The final 3 years covers 100 percent of sheeting replacement.
Encapsulated lens sign sheeting for traffic cones	Replacement of defective products.
Encapsulated lens sign sheeting for tubular markers	Replacement of defective products.
Prismatic sign sheeting for rigid Signs (work zone use)	3 years covers 100 percent sheeting replacement.
Prismatic sign sheeting for reboundable plastic drums and weighted channelizers	Replacement of defective products.
Prismatic sign sheeting for work zone barricades	Prorated warranty for 3 years covers sheeting replacement.
Rollup Sign Sheeting (work zone use)	Prorated warranty for 3 years covers sheeting replacement.

The Department will require the manufacturer's warranty to cover the loss of retroreflectivity, loss of colorfastness, cracking, and other conditions inherent to the sheeting, including inks and overlay film that causes ineffectiveness in meeting the intended use.

If the sheeting color does not meet the color specifications of ASTM D 4956-09, Table 11 during the warranty period, the Department will consider the sheeting to have lost colorfastness.

Submit applicable warranties for retroreflective sheeting to the Department. Ensure the Department is named the obligee on manufacturer warranties. The Department may remove products from the Mn/DOT-Approved Product List if the Contractor does not honor the warranties.

Maintain retroreflectivity values during the warranty in accordance with the following:

Table 3352-3 Minimum Retroreflectivity Values			
Sign Sheeting Type	Warranty Period, years	Minimum Allowable Retroreflection	Total Daytime Luminance Factor Minimum
Type III	1 – 7	80%	—
Type III	8 – 10	70%	—
Type III MC	None	—	—
Type III MT	None	—	—
Type VI	1 – 3	50%	20%
Type VIII Cylinder Style Delineators	1 – 7	80%	—
Type VIII Cylinder Style Delineators	8 – 12	70%	—
Type VIII Fluorescent Orange	None	—	—
Type IX	1 – 7	80%	—
Type IX	8 – 12	70%	—
Type IX Fluorescent Yellow-Green	1 – 10	70%	60%
Type IX Fluorescent Yellow	1 – 10	70%	40%
Type XI FO Fluorescent Orange	1 – 3	70%	20%
Type XI	1 – 7	80%	—
Type XI	8 – 12	70%	—
Type XI Fluorescent Yellow Green	1 – 10	70%	60%

Type XI FO Fluorescent Yellow	1 – 10	70%	40%
Type XI FO Fluorescent Orange	1 – 10	70%	20%
Type XI B	1 – 10	50%	—
Note: Percentages are based on minimum original values meeting the requirements of ASTM D 4956-09			

A.4 Pigmented Plastic Film Sign Face

Use sign faces made of pigmented, flexible, weather-resistant plastic film free from streaks, blisters, wrinkles, and other surface imperfections. Use plastic film with a high gloss surface that, if applied over a contrasting black and white surface, can completely hide the colors, and can be applied over embossed surfaces. Apply the film to aluminum panels in accordance with the manufacturer’s recommendations. Cure the film for 48h from 70 °F [21 °C] to 90 °F [32 °C] and ensure the film meets the following characteristics:

- (1) Film does not shrink more than 1/32 in [1 mm] from the edge of a panel at 150 °F [65 °C] for 48h,
- (2) Film and adhesive do not separate at -10 °F [-23 °C] for 24h,
- (3) Adhesion, color, and general appearance show no visible effects from immersion in distilled water for 24h, and
- (4) Film and adhesive do not delaminate at 150 °F [65 °C] after 24 h.

A.5 Direct Applied Legend

Do not apply the legend to demountable shapes before applying the legend. Directly apply the legend to the sign face in accordance with the following:

A.5.a Sign Sheeting Type IX.....3352.2.A.2.e

A.5.b Sign Sheeting Type XI..... 3352.2.A.2.f

A.5.c Screen Processed Painted Legend

Use a direct or reverse screening process to apply the painted legend to the face. Use screen process paints approved by the sheeting manufacturer that will adhere to the reflective sheeting surface in accordance with manufacturer’s recommendations.

A.5.d Pigmented Plastic Film Legend

Provide a legend consisting of shapes cut from pigmented plastic film as specified in 3352.2.A.4, "Pigmented Plastic Film Sign Face." Apply the pigmented plastic film directly to the sign face.

A.6 Fasteners

A.6.a Fasteners for Flat Sheet Sign Panel Sections

Use solid, grooved pin rivet fasteners, consisting of a pin meeting the requirements of ASTM B 209M, Alloy 2024-T4 and a collar meeting the requirements of ASTM B 209M, Alloy 6061-T6A, to assemble sign panel sections. The grooved pin shall provide a secure grip for the swaged collar. Use brazier head pins, except use counter sunk head pins or aluminum, stainless steel, nylon, or vinyl plastic shim collars to eliminate interference with legend components or overlays.

A.6.b Fasteners for Type Overlays

Use aluminum alloy pull-through rivet fasteners to attach Type Overlays. Place nylon washers under fastener heads to protect the surface of the reflective sheeting.

B Fabrication

B.1 General

Fabricate signs, delineators and markers as shown on the plans and with details and alphabets contained in the Standard Signs Manual and Federal Standard Highway Signs and Markings book. Fabricate signs, delineators, and markers as recommended by the manufacturer and free of cracks, wrinkles, blisters, and other blemishes.

B.2 Design and Dimensions

Fabricated finished signs, delineators, and markers must be in accordance with the designs, dimensions, and punching as shown on the plans or in the special provisions.

B.3 Surface Treatment of Metal

B.3.a Aluminum Signs

Clean and treat the metal in accordance with manufacturer's recommendations before applying the sign face material. Do not use chromate type chemical conversion treatment.

Apply cleaning or treatment chemicals or detergents as directed by the manufacturer. Maintain laboratory facilities to test and control the concentration of

the solutions used at the treatment plant. Maintain a log of the concentration of treating solutions.

B.3.b Cleaning and Handling

Before painting or applying reflectorizing material, clean surfaces with detergents or cleaners that will not harm any surface treatment on the metal.

After treatment and cleaning, use a device or clean canvas gloves to handle sign base material until after the application of sign face material.

B.4 Applying Sign Face and Legend Sheeting

Apply reflective sheeting, pigmented plastic film sign face, and legend material as recommended by the manufacturer.

If the sign face consists of at least 2 sheeting pieces, match the sheeting for color and brilliance to provide a uniform finish. Reverse the placement of alternate successive width sections of sheeting and place in consecutive order so that the corresponding edges lie adjacent on the finished sign. For adhesive coated sheeting, butt splice the joints. Only use butt splices on signs that will be screen processed with transparent color.

Edge seal or clear coat reflective sheeting for background as recommended by the sheeting manufacturer. Use the sealing material provided by the sheeting manufacturer, or an approved equal.

C Packaging

Before packaging, allow signs to stand for at least 12 h. Pack single panel signs in corrugated paper cartons or other containers to prevent the package from breaking and to protect the signs from damage during shipment. Separate signs with coated paper that will not stick to the sign face material. Package single-panel signs in packages weighing no greater than 125 lb [57 kg] and no thicker than 3½ in [90 mm]. The Department will not require packaging of multiple-panel signs unless shipped by public carrier. Deliver multiple-panel signs without damage.

3352.3 SAMPLING AND TESTING

The Engineer may inspect signs at the manufacturer's plant or at the project. The Engineer will perform final acceptance of signs at the project.

Obtain the Engineer's approval for all sign materials before use. The manufacturer will notify the Engineer at least 14 days before fabricating the signs. The Engineer may send an inspector to the plant to inspect the raw materials or the fabrication. If the inspector inspects the signs during manufacture, the inspector will

stamp each package of signs with the Department inspection mark or with the mark of its delegated representative.

3354 PREFORMED PAVEMENT MARKING TAPE FOR PERMANENT TRAFFIC LANE DELINEATION AND LEGENDS

3354.1 SCOPE

Provide white and yellow retroreflective pavement marking tape prefabricated for recessed traffic marking on bituminous and concrete pavements.

3354.2 REQUIREMENTS

A General

Provide pavement marking tape meeting the following requirements and characteristics:

- (1) Made of prefabricated retroreflective pliant polymer material,
- (2) Provides a cushioned resilient substrate that reduces bead crushing and loss,
- (3) Weather resistant,
- (4) Under traffic wear, shows no appreciable fading in accordance with the color requirements in 3354.2.C, "Color," lifting, or shrinkage throughout the life of the marking,
- (5) Shows no significant tearing, roll back, or other signs of poor adhesion,
- (6) Underside of the pavement marking tape precoated with pressure sensitive adhesive, and
- (7) Protected during shipment and in storage.

Apply the preformed pavement marking tape as recommended by the manufacturer to provide a neat, durable marking that will not flow or distort due to temperature if the pavement surface remains stable. Use equipment and application methods specified by the manufacturer.

Uniformly distribute beads throughout the polymer with strongly bonded protruding surface beads.

Provide precut messages and symbols meeting the requirements of MN MUTCD and FHWA *Standard Alphabets for Highway Signs and Pavement Markings* in custom kits. Use separate pieces or segments to form individual letters or symbols only to the extent supplied by the manufacturer. Do not use standard rolls of line material to piece together individual letters or symbols. Provide lane line widths, tape colors, and adhesive type as required by the contract.

B Retroreflectivity

Provide preformed pavement marking material meeting the minimum initial pavement marking retroreflectivity values using 30 m geometry and meeting the testing procedures of ASTM E 1710:

Table 3354-1		
Minimum Initial Pavement Marking Retroreflectivity		
	White	Yellow
Tape	600 mcd/sq. m/lux	500 mcd/sq. m/lux

C Color

Provide preformed pavement marking tape meeting the following requirements:

- (1) White color no darker or yellower than 17778 of Federal Standard Number 595C,
- (2) Daytime color of yellow meeting the following CIE Chromaticity limits using illuminant "D65"

Table 3354-2				
Daytime Chromaticity Coordinates (Corner Points)				
	1	2	3	4
x	0.470	0.485	0.520	0.480
y	0.440	0.460	0.450	0.420

- (3) Luminance Factor, Cap Y meeting the requirements of ASTM D 6628, Table 3, and
- (4) Nighttime color of yellow meeting the following chromaticity limits as specified in ASTM D 6628, Table 2:

Table 3354-3				
Nighttime Chromaticity Coordinates (Corner Points)				
	1	2	3	4
x	0.575	0.508	0.473	0.510
y	0.425	0.415	0.453	0.490

D Tensile Stress

Provide preformed pavement marking tape with a tensile stress of at least 40 psi [276 kPa] at maximum load when tested in accordance with ASTM D 638. Test a sample 6 in × 1 in × 0.060 in [150 mm × 25 mm × 1.5 mm] at a temperature from 70 °F to 81 °F [21 °C to 27 °C] using a jaw speed of 6 in [150 mm] per min.

E Elongation

Provide preformed pavement marking tape with an elongation of at least 15 percent at maximum load, when tested in accordance with ASTM D 638.

F Skid Resistance

Ensure the surface of the retroreflective pliant polymer provides a skid resistance value of at least 45 British Pendulum Number (BPN) when tested in accordance with ASTM E 303.

G Thickness

G.1 Unpatterned

Provide unpatterned retroreflective pavement marking tape at least 0.060 in [1.5 mm] thick.

G.2 Patterned

Provide patterned retroreflective pavement marking tape at least 0.065 in [1.6 mm] thick at the thickest portion of the patterned cross-section and at least 0.020 in [0.5 mm] thick at the thinnest portion of the cross-section.

3354.3 SAMPLING AND TESTING

Submit samples at least 10 ft [3 m] long of each color required to the Materials Laboratory. Submit to the Engineer a manufacturer's Certificate of Compliance.

Mark the samples with the following information:

- (1) Name of manufacturer,
- (2) Place of manufacture,
- (3) Batch or lot number, and
- (4) Month and year of manufacture.

3355 REMOVABLE PREFORMED PAVEMENT MARKING TAPE FOR TRAFFIC LANE DELINEATION AND LEGENDS

3355.1 SCOPE

Provide white and yellow removable retroreflective preformed pavement marking tape for use as temporary traffic markings.

3355.2 REQUIREMENTS

A General

Provide removable retroreflective preformed pavement marking tape listed on the Approved/Qualified Products List and meeting the following requirements and characteristics:

- (1) Precoated with a pressure sensitive adhesive;
- (2) Capable of adhering to asphalt concrete and portland cement concrete surfaces as recommended by the manufacturer without the use of heat, solvents, or other additional adhesive means, and immediately ready for traffic after application;
- (3) Capable of performing for the duration of six non-winter months;
- (4) Capable of being removed intact or in large pieces without the use of heat, solvents, grinding, or blasting;
- (5) Reinforced by a non-metallic medium to facilitate removal;
- (6) Provided in the widths and shapes required by the contract;
- (7) Available in preformed words and symbols meeting the requirements for the applicable shapes and sizes in accordance with the MN MUTCD;
- (8) Packaged in a way that the chemical composition is not altered or compromised; and
- (9) Meets all requirements in this specification for at least 1 year after the date of purchase, when stored in a cool dry indoor area.

B Color

Provide white retroreflective preformed pavement marking tape no darker or yellower than 17778 of Federal Standard Number 595C.

Provide yellow retroreflective preformed pavement marking tape meeting the following requirements:

- (1) Daytime color meeting the following CIE Chromaticity limits using illuminant "D65/2:"

	1	2	3	4
x	0.470	0.485	0.520	0.480
y	0.440	0.460	0.450	0.420

- (2) Luminance Factor, Cap Y, meeting the requirements of ASTM D 6628, Table 3, and

- (3) Nighttime color meeting the following chromaticity limits as specified in ASTM D 6628, Table 2:

Table 3355-2				
Nighttime Chromaticity Coordinates (Corner Points)				
	1	2	3	4
x	0.575	0.508	0.473	0.510
y	0.425	0.415	0.453	0.490

C Retroreflectivity

Provide retroreflective preformed pavement marking material meeting the minimum initial pavement marking retroreflectivity values using 30 m geometry and meeting the testing procedures of ASTM E 1710:

Table 3355-3		
Minimum Initial Pavement Marking Retroreflectivity		
	White	Yellow
Tape	600 mcd/m ² /lux	500 mcd/m ² /lux

D Frictional Resistance

Ensure the surface of the retroreflective pavement marking film provides a frictional resistance value of at least 45 British Pendulum Number (BPN) when tested in accordance with ASTM E 303.

E Thickness

Provide retroreflective pavement marking film, including beads, at least 50 mils [1.3 mm] thick.

3355.3 SAMPLING AND TESTING

Submit samples at least 10 ft [3 m] long of each color to be used. Submit to the Engineer a manufacturer's Certificate of Compliance. Clean the surface of the tape sample of dirt, adhesive, and asphalt. Provide tape samples capable of being unrolled for the entire length on a surface for testing.

Mark the rolls of material with the following information:

- (1) Name of manufacturer,
- (2) Place of manufacture,
- (3) Batch or lot number, and
- (4) Month and year of manufacture.

3361 STRUCTURAL STEEL TUBING

3361.1 SCOPE

Provide steel tubing for structural use in trusses or bridge rails.

3361.2 REQUIREMENTS

Provide steel tubing that conforms to the following requirements:

- (1) The ASTM requirements below and 3308, "General Requirements for Structural Steel,"
- (2) The requirements for Type A or the plans,
- (3) Either welded or seamless tubing for all applications, and
- (4) Easily weldable using conventional shop practices.

A Type A — Cold formed Carbon Steel Tubing

Provide Type A square or rectangular structural tubing meeting the requirements of ASTM A 500, for Grade B.

B Type B — Hot formed Carbon Steel Tubing

Provide Type B square or rectangular structural tubing meeting the requirements of ASTM A 501.

C Type C — High Strength Low Alloy Weathering Steel Tubing

Provide Type C square or rectangular structural tubing meeting the requirements of ASTM A 847 or ASTM A 618, for Grade Ia, Grade Ib, or Grade II.

3361.3 SAMPLING AND TESTING — (BLANK)

3362 STRUCTURAL STEEL PIPE

3362.1 SCOPE

Provide steel pipe for structural use in railing.

3362.2 REQUIREMENTS

Provide steel pipe for structural use meeting the requirements of ASTM A 53/A 53M, ASTM A 106 (seamless pipe); ASTM A 135 (welded pipe); or

provide structural steel tubing meeting the requirements of ASTM A 500, or ASTM A 501 with the following modifications:

- (1) Unless the contract requires a different mass or wall thickness, provide pipe with a mass of at least the standard mass for Schedule 40 in accordance with ASTM A 53/A 53M;
- (2) Provide pipe with a minimum yield strength of 35,000 psi [240 MPa];
- (3) Unless required by the contract, the Engineer will not require hydrostatic testing;
- (4) Provide pipe free of dirt, grease, loose scale, and rust;
- (5) Provide pipe with plain ends unless the contract requires threaded ends;
- (6) Provide pipe free of mill stamps and large or heavy knurl marks;
- (7) Provide screw fittings 3 in [75 mm] or less in diameter made from either steel or malleable iron. Provide cast steel for screw fittings over 3 in [75 mm] in diameter;
- (8) Provide high-strength low-alloy structural tubing meeting the requirements of ASTM A 618, for Grade 1; and
- (9) Provide welding fittings meeting the requirements of ASTM A 234/A 234M for factory-made wrought carbon steel and ferritic alloy steel welding fittings. Use a grade equivalent to the tensile properties specified for the steel pipe.

3362.3 SAMPLING AND TESTING — (BLANK)

3363 ALUMINUM TUBE FOR PIPE RAILING

3363.1 SCOPE

Provide aluminum alloy extruded tubes for bridge railing.

3363.2 REQUIREMENTS

Provide aluminum alloy extruded tubes for bridge railing meeting the requirements of ASTM B 221, Alloy 6061-T6510.

3363.3 SAMPLING AND TESTING — (BLANK)

3364 WROUGHT STEEL PIPE

3364.1 SCOPE

Provide wrought steel pipe for bridges and structures.

3364.2 REQUIREMENTS

Provide wrought steel pipe meeting the requirements of ASTM A 53/A 53M with a mass or wall thickness that at least meets the requirements of ASTM A 53/A 53M, Schedule 40, unless the contract requires otherwise.

Galvanize the pipe and fittings, unless the contract requires otherwise.

The Contractor may provide cast steel or malleable iron screw fittings for fittings no greater than 3 in [75 mm] in diameter. Provide cast steel screw fittings for fittings greater than 3 in [75 mm] in diameter.

Provide welding fittings meeting the requirements of ASTM A 234/A 234M for butt welding fittings.

3364.3 SAMPLING AND TESTING — (BLANK)

3365 DUCTILE IRON PRESSURE PIPE

3365.1 SCOPE

Provide ductile iron pressure pipe.

3365.2 REQUIREMENTS

Provide ductile iron pressure pipe meeting the requirements of ASTM A 377 for the diameter and relevant American Standard required by the contract. Provide ductile iron pressure pipe coated with bituminous enamel lining and exterior coating.

3365.3 SAMPLING AND TESTING — (BLANK)

3366 COPPER WATER TUBE AND FITTINGS

3366.1 SCOPE

Provide copper water tube and fittings.

3361.2 REQUIREMENTS

Provide copper water tube meeting the requirements of ASTM B 88/B 88M for Type A pipe, annealed. Provide red brass, flared fittings for copper water tube.

3361.3 SAMPLING AND TESTING — (BLANK)

3371 STEEL SHELLS FOR CONCRETE PILING

3371.1 SCOPE

Provide steel shells for cast-in-place concrete piling.

3371.2 REQUIREMENTS

Provide cylindrical steel shells for cast-in-place concrete piles meeting the physical strength and chemical requirements of ASTM A 252, Grade 3.

If specified in the plans as an alternative, the Contractor may provide cold-rolled fluted steel shells meeting the requirements of SAE 1010 or SAE 1015 with a tensile yield strength of at least 50,000 psi [345 MPa] in accordance with ASTM A 370. Provide tapered piles with a tip diameter of at least 8 in [200 mm] and a butt diameter of at least the nominal diameter required by the contract.

Provide steel shells with a thickness and strength capable of withstanding the driving forces to substantial refusal in accordance with 2452.3.E, "Penetration and Bearing," and with a nominal wall thickness as specified in Table 3371-1, "Steel Shell Requirements."

For piling with a painted finish in accordance with 2452.3.J, "Painting Steel H-Piles and Steel Pile Shells," or with a galvanized finish in accordance with 3394, "Galvanized Structural Shapes," provide piling free of irregularities or deleterious matter adversely affecting the finished coating.

The Contractor may request the Engineer's approval of the use of small quantities of piling representing less than 5 percent of the entire structure, from the Contractor's surplus of cut-offs and overruns. Submit mill test reports and a certification stating that the Department previously approved the piling for use on another Department project.

Table 3371-1	
Steel Shell Requirements	
	Steel Shell Options

Nominal Pile Size, in [mm]	Nominal Outside Diameter, in [mm]	Minimum Wall Thickness, in [mm]*
10 [254]	10 [254]	0.219 [5.56]
	10¾ [273]	0.219 [5.56]
12 [305]	12 [305]	0.250 [6.35]
	12¾ [324]	0.250 [6.35]
	12 [305], fluted	0.179 [4.55]
16 [406]	16 [406]	0.312 [7.92]
	16 [457], fluted	0.203 [5.16]
18 [457]	18 [457]	0.375 [9.53]
	18 [457], fluted	0.250 [6.3]
20 [508]	20 [508]	0.375 [9.53]
24 [610]	24 [610]	0.500 [12.70]
* Unless otherwise shown on the plans or special provisions. Do not use fluted or tapered shells for exposed pile-bent piles unless otherwise shown on the plans or special provisions for a particular structure.		

3371.3 SAMPLING AND TESTING

Provide one certified copy of mill test reports with heat numbers identified, including physical test reports and chemical analyses, and mill shipping papers to the Engineer before delivering the material to the project. Include the actual carbon, manganese, and phosphorus contents in the chemical analysis report.

3372 STEEL PILING

3372.1 SCOPE

Provide steel H-piles for structure construction.

3372.2 REQUIREMENTS

Provide steel H-piles for bearing sections in the size and weight per unit of length as shown on the plans and meeting the requirements of ASTM A 572/ASTM A 572M, Grade 50 [Grade 345] for structural quality carbon steel shapes.

Provide steel H-pile tip listed on the Approved/Qualified Products List.

3372.3 SAMPLING AND TESTING

Provide one certified copy of mill test reports with heat numbers identified, including physical test reports and chemical analyses, and mill shipping papers to the Engineer before delivering the material to the project. Include the actual carbon, manganese, and phosphorus contents in the chemical analysis report.

3373 STEEL SHEET PILING

3373.1 SCOPE

Provide steel sheet piling for construction of bridges and piers.

3373.2 REQUIREMENTS

Provide a steel sheet piling of the style, dimensions, and mass required by the contract and meeting the requirements of ASTM A 328/A 328M or ASTM A 572/A 572M for Grade 290 [42], Grade 345 [50], or Grade 415 [60].

3373.3 SAMPLING AND TESTING — (BLANK)

3376 FENCE WIRE

3376.1 SCOPE

Provide barbed, woven, and chain link fencing wire, wire fasteners, tie wires, hardware, and tension wire.

3376.2 REQUIREMENTS

A Barbed Wire

Provide 4 point, full round barbs at least 0.375 in [9.5 mm] long. The Contractor may provide one of the following types of barbed wire, meeting the requirements of AASHTO M 280, unless the contract requires otherwise:

- (1) Zinc-coated barbed wire meeting the requirements of Class 3,
- (2) Standard security grade aluminum-coated barbed wire, or
- (3) High security grade aluminum-coated barbed wire.

B Woven Wire

Provide metallic-coated, Type A or Type Z Class 3 steel woven wire fence fabric meeting the requirements of AASHTO M 279, for the size and construction required by the contract.

Provide No. 9 Grade 60 design woven wire fabric meeting the requirements of AASHTO M 279 if the contract does not specify the size and construction.

Use the hinge joint method with at least 1½ tightly wrapped twists to join the vertical stay wires to each horizontal line wire.

C Chain Link

Provide chain link fabric meeting the requirements of AASHTO M 181 for the type required by the contract. Use chain link fence with the finished wire size, mesh size, selvage type, and fabric height as shown on the plans. Use Class A extruded and bonded or Class B bonded Type IV fabric, PVC coated steel.

D Miscellaneous Items

Provide hardware items meeting the requirements of AASHTO M 181 unless otherwise specified in this section or required by the contract.

Use L-shaped staples with barbed, serrated, or ring shanks or U-shaped staples made of 9 gauge [3.8 mm] diameter wire galvanized after fabrication meeting the requirements of ASTM A 153 to attach wire to wood posts with shank length as specified in 2557.3.C.2, "Barbed Wire and Woven Wire.

Use flat metal bands instead of wire fasteners if approved by the Engineer.

Provide hog rings meeting the requirements of ASTM F 626. When polymer coating is required, provide hog rings with a Class 2A or Class 2B polymer coating thickness meeting the requirements of ASTM F 668.

Provide wire ties meeting one of the following requirements:

- (1) 9 gauge steel meeting the requirements of AASHTO M 181, or
- (2) At least 0.179 in [4.55 mm] aluminum alloy meeting the requirements of ASTM B 211, Alloy 1100 H18.

Provide polymer-coated wire ties meeting the same coating thickness requirements as polymer-coated fabric.

Provide tension wire meeting the requirements of AASHTO M 181.

Provide tension bars, truss rods, truss rod tighteners, barbed wire arms, tension bands, brace bands, rail and brace ends, rail sleeves, post and line caps, and cups meeting the requirements of AASHTO M 181.

Provide polymer-coated tension bars, truss rods, truss rod tighteners, tension bands, brace bands, post and line caps, and cups with a bonded polymer coating thickness of at least 0.010 in [0.25 mm].

Provide zinc coated nuts and bolts meeting the requirements of AASHTO M 232. Shop-paint or field-paint nuts and bolts when polymer-coated fence is required.

3376.3 SAMPLING AND TESTING

Submit to the Engineer a manufacturer's Certificate of Compliance for each fence component specified in this specification.

3379 FENCE GATES

3379.1 SCOPE

Provide vehicular gates and pedestrian gates with pipe frames.

3379.2 REQUIREMENTS

A General

Use the same pipe, hardware, fittings, fence wire, and appurtenance materials to assemble all gates provided to the project.

B Materials

Use a frame made of galvanized steel pipe or aluminum alloy pipe.

B1 Galvanized Steel Pipe

Provide galvanized steel pipe meeting the requirements of ASTM A 53 for galvanized Standard Schedule 40 pipe with plain ends. Hydrostatic testing of the pipe is not required.

B2 Aluminum Alloy Pipe

Provide aluminum alloy pipe meeting the requirements of AASHTO M 181.

B3 Fittings and Hardware

As shown on the plans, use corner fittings, tops, stretcher bars, truss rods, and other required fittings, hardware, and appurtenances made of steel, malleable iron, wrought iron, or aluminum alloy. If using steel or iron, galvanize fittings or hardware in accordance with AASHTO M 181 after fabrication.

B4 Wire

Provide barbed wire, gate fabric for woven wire fence, and gate fabric for chain link fence as specified in 3376, "Fence Wire."

C Physical Properties

Use gate and members with physical properties as shown on the plans.

Use fittings, hardware, and other required appurtenances capable of being securely fastened and fitted to meet the requirements of the approved design.

Provide hinges and catch and locking devices meeting the requirements of an approved design.

3379.3 SAMPLING AND TESTING

Submit to the Engineer a manufacturer's Certificate of Compliance for each component in this section.

A Metal Pipe and Fittings	3406
B Fence Wire and Fasteners	3376

3381 WIRE ROPE AND FITTINGS FOR CABLE GUARDRAIL

3381.1 SCOPE

Provide wire rope and accessory fittings for use in cable guardrail construction.

3381.2 REQUIREMENTS

Provide wire rope and fittings for proprietary high-tension cable guardrail systems meeting the manufacturer's specifications.

Provide wire rope and fittings for low-tension cable guardrail meeting the requirements of AASHTO M 30 and the following:

A Wire Rope Requirements

Provide wire rope meeting the requirements of Type 1 with Class A coating unless otherwise specified.

B Fitting Requirements

Unless the manufacturer specifies otherwise, provide bolts and nuts used to assemble the guardrail elements meeting the requirements of ASTM A 307.

Provide bolt heads and nuts with dimensions meeting the requirements of ANSI No. B 18.2 for the type shown on the plans.

Use externally threaded fittings including end tie rods, anchor rods, post loops, and splicing studs that transmit direct tensile stress having a tensile strength of at least 75,000 psi [520 MPa]. Use internally threaded fittings such as turnbuckles, cable sockets, and nuts capable of withstanding a proof load equal to 85 percent of the proof load requirements for nuts as specified in ASTM A 307, Table III. Use expansion assemblies, cable splices, and connections capable of withstanding a proof load equal to the tensile strength required of the attached wire rope cable or as specified by the manufacturer.

Provide steel rectangular plate washers and cable clamps with a tensile strength of at least 60,000 psi [420 MPa]. Provide ferrous metal plain circular washers meeting the requirements of ANSI/ASME B 18.22.1, Type A.

3381.3 SAMPLING AND TESTING

Provide samples for testing as directed by the Engineer.

The Engineer will test wire rope and fittings for cable guardrail meeting the requirements of AASHTO M 30.

3382 STEEL PLATE BEAMS AND FITTINGS FOR TRAFFIC BARRIERS (GUARDRAIL)

3382.1 SCOPE

Provide steel plate beams and fittings for use in guardrail construction.

3382.2 REQUIREMENTS

Provide steel plate beams and fittings for guardrail construction meeting the requirements of AASHTO M 180 for the type and class required by the contract.

Unless the plans show otherwise, provide beams meeting the requirements for Class A, Type II (galvanized).

Provide w-beam and thrie-beam rail elements, posts, blocks, soil plates, reducer sections, and end treatments that meet the requirements of *A Guide to Standardized Highway Barrier Hardware*, published by AASHTO, ARTBA, and AGC.

3382.3 SAMPLING AND TESTING

Triple-spot test galvanized beams and fittings.

3385 ANCHOR RODS

3385.1 SCOPE

Provide anchor rod material in four general strength levels. The plans may show, or the special provisions may specify other types of anchor rod material.

3385.2 REQUIREMENTS

Use the ASTM or product reference for each type of anchor rod material. Unless the contract requires otherwise, provide anchor rods meeting the requirements for Type A and fabricated from single rounds. Galvanize Type A, Type B, and Type C anchor rods in accordance with 3392, "Galvanized Hardware," unless otherwise shown on the plans.

A Type A — Carbon Steel Anchor Rods

Provide Type A anchor rods meeting the requirement of ASTM F 1554, for Grade 36, Type 2A, with supplementary requirement S3 for permanent grade identification. Provide nuts and washers as recommended in ASTM F 1554 for Grade 36 anchor rods.

B Type B — Intermediate Strength Anchor Rods

Provide Type B anchor rods meeting the requirements of ASTM F 1554, for Grade 55, Type 2A, with supplementary requirement S1 for weldability and supplementary requirement S3 for permanent grade identification. Provide nuts and washers as recommended in ASTM F 1554 for Grade 55 anchor rods.

C Type C — High Strength Anchor Rods

Provide Type C anchor rods meeting the requirements of ASTM F 1554, for Grade 105, Type 2A, with supplementary requirement S3 for permanent grade

identification and supplementary requirement S5 for Charpy impact testing. Provide nuts and washers as recommended in ASTM F 1554 for Grade 105 anchor rods. Do not make an anchorage cage by tack-welding Type C anchor rods or welding anchor rods to other material. Hold Type C anchor rods in place mechanically using methods approved by the Engineer.

D Type D — Stainless Steel Anchor Rods

Provide Type D anchor rods, nuts, and washers meeting the requirements of ASTM A 276 for Type 304 or Type 316 stainless steel, and 3391.2, "Fasteners, Requirements," for stainless steel fasteners. Do not make an anchorage cage by tack welding Type D anchor rods or welding anchor rods to other material. Hold Type D anchor rods in place mechanically using methods approved by the Engineer.

3385.3 SAMPLING AND TESTING — (BLANK)

3391 FASTENERS

3391.1 SCOPE

Provide various types and grades of fasteners for use in general and structural applications.

3391.2 REQUIREMENTS

Provide fasteners of the type shown on the plans. Provide bolts, nuts, and washers meeting the requirements of ANSI for the type required by the contract. Unless otherwise required by the contract, provide threads that are ANSI Coarse Thread Series with a Class 2A tolerance for bolts and Class 2B tolerance for nuts.

A Common Structural Steel Bolts

Provide bolts and nuts meeting the requirements of ASTM A 307. For bolts at least $\frac{1}{2}$ in [13 mm] in diameter, use Grade B bolts with heavy hexagon nuts.

B High Strength Structural Steel Bolts

Provide field and shop bolts for steel bridges meeting the requirements of ASTM A325, Type 3 bolts. Provide bolts that project through the nut from $\frac{1}{8}$ in [3 mm] to $\frac{3}{8}$ in [10 mm]. Provide field and shop nuts for steel bridges that meet ASTM A 563/A 563M, Grade C3 or DH3 nuts and shop washers for steel bridges that meet ASTM F 436/F 436M, Type 3 washers.

Provide bolts, nuts, and washers installed before the application of the prime coat, in the uncoated "Black" condition. Apply the same paint coatings to the bolts as applied to the structural steel. Provide mechanically galvanized fasteners that are to be field installed after the application of the prime coat meeting the requirements of ASTM B 695, Class 50, Type 1.

For all other bridges and structures, provide bolts meeting the requirements of ASTM A 325, Type 1, (for painted or galvanized applications) or Type 3 (for unpainted weathering steel applications). Provide bolts that project through the nut from $\frac{1}{8}$ in [3 mm] to $\frac{3}{8}$ in [10 mm]. Provide nuts meeting the requirements of ASTM A 563/A 563M and washers meeting the requirements of ASTM F 436/F 436M.

Only retighten bolts meeting the requirements of ASTM A 325 once.

Regardless of specified finish, provide nuts lubricated with a lubricant of contrasting color meeting the requirements of ASTM A 563 Supplementary requirements S1, S2, and S3 at the time of the installation of the fasteners.

C Bolts for Wood Construction

Unless otherwise shown on the plans, provide bolts for wood construction in accordance with 3391.2.A, "Common Structural Steel Bolts," and galvanized by a mechanical or hot-dip process. Provide the mass of coating meeting the requirements of ASTM A 153/A 153M.

D Stud Welded Fasteners

Provide studs in the size and configuration required by the contract. Provide defect-free, weldable carbon steel studs meeting the requirements of ASTM A 108 for cold drawn bars, Grade 1015, Grade 1018, or Grade 1020. For the purpose of welding, provide studs with fluxed tips or fluxed ferrules and equipped with a ceramic ring or ferrule arc shield.

Provide material for the studs meeting the following characteristics:

- (1) An ultimate strength of at least 60,000 psi [420 MPa];
- (2) A yield strength of at least 50,000 psi [345 MPa];
- (3) A elongation of at least 20 percent in 2 in [50 mm]; and
- (4) A reduction of area of at least 50 percent.

Provide threaded studs with nuts capable of developing the minimum ultimate strength requirement of the net cross section area of the threaded portion of the stud.

Provide shear connector studs with a head height and head diameter within a dimensional tolerance of $\frac{1}{16}$ in [1.5 mm].

Identify stud containers by the heat number of the steel from which the studs were produced.

E Stainless Steel Bolts

Provide stainless steel bolts and nuts made of material meeting the requirements of ASTM A 276, for Condition A or Condition B, Type 302, Type 304, or Type 316. Provide finished bolts with the following characteristics:

- (1) A yield strength of at least 30,000 psi [205 MPa],
- (2) An ultimate tensile strength of 75,000 psi [520 MPa], and
- (3) A minimum elongation of 40 percent in 2 in [50 mm].

After fabrication (if required), fully anneal bolts, nuts, and washers to promote maximum corrosion resistance of the stainless steel. After heat treatment, give parts a pacifying treatment in a nitric acid solution. Perform the pacifying treatment in accordance with standard commercial practice. Provide bolts of dimensions meeting the requirements of ANSI B 18.2 for Regular Hexagon-head Cap Screws. Finish surfaces in accordance with the American bolt, nut and rivet manufacturers. Provide nuts meeting the requirements for ANSI B 18.2 for Regular Finished Hexagon. Provide washers as shown on the plans.

F Tension Indicators

Provide and test compressible-washer-type, direct tension indicators (DTI) in accordance with ASTM F 959/F 959M. Submit three samples of each lot of tension indicators with the test reports to the Materials Laboratory for testing. The Engineer will reject lots if the representative washer samples fail the tests performed.

3391.3 SAMPLING AND TESTING

If the minimum bolt strength requirements are specified in the contract, perform testing in accordance with ASTM A 370, except only use a wedge for testing high-strength structural steel bolts. Do not use reduced-dimension specimens for test purposes. Determine the yield strength using relevant methods specified in ASTM E 8M. For bolts with nuts, provide nuts capable of withstanding a proof load equal to the required tensile strength of the bolt.

Provide test bolts and nuts of each type, in each size and length. Provide two test bolts and nuts for each increment of 1,000, or fraction of 1,000, bolts supplied.

3392 GALVANIZED HARDWARE

3392.1 SCOPE

Provide galvanized hardware as specified in the contract.

3392.2 REQUIREMENTS

Provide galvanized hardware and miscellaneous items as shown on the plans. Galvanize hardware items using the hot-dip process meeting the requirements of with ASTM A 153, or mechanically galvanize the hardware meeting the requirements of ASTM B 695, Class 50, Type I.

3392.3 SAMPLING AND TESTING

Sample and test meeting the requirements of the Schedule of Materials Control.

3394 GALVANIZED STRUCTURAL SHAPES

3394.1 SCOPE

Provide galvanized structural shapes, plates, bars, and castings for pipes and structures.

3394.2 REQUIREMENTS

Blast clean all items in accordance with SSPC-SP6/NACE No. 3 – Commercial Blast Cleaning before galvanizing.

Provide structural shapes, plates, bars, and castings galvanized meeting the requirements of ASTM A 123. Provide castings that have been pickled before galvanizing.

For galvanized items that are warped or distorted, straighten to tolerance no greater than $\frac{1}{8}$ in [3 mm] in 10 ft [3,000 mm], or as directed by the Engineer.

For galvanized surfaces that have handling marks or minor chips that no greater than $\frac{1}{2}$ in [12.5 mm] at the narrowest dimension, repair in accordance with ASTM A 780, Annex 1 or Annex 2 (brush applied paint only). Ensure the dry film thickness (DFT) of the coating repair is in accordance with ASTM A 123. Perform repairs in accordance with the supplier's quality procedures. Obtain an approved non-conformance report (NCR) for each repair.

3394.3 SAMPLING AND TESTING — (BLANK)

3399 FLAP GATES

3399.1 SCOPE

Provide flap-type drainage control gates for direct attachment to the outlet ends of culvert and sewer pipe as shown on the plans or required by the special provisions. If shown on the plans or required by the special provisions, provide gates with attachment to the outlet structure.

3399.2 REQUIREMENTS

A Base Metal

Provide frame, flap, flange, hinge bars, and other basic components of the gate assembly made of cast iron, cast steel, structural steel, or other metals approved by the Engineer. Provide hinge bushings and pins made of non-corrosive metal approved by the Engineer. Do not use bronze or brass fittings on gates attached to aluminum alloy drainage structures.

Provide iron castings meeting the requirements of ASTM A 48, Class 30B or better, ASTM A 47 or ASTM 47 M, Grade 32510. Provide steel castings meeting the requirements of ASTM A 27, Grade 60-30 or better. Provide steel components in accordance with 3306, "Low-Carbon Structural Steel," or 3309, "High-Strength Low-Alloy Structural Steel."

B Dimensions and Design

Provide flap gates designed to permit direct attachment to pipe of the type and size required by the contract, or to the outlet structure as shown on the plans or required by the special provisions. Ensure the gates provide practical water tightness against a face pressure and open automatically under a back head allowing free outflow.

Provide a double pivoted flap hinge or a flap hinge otherwise designed to provide accurate seating of the flap and frame and ensure complete closure of the flap using its own mass. Use a design that limits the hinge movement to prevent the flap from becoming lodged in the frame opening.

Provide gates designed to adequately withstand the seating head as shown on the plans. If the plans do not show seating head requirements, provide gates designed to withstand a 10 ft [3 m] seating head.

Provide gates designed or installed to hang closed at all times. Provide suitable flange or hinge fastening adjustments that provide a vertical frame seat when installed. Include provisions for attaching the gate assembly to the pipe or structure as shown in the plans or required by the special provisions, using bolts, flanges, and compression bands or other devices.

For metal pipe installations, the Contractor may shop assemble the gates on a 24 in [600 mm] section of pipe with rivets or bolts. Install the stub section of pipe, with gate attached, on a zero or flat grade when feasible.

The Engineer will approve all critical dimensions and design details of the gate assembly. Provide shop drawings to the Engineer upon request.

C Fabrication and Assembly

Provide castings and fabricated steel components that are free of defects that affect its ability to function for its intended purpose

Machine mill or grind the contact surfaces between frame and flap to provide true bearing around the entire circumference.

Galvanize cast steel and fabricated steel components of the gate assembly, including steel bolts, nuts, and washers in accordance with ASTM A 153 for the appropriate class of material. In lieu of galvanizing, the Contractor may paint steel specified in 3309, "High-Strength Low-Alloy Structural Steel," in accordance with 2478, "Organic Zinc-Rich Paint System," with an aluminum finish coat. Paint iron castings with an asphalt or coal-tar pitch varnish, or galvanize as required for steel castings. Paint and galvanize after fabrication and before assembly.

3399.3 SAMPLING AND TESTING

Ensure the manufacturer prepared and tested physical test specimens for the tests required in accordance with this section at no additional cost to the Department. Submit to the Engineer the certified test reports provided by the manufacturer showing the results of each test before delivering the material to the project. The Engineer may require the manufacturer make check tests, if results of previous tests are not conclusive.