



## SECTION 1020

### CORRUGATED METALLIC-COATED STEEL CULVERT PIPE, PIPE-ARCHES AND END SECTIONS

**1020.1 Scope.** This specification covers corrugated steel pipe, pipe-arches and flared end sections intended for use in the construction of culverts and similar uses. The steel used in fabrication shall have a protective metallic coating of zinc (galvanizing) or aluminum.

**1020.2 Basis of Acceptance.** Unless otherwise specified, the basis of acceptance will be in accordance with AASHTO M 36. Pipe shall be from an approved qualified plant and will be accepted based on certification, manufacturer quality control documentation and tests on samples as required by the engineer. Pipe may be fabricated using English units of measurement. Pipe fabricated using English measurements shall be in accordance with the dimensions and tolerances shown on the plans.

#### **1020.3 Material.**

**1020.3.1 Steel Sheet.** Steel sheet shall be certifiable in accordance with AASHTO M 218 or AASHTO M 274. Finished steel sheet shall be free from injurious defects such as blisters, flux and uncoated spots.

**1020.3.2 Zinc Coating.** Zinc for coating or galvanizing shall be prime western grade or better. Zinc-coated steel shall have a weight of zinc coating no less than 2.00 ounces psf of double exposed surface. If the average weight of zinc coating, as determined from the required samples, is less than 2.00 ounces psf, or if any one specimen has less than 1.80 ounces of zinc psf of double exposed surface, the lot sampled will be rejected or resampled, as determined by the engineer. If a retest is conducted, the weight of zinc coating of all of the original samples and the samples for retest shall average at least 2.00 ounces psf of double exposed surface, and no specimen shall have less than 1.80 ounces psf, or the entire lot sampled will be rejected. Adherence of coating shall be such that no peeling occurs while the material is being corrugated or formed into pipe.

**1020.3.3 Aluminum Coating.** Aluminum for coating shall be commercially pure aluminum. The bath analysis shall be in accordance with the *Aluminum Bath Analysis* table shown on the plans. Aluminum-coated steel shall have a weight of aluminum coating no less than 1.00 ounce psf of double exposed surface. If the average weight of aluminum coating, as determined from the required samples, is less than 1.00 ounce psf or if any one specimen has less than 0.90 ounce of aluminum psf of double exposed surface, the lot sampled will be rejected or resampled, as determined by the engineer. If a retest is conducted, the weight of aluminum coating of all of the original samples and the samples for retest shall average at least 1.00 ounce psf of double exposed surface and no specimen shall have less than 0.90 ounce psf or the entire lot sampled will be rejected.

#### **1020.3.4 Documentation.**

**1020.3.4.1 Sheet Manufacturer's Certified Analysis.** The manufacturer of each brand shall file with Construction and Materials a certificate setting forth the name or brand of metal to be furnished, the specified chemical composition and a typical or average analysis showing the

percent of carbon, phosphorus, manganese, sulfur and silicon. The certificate shall be sworn to, for the manufacturer, by a person having legal authority to bind the company.

**1020.3.4.2 Sheet Manufacturer's Guarantee.** The manufacturer of the steel sheet shall submit with the certified analysis a guarantee providing that all metal furnished is in accordance with the specification requirements, shall bear a suitable identification brand or mark and shall be replaced without cost to the Commission when not in accordance with the specified analysis, sheet thickness or coating. The guarantee shall be so worded as to remain in effect as long as the manufacturer continues to furnish material. The manufacturer shall conduct such tests and measurements as necessary to ensure the material produced is in accordance with all specification requirements. These tests and measurements shall be identified by the identification symbols or code used on the sheet in a manner that will permit the manufacturer to produce specific reports showing test results representative of specific lots of steel sheet. Copies of reports of these tests shall be kept on file and shall be submitted to the engineer upon request. The brand shall be removed or obliterated by the manufacturer on all material where control tests, as outlined herein, do not show conformance to this specification.

#### **1020.4 Fabrication.**

**1020.4.1 Riveted Seams.** A longitudinal seam will not be permitted on the corner radius or invert of pipe-arch.

**1020.4.2 Resistance Spot Welded Seams.** A longitudinal seam will not be permitted on the corner radius or invert of pipe arch.

**1020.4.3 Shop Elongation.** If round pipe is required to be shop elongated, the vertical axis shall be five percent greater than the nominal diameter. A tolerance of one percentage point in elongation will be permitted. Approximately 2 feet at each end of an installation may be left round to accommodate connecting end treatments or extensions. A paint mark to indicate the top of the pipe shall be placed on each piece of shop elongated pipe, and round ends on an elongated pipe shall be clearly marked "Outside End-Round".

**1020.4.4 Beveled Ends.** Corrugated metal pipe requiring beveled ends to conform to the adjacent roadway slope shall be cut in such a manner as to leave smooth edges without damage to the coating away from the cut edge. Cut edges shall be completely covered with two coats of single component inorganic zinc or organic zinc-rich paint meeting the approval of the engineer. No other end finish will be required for pipe with beveled ends.

**1020.4.5 End Sections.** Metal end sections shall be in accordance with the requirements for base metal, coating, fabrication, sampling, accepted brands of metal, sheet manufacturer's certified analysis, sheet manufacturer's guarantee, sheet thickness, workmanship and repair of coating. The sections shall conform to the shape, dimensions and sheet thicknesses shown on the plans, and shall be manufactured as integral units or so the sections may be readily assembled in place.

**1020.4.6 Bands.** Formed bands may be used on pipe with annular corrugations and helically corrugated pipe with reformed ends. Bands shall be formed with a minimum of two corrugations matching the profile of the pipes being joined together. The corrugations shall be spaced to provide seating in the second corrugation of each pipe and without creating more than 1/2-inch annular space between the pipe ends when joined together.

**1020.4.6.1** Circumferentially corrugated bands, bands with projections and helically corrugated bands shall be so constructed as to lap on an equal portion of each of the culvert sections and shall be connected at the ends by galvanized angles having minimum dimensions

of 2 x 2 x 3/16 inch, fastened with galvanized bolts of 1/2-inch minimum diameter. Formed bands shall be fastened together by two 1/2-inch bolts through a bar, and strap welded to the band. Angles shall be secured to the coupling bands by riveting, welding, resistance spot welding or a method approved by the engineer at each corrugation. Rivets shall be placed such that the head of the rivet will be on the inside of the band. Welds, except for resistance spot welds, shall be painted with one coat of zinc dust-zinc oxide or zinc-rich paint meeting the approval of the engineer. The 7-inch and 10 1/2-inch bands shall have at least two fastening bolts, the 12-inch and 14-inch bands shall have at least three fastening bolts and the 16 1/4-inch or greater bands shall have at least four fastening bolts. Alternate methods of fastening the ends of coupling bands may be used if approved by the engineer. Coupling bands for pipe-arch and shop elongated pipe shall be shaped to fit the structure.

**1020.4.6.2** As an alternate to coupling bands, a bell and spigot joint system may be used as approved by Construction and Materials.

**1020.4.7 Special Fittings.** Special fittings, angles and tees shown on the plans shall be fabricated by welding in such a manner as to avoid excessive damage to the coating away from the welded area. The welded area and adjacent damaged coating shall be repaired in accordance with [Sec 1020.6](#).

**1020.5 Sampling, Testing and Acceptance Procedures.** All fabrication plants furnishing pipe for MoDOT projects shall be qualified as herein described. A pipe distributor, who does not fabricate pipe, may attain qualification as set forth for a pipe manufacturer or may furnish pipe for MoDOT projects that is marked and certified from an approved plant. All pipe will be subject to inspection by the engineer at the source of manufacture, at an intermediate shipping terminal or at destination. The engineer shall be allowed unlimited access to all facilities and records, as required, to conduct inspection and sampling in accordance with [Sec 106](#).

**1020.5.1 Application for Placement on the Qualified List.** For a plant to become qualified, a written request shall be sent by the manufacturer to Construction and Materials with the following information:

- (a) A QC Plan, in accordance with [Sec 1020.5.2](#), for each plant from which pipe is to be fabricated for use on MoDOT projects.
- (b) A certification statement from the manufacturer that the quality control procedures at the plant, at a minimum, meet the requirements set forth in the manufacturer's QC Plan.
- (c) Sources for each material to be used in the fabrication of pipe shall be provided.
- (d) A guarantee that all material to be used in the fabrication of pipe will be in accordance with MoDOT specifications and that pre-approval for any source of material will be received prior to use.
- (e) Units of measurement, English or metric, used to fabricate the pipe.

**1020.5.2 Manufacturer's QC Plans.** The QC Plan for each plant shall include the following:

- (a) A list of personnel with corresponding authority and responsibility.
- (b) Qualifications and training of QC personnel, current and proposed.

(c) A description of how the manufacturer proposes to control production in order to assure all material and workmanship incorporated into the fabrication of pipe meets the applicable specification requirements.

(d) Lot sizes, the specific tests to be performed during or after production, frequency of these tests, the point where samples or inspections will be obtained or performed, and the format for recording test data.

(e) A drawing, photograph or copy of the manufacturer's identification marking.

(f) A plan for resolving conflicts.

(g) Designate how the pipe will be identified as pipe for MoDOT projects if the pipe is stockpiled and not marked in accordance with [Sec 1020.7](#).

**1020.5.3 Maintaining Qualification.** To maintain qualification, the manufacturer and plant shall perform and maintain quality control in accordance with the manufacturer's QC Plan approved by Construction and Materials. The manufacturer or plant shall conduct tests and inspections to verify that adequate quality control is maintained and that the pipe furnished is in accordance with [Sec 1020](#). The manufacturer or plant shall maintain for three years a record of all test results and inspections for review by the engineer. The records shall show that each shipment of pipe has been inspected by the plant's QC personnel. The record shall indicate the purchase order number or the project number, route, county, date of inspection, size of corrugation, type of fabrication, quantity in lineal feet, number of bands and end sections, pipe diameter, sheet thickness, brand and heat number of the base metal, and the coating lot number. The manufacturer or plant shall notify the engineer responsible for inspection of that plant at least 24 hours prior to each shipment. Additional pipe may be considered part of the original shipment when the ordered quantity was underestimated or material was lost or damaged. A bill of lading in accordance with [Sec 1020.10](#) shall be provided for each shipment of pipe. Each plant shall maintain a current list of QC personnel with corresponding authority and responsibility. All training provided to QC personnel shall be documented with a brief description of the training and shall be kept on file at the plant.

**1020.5.4 Disqualification of a Manufacturer or Plant.** A manufacturer or plant may be disqualified to provide pipe for use on MoDOT projects based on the discretion of Construction and Materials, for reasons including, but not limited to, noncompliance with the manufacturer's QC Plan, failure of pipe to consistently meet specifications, falsification of documentation, unsatisfactory performance in the field or for other reasons indicating lack of consistent material or workmanship quality.

**1020.5.4.1** A manufacturer or plant will not be considered for reinstatement until after one year from the date of removal for falsification of documents.

**1020.5.4.2** Three notices of failure to meet the specification requirements within a 12-month period will be cause for disqualification of a plant for one year, effective from the date of the third notice.

**1020.5.4.3** A manufacturer having two or more plants disqualified will constitute disqualification of the manufacturer for one year.

**1020.5.4.4** A manufacturer or plant disqualified within one year of the end of a disqualification may be subject to permanent removal, with no application to be reinstated for a period of three years.

**1020.5.5 Reinstatement of a Manufacturer or Plant.** Consideration of reinstatement of a manufacturer or a plant once disqualified will be no sooner than specified in [Sec 1020.5.4](#), will require a written document from the manufacturer or plant stating the reasons for disqualification and the action taken to correct those deficiencies, written concurrence from Construction and Materials that the problem has been suitably addressed, and followed by an application in accordance with [Sec 1020.5.1](#).

**1020.5.6 Sampling of Material.** Random sampling of the pipe or material used in the production of pipe will be conducted by the engineer to verify if the pipe and material are in accordance with the applicable specifications. Sampling size and frequency will be at the discretion of the engineer. In the event pipe materials certified by the manufacturer are not in accordance with [Sec 1020](#) as determined by random sampling, testing and inspection, all pipe incorporating that material will be rejected.

**1020.5.7 Mill and Factory Inspection.** The engineer may have the material inspected and sampled in the rolling mill or in the shop where fabricated. The engineer may require from the mill the chemical analysis of any heat number. The inspection, either in the mill or in the shop, shall be under the direction of the engineer. The engineer shall have unlimited access to the mill or shop for inspection, and every facility shall be extended for the purpose of inspection. Any material or pipe that has been previously rejected at the mill or shop and included in a later lot will be considered sufficient cause for rejection of the entire lot.

**1020.5.8 Inspection.** Inspection by the engineer will include an examination of the pipe for deficiency in specified diameter, net length of finished pipe and any evidence of poor workmanship. The inspection may include taking samples for chemical analysis, mechanical properties and determination of weight of coating. The pipe making up the shipment shall meet all requirements of these specifications. If 10 percent of the pipe in any lot fails to meet these requirements, the entire lot may be rejected.

**1020.5.9 Sampling of Coated Steel.** Samples of coated steel sheet may be obtained from coils, flat or corrugated cut lengths or fabricated culverts. Samples shall be taken at a frequency determined by the manufacturer's QC Plan or as required by the engineer.

**1020.5.9.1** For testing weight of coating of flat or corrugated cut lengths before fabrication, three specimens, each no less than 2 1/4 inches square or of an equivalent area, shall be taken from each test sheet selected to represent the lot. The specimens shall be taken such that no part includes metal closer than 2 inches from an edge or 4 inches from an end of the cut length. These specimens shall be obtained in any one of the following patterns:

(a) One specimen shall be obtained from the center of the cut length and the other two in a straight line diagonally at the opposite corners.

(b) Specimens shall be taken in a straight line from one end of the cut length, one from the middle portion and one from near each edge.

**1020.5.9.2** For testing weight of coating of coils before fabrication, three specimens, each no less than 2 1/4 inches square or of an equivalent area, shall be taken, one from the middle of the width and one from each side. No specimen shall be taken closer than 2 inches from an edge or 4 inches from an end of the coil.

**1020.5.9.3** For testing weight of coating of fabricated pipe or pipe-arch, at least one specimen 2 1/4 inches square or of equivalent area, shall be selected for each 20 pieces of pipe within a given lot selected to be tested, provided that no less than three specimens, each from a different piece, shall represent any one lot. The three specimens shall constitute one sample and shall be in accordance with [Sec 1020.3](#).

**1020.5.9.4** For chemical analysis of the base metal of flat or corrugated cut lengths before fabrication, a specimen, no less than 2 1/4 inches square or of an equivalent area, shall be taken from each of three different cut lengths for lots weighing 5 tons or less, from four cut lengths for lots weighing more than 5 tons and less than 10 tons and from five cut lengths for lots weighing 10 tons or more. Drillings or chips from the specimens shall be thoroughly mixed for analysis.

**1020.5.9.5** For chemical analysis of the base metal of coils, three specimens, each no less than 2 1/4 inches square or of an equivalent area, shall be taken from across the width of the coil, or if more than one mill lift or coil is involved, three specimens shall be selected from each of at least two different coils. Drillings or chips from the specimens shall be thoroughly mixed for analysis.

**1020.5.9.6** When chemical analysis of base metal of fabricated pipe or pipe-arch is required, the analysis shall be performed on the same specimens taken for determination of weight of coating.

**1020.5.9.7** For testing mechanical properties of the base metal, two specimens, each 4 x 14 inches, shall be taken from one end of a cut length or coil. The 14-inch dimension shall be in the longitudinal direction of the steel sheet. No specimen shall be taken closer than 2 inches from an edge or 4 inches from an end of a sheet.

**1020.5.9.8** Samples for retest of weight of coating on cut lengths shall be taken in accordance with pattern (a) of [Sec 1020.5.9.1](#). Samples for retest of mechanical properties or chemical composition of any base metal or retest of weight of coating on coils or fabricated pipe or pipe-arch shall be taken in the same manner as for the original test.

**1020.5.10 Testing of Metallic-Coated Steel.** Tests for weight of coating, chemical composition and mechanical properties of metallic-coated steel sheets shall be as herein specified.

**1020.5.10.1** Test specimen size and method of test for determining weight of coating shall be in accordance with AASHTO T 65 for zinc coatings, and AASHTO T 213 for aluminum coatings. At the option of the engineer, material may be accepted on the basis of magnetic gauge determinations made in accordance with ASTM E 376.

**1020.5.10.2** The method of test for chemical analysis shall be in accordance with ASTM E 30-68, exclusive of any later revisions or additions.

**1020.5.10.3** Test specimen size and method of test for determining tensile strength, yield strength and elongation shall be in accordance with ASTM A 370 for sheet steel.

**1020.5.11 Acceptance of Metallic-Coated Steel Sheet.** Acceptance of metallic-coated steel sheet will be based on a satisfactory sheet manufacturer's certified analysis and guarantee and sheet identification markings, upon tests on samples of the material, or upon both. The frequency of sampling will be determined by the engineer. The fabricator shall provide the equipment and personnel required to obtain the samples as directed by the engineer.

**1020.5.12 Accepted Brands of Metal.** No metal will be accepted under these specifications until the sheet manufacturer's certified analysis and manufacturer's guarantee have been approved by the engineer. Misbranding or other misrepresentation and non-uniformity of product, will each be considered sufficient reason to discontinue the acceptance of any brand under these specifications, and notice sent to the sheet manufacturer of the discontinuance of

acceptance of any brand will be considered to be notice to all culvert companies that handle that particular brand.

**1020.5.13 Sampling and Testing of Continuous Lock Seam.** Sampling and testing for continuous lock seam quality control shall be in accordance with AASHTO T 249.

**1020.5.13.1** The pipe manufacturer or plant shall cut, log and retain quality control samples, which shall be retained for two years. Visual examination samples for quality control shall be cut during production. The manufacturer or plant shall sample a minimum of one lock per coil when the same diameter of pipe is being produced. The samples shall be taken from the beginning of the coil. If diameters are changed within a coil, at least one lock per diameter shall be taken. Quality control tension test specimens shall be taken from pipe representing each sheet thickness and diameter the first time that sheet thickness and diameter is produced. In addition, each sheet thickness thereafter shall be sampled on a monthly basis during production for tension testing of the seam. The manufacturer or plant shall record all tension test results and retain those records for two years.

**1020.5.13.2** Inspection by the engineer will include random visual examination samples and tension test samples taken in the presence of the engineer. If visual examination samples indicate nonconformance, that length of the pipe will be rejected, and a resample will be taken from a different length of pipe of the same sheet thickness of the same diameter. If the resample fails, each shipment of that sheet thickness thereafter shall be sampled for visual examination and tension testing until the engineer determines that satisfactory quality control is established. Pipe from which tension test specimens have been taken may be cut and the undamaged portion accepted for use.

**1020.6 Repair of Damaged Coating.** Damaged coating on pipe shall be repaired in accordance with AASHTO M 36, except as follows. Coating damaged in the field shall be repaired by recoating by the hot-dip process or by the metallizing process, except that in instances of minor damage to areas in the upper two-thirds of the perimeter as installed, the engineer may permit repair in the same manner as specified for repair during fabrication. The fabricated unit shall be thoroughly cleaned prior to recoating. The hot-dip process shall be in accordance with [Sec 1020.3](#).

**1020.7 Marking.** Each section of pipe to be used on MoDOT projects shall be marked with an approved manufacturer's identification marking prior to shipment. The marking shall be permanent and located within 12 inches of the downstream end of the pipe.

**1020.8 Handling.** All pipe shall be handled with care to avoid damage. Pipe having damaged coating, localized bends in excess of 5 percent of the specified pipe diameter or any dent in excess of 1/2 inch will be rejected at the site of the work regardless of previous approvals. Rejected damaged pipe may be used if repaired to the satisfaction of the engineer.

**1020.9 MoDOT Identification Number.** When the manufacturer contacts the engineer in accordance with [Sec 1020.5.3](#), the engineer will assign a specific MoDOT identification number for each size of pipe in the shipment.

**1020.10 Bill of Lading.** A bill of lading or delivery receipt for each shipment of pipe shall be furnished to the engineer at the shipping and destination points. The bill of lading shall contain an itemized statement of the sizes and lengths of pipe with the corresponding designated MoDOT identification number provided to the manufacturer for each size of pipe for that shipment. The bill of lading shall contain a certified statement. The certified statement shall be signed by an authorized representative of the manufacturer and shall state the following:

“This certifies that the pipe, bands and end sections in this shipment are in accordance with MoDOT specifications, were fabricated at an approved plant and were fabricated from the following brand names:”