Standard Specification for

Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement

AASHTO Designation: M 322M/M 322-10
ASTM Designation: A 996/A 996M-09
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1. SCOPE

1.1. This specification covers rail-steel and axle-steel bars for concrete reinforcement. Three types of product are included, designated with a "rail symbol" and an "R" for bars made of rail-steel and with an "A" for bars made of axle-steel. The standard sizes and dimensions of deformed bars and their number designations are given in Table 1. All sizes and grades of all types may not be readily available; manufacturers should be consulted to verify availability.

1.2. The text of this specification references notes and footnotes that provide explanatory material. These notes and footnotes, excluding those in tables and figures, shall not be considered as requirements of the specification.

1.3. Type "rail symbol" and Type R are of two minimum yield levels, namely 350 MPa [50 000 psi] and 420 MPa [60 000 psi] designated as Grade 350 [50] and Grade 420 [60], respectively. Type A is of two minimum yield levels, namely 300 MPa [40 000 psi] and 420 MPa [60 000 psi] designated Grade 300 [40] and Grade 420 [60].

1.4. The weldability of the steel is not a requirement of this specification.

1.5. This specification is applicable for orders in either SI units (M 322M) or inch-pound units (M 322).

1.6. The values stated in either SI units or inch-pound units are to be regarded as standard. Within the text, the inch-pound units are shown in brackets. The values stated must be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

1.7. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.
Table 1—Deformed Bar Designation Numbers, Nominal Masses [Weights], Nominal Dimensions, and Deformation Requirements

<table>
<thead>
<tr>
<th>Bar Designation No.</th>
<th>Nominal Mass [Weight], kg/m [lb/ft]</th>
<th>Nominal Dimensions&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Deformation Requirements, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Diameter, mm [in.]</td>
<td>Cross-Sectional Area, mm&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Maximum Average Spacing</td>
</tr>
<tr>
<td>10</td>
<td>0.569 [0.376]</td>
<td>9.5 [0.375]</td>
<td>29.9 [1.178]</td>
</tr>
<tr>
<td>[3]</td>
<td>0.994 [0.688]</td>
<td>12.7 [0.500]</td>
<td>39.9 [1.571]</td>
</tr>
<tr>
<td>13</td>
<td>1.552 [1.043]</td>
<td>15.9 [0.625]</td>
<td>49.9 [1.963]</td>
</tr>
<tr>
<td>16</td>
<td>2.235 [1.502]</td>
<td>19.1 [0.750]</td>
<td>59.8 [2.356]</td>
</tr>
<tr>
<td>19</td>
<td>3.042 [2.044]</td>
<td>22.2 [0.875]</td>
<td>69.8 [2.749]</td>
</tr>
<tr>
<td>22</td>
<td>3.973 [2.670]</td>
<td>25.4 [1.000]</td>
<td>79.8 [3.142]</td>
</tr>
<tr>
<td>25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*The nominal dimensions of a deformed bar are equivalent to those of a plain round bar having the same mass [weight] per meter [foot] as the deformed bar.

2. REFERENCED DOCUMENTS

2.1. AASHTO Standard:
- T 244, Mechanical Testing of Steel Products

2.2. ASTM Standards:
- E 29, Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

2.3. Military Standards:
- MIL-STD-129, Marking for Shipment and Storage
- MIL-STD-163, Steel Mill Products Preparation for Shipment and Storage

2.4. Federal Standard:
- Fed. Std. No. 123, Marking for Shipment (Civil Agencies)

3. TERMINOLOGY

3.1. Description of Terms Specific to This Standard:

3.1.1. Deformations—transverse protrusions on a deformed bar.

3.1.2. Deformed Bar—steel bar with transverse protrusions; a bar that is intended for use as reinforcement in reinforced concrete construction.

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3.1.2.1. *Discussion*—The surface of the bar is provided with lugs or protrusions that inhibit longitudinal movement of the bar relative to the concrete surrounding the bar in such construction. The lugs or protrusions conform to the provisions of this specification.

3.1.3. *rib*—longitudinal protrusion on a deformed bar.

4. **ORDERING INFORMATION**

4.1. It shall be the responsibility of the purchaser to specify all requirements that are necessary for material ordered to this specification. Such requirements shall include, but are not limited to, the following:

4.1.1. Quantity (mass) [weight],

4.1.2. Name of material (rail-steel or axle-steel deformed bars for concrete reinforcement),

4.1.3. Type,

4.1.4. Size,

4.1.5. Grade,

4.1.6. Packaging (see Section 20),

4.1.7. AASHTO designation and year of issue, and

4.1.8. Certified mill test reports (if desired). (See Section 18.)

5. **MATERIAL AND MANUFACTURE**

5.1. The bars shall be rolled from standard section Tee-rails or from carbon-steel axles for railway cars and locomotives. No other materials, such as those known by the terms “rerolled, rail-steel equivalent, and rail-steel quality,” shall be substituted.

6. **CARBON DETERMINATION**

6.1. For axle-steel product, the manufacturer shall make a determination for the carbon content of each axle received for manufacture into reinforcing bars. Based on these carbon determinations, all steel axles shall be stocked for subsequent rolling in separated lots by carbon range. The ranges of carbon shall be determined by the manufacturer as those best suited to meet the mechanical requirements.

6.2. When requested by the purchaser, the manufacturer shall report the carbon range for each lot of bars furnished.

7. **REQUIREMENTS OF DEFORMATIONS**

7.1. Deformations shall be spaced along the bar at substantially uniform distances. The deformations on opposite sides of the bar shall be similar in size, shape, and pattern.
7.2. The deformations shall be placed with respect to the axis of the bar so that the include angle is not less than 45 degrees. Where the line of deformations forms an include angle with the axis of the bar from 45 degrees to 70 degrees inclusive, the deformations shall alternate. In direction from those on the opposite side. Where the line of deformation is greater than 70 degrees, a reversal in direction shall not be required.

7.3. The average spacing or distance between deformations on each side of the bar shall not exceed seven-tenths of the nominal diameter of the bar.

7.4. The overall length of deformations shall be such that the gap between the ends of the deformations shall not exceed 12.5 percent of the nominal perimeter of the bar. Where the ends terminate in a rib, the width of the rib shall be considered as the gap between these ends. The summation of the gaps shall not exceed 25 percent of the nominal perimeter of the bar. The nominal perimeter of the bar shall be 3.1416 times the nominal diameter.

7.5. The spacing, height, and gap of deformations shall conform to the requirements prescribed in Table 1.

8. MEASUREMENTS OF DEFORMATIONS

8.1. The average spacing of deformations shall be determined by measuring the length of a minimum of ten spaces and dividing that length by the number of spaces included in the measurement. The measurement shall begin from a point on a deformation at the beginning of the first space to a corresponding point on a deformation after the last included space. Spacing measurements shall not be made over a bar area containing bar marking symbols involving letters or numbers.

8.2. The average height of deformations shall be determined from measurements made on not fewer than two typical deformations. Determinations shall be based on three measurements per deformation, one at the center of the overall length and the other two at the quarter points of the overall length.

8.3. Insufficient height, insufficient circumferential coverage, or excessive spacing of deformations shall not constitute cause for rejection unless it has been clearly established by determinations on each lot (Note 1) tested that typical deformation height, gap, or spacing do not conform to the minimum requirements prescribed in Section 7. No rejection may be made on the basis of measurements if fewer than ten adjacent deformations on each side of the bar are measured.

Note 1—As used within the intent of Sections 8.3 and 14.1, the term “lot” shall mean all the bars of one bar number and pattern of deformations contained in an individual shipping release or shipping order.

9. TENSILE REQUIREMENTS

9.1. The material, as represented by the test specimens, shall conform to the requirements for tensile properties prescribed in Table 2.

9.2. The yield point or yield strength shall be determined by one of the following methods:

9.2.1. The yield point shall be determined by the drop of the beam or hilt in the gauge of the testing machine.
9.2.2. Where the steel tested does not exhibit a well-defined yield point, the yield strength shall be determined by the offset method (0.2 percent offset), as described in T 244 (Section 13.2.1).

9.3. The percentage of elongation shall be as prescribed in Table 2.

Table 2—Tensile Requirements

<table>
<thead>
<tr>
<th></th>
<th>Grade 300 [40]</th>
<th>Grade 350 [50]</th>
<th>Grade 420 [60]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength, min, MPa [psi]</td>
<td>500 [70 000]</td>
<td>550 [80 000]</td>
<td>600 [90 000]</td>
</tr>
<tr>
<td>Yield strength, min, MPa [psi]</td>
<td>300 [40 000]</td>
<td>350 [50 000]</td>
<td>400 [60 000]</td>
</tr>
<tr>
<td>Elongation in 200 mm [8 in.], min, percent</td>
<td>11</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Bar Designation No.:</td>
<td>12</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>5</td>
<td>8</td>
</tr>
</tbody>
</table>

* Sizes 10 through 19 may not be readily available; manufacturers should be consulted to verify availability.

10. BENDING REQUIREMENTS

10.1. The bend-test specimen shall withstand being bent around a pin without cracking on the outside of the bent portion. The requirements for degree of bending and sizes of pins are prescribed in Table 3.

Table 3—Bend-Test Requirements

<table>
<thead>
<tr>
<th>Bar Designation No.</th>
<th>Pin Diameter for Bend Testsa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Type Rail Symbol</td>
</tr>
<tr>
<td>10, 13, 16 [3, 4, 5]</td>
<td>6d</td>
</tr>
<tr>
<td>19, 22, 25 [6, 7, 8]</td>
<td>6d</td>
</tr>
</tbody>
</table>

* Test bends 180°.

10.2. The bend test shall be made on specimens of sufficient length to ensure free bending and with an apparatus that provides the following:

10.2.1. Continuous and uniform application of force throughout the duration of the bending operation;

10.2.2. Unrestricted movement of the specimen at points of contact with the apparatus and bending around a pin free to rotate;

10.2.3. Close wrapping of the specimen around the pin during the bending operation.

10.3. It shall be permissible to use other acceptable, more severe methods of bend testing, such as placing a specimen across two pins free to rotate and applying the bending force with a fixed pin. When failures occur under more severe methods, retests shall be permitted under the bend-test method prescribed in Section 10.2.
11. **PERMISSIBLE VARIATION IN MASS [WEIGHT]**

11.1. Deformed reinforcing bars shall be evaluated on the basis of nominal mass [weight]. The mass [weight] determined using the measured mass [weight] of the test specimen and rounding in accordance with ASTM E 29 shall be at least 94 percent of the applicable mass [weight] per unit length prescribed in Table 1. In no case shall excess mass [overweight] of any deformed bar be cause for rejection.

12. **FINISH**

12.1.1. The bars shall be free of detrimental surface imperfections.

12.1.2. Rust, seams, surface irregularities, or mill scale shall not be cause for rejection, provided the mass [weight], dimensions, cross-sectional area, and tensile properties of a hand wire-brushed test are not less than the requirements of this specification.

12.1.3. Surface imperfections or flaws other than those specified in Section 12.1.2 shall be considered detrimental when specimens containing such imperfections fail to conform to either tensile or bending requirements. Examples include, but are not limited to, laps, seams, slivers, cooling or casting cracks, and mill or guide marks.

13. **TEST SPECIMENS**

13.1. All mechanical tests shall be conducted in accordance with T 244, including Annex A9.

13.2. Tension test specimens shall be the full section of bar as rolled.

13.3. The unit stress determinations on full-sized specimens shall be based on the nominal bar area.

13.4. The bend-test specimens shall be the full section of the bar as rolled.

14. **NUMBER OF TESTS**

14.1. For bar sizes No. 10 to No. 25 [No. 3 to No. 8] inclusive, one tension test and one bend test shall be made from each lot (Note 1) of 9 Mg [10 tons] or fraction thereof. Each lot of rails (“rail symbol” or “R”) shall not vary more than 5 kg/m [10 lb/yd] of nominal mass [weight]. Each lot of axles (Type A) shall be asserted in groups as specified in Section 6.

15. **RETESTS**

15.1. If results of an original tension specimen fail to meet the specified minimum requirements and are within 14 MPa [2000 psi] of the required tensile strength, within 7 MPa [1000 psi] of the required yield point, or within two percentage points of the required elongation, a retest shall be permitted on two random specimens for each original tension specimen failure from the lot. Both retest specimens shall meet the requirements of this specification.

15.2. If a bend test fails for reasons other than mechanical reasons or flaws in the specimen as described in Sections 15.4.2 and 15.4.3, a retest shall be permitted on two random specimens from the same lot. Both retest specimens shall meet the requirements of this specification. The retest shall be performed on test specimens that are at air temperature, but not less than 16°C [60°F].

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15.3. If a weight [mass] test fails for reasons other than flaws in the specimen as described in Section 15.4.3, a retest shall be permitted on two random specimens from the same lot. Both retest specimens shall meet the requirements of this specification.

15.4. If the original test or any of the random retests fails because of any reasons listed in Sections 15.4.1, 15.4.2, or 15.4.3, the test shall be considered an invalid test. The results shall be discarded and the test shall be repeated on a specimen from the same lot.

15.4.1. The elongation property of any tension test specimen is less than that specified, and any part of the fracture is outside the middle half of the gauge length, as indicated by scribe marks on the specimen before testing.

15.4.2. Mechanical reasons such as failure of testing equipment or improper specimen preparation.

15.4.3. Flaws are detected in a test specimen, either before or during the performance of the test.

Note 2—Marking specimens with multiple scribe or punch marks can reduce the occurrence of fracture outside or near these marks and the need for declaring the test invalid.

16. INSPECTION

16.1. The inspector representing the purchaser shall have free entry, at all times, while work on the contract of the purchaser is being performed, to all parts of the manufacturer’s works that concern the manufacture of the material ordered. The manufacturer shall afford the inspector all reasonable facilities to satisfy him that the material is being furnished in accordance with this specification. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

16.2. For Government Procurement Only—Except as otherwise specified in the contract, the contractor is responsible for the performance of all inspection and test requirements specified herein and shall be permitted to use one’s own or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless disapproved by the purchaser at the time of purchase. The purchaser shall have the right to perform any of the inspections and tests at the same frequency as set forth in this specification where such inspections are deemed necessary to assure that material conforms to prescribed requirements.

17. REJECTION

17.1. Material that shows injurious defects subsequent to its acceptance at the manufacturer’s works will be rejected, and the manufacturer shall be notified.

18. TEST REPORTS

18.1. When specified in the purchase order, report the following information on a per-lot basis. Additional items may be reported as requested or desired.

18.1.1. Carbon level—Type A only,

18.1.2. Tensile properties,
18.1.3. Bend test.

18.2. A material test report, certificate of inspection, or similar document printed from or used in electronic form from an electronic data interchange (EDI) transmission shall be regarded as having the same validity as a counterpart printed in the certifier's facility. The content of the EDI transmitted document must meet the requirements of the invoked AASHTO standard(s) and conform to any EDI agreement between the purchaser and the supplier. Notwithstanding the absence of a signature, the organization submitting the EDI transmission is responsible for the content of the report.

Note 3—The industry definition invoked here is: EDI is the computer to computer exchange of business information in a standard format such as ANSI ASC X12.

19. MARKING

19.1. When loaded for mill shipment, bars shall be properly separated and tagged with the manufacturer's test identification number.

19.2. Each manufacturer shall identify the symbols of his marking system.

19.3. All bars produced to this specification shall be identified by a distinguishing set of marks legibly rolled into the surface of one side of the bar to denote in the following order:

19.3.1. Point of Origin—letter or symbol established as the manufacturer's mill designation;

19.3.2. Size Designation—Arabic number corresponding to bar designation number of Table 1;

19.3.3. Type of Steel—rail symbol, letter R or letter A, indicating that the bar was produced from rail or axle steel;

19.3.4. Minimum Yield Designation—for Grade 420 [60] bars, either the number 4 [60] or a single continuous longitudinal line through at least five spaces offset from the center of the bar side. (There is no marking designation for Grade 350 [50] or Grade 300 [40] bars.)

19.3.5. It shall be permissible to substitute bars having sizes and grades in SI units for bars ordered to the corresponding sizes and grades in inch-pound units.

20. PACKAGING

20.1. When specified in the purchase order, packaging shall be in accordance with the procedures in ASTM A 700.

20.2. For Government Procurement Only—When specified in the contract or order, and for direct procurement by or direct shipment to the U.S. Government, material shall be preserved, packaged, and packed in accordance with the requirements of MIL-STD-163. The applicable levels shall be as specified in the contract. Marking for shipment of such material shall be in accordance with Fed. Std. No. 123 for civil agencies and MIL-STD-129 for military agencies.

21. KEYWORDS

21.1. Concrete reinforcement; deformations (protrusions); steel bars.
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Cincinnati, OH 45225-2160
Contact Name: Virginia Gastrich, President
Telephone: 513-541-6009
Fax: 513-541-3456
Email:
Web Site Address:
Product / Service Description:
Description Line # 1: COLD-ROLLED STEEL SHEET STRIP & BARS
Description Line # 2:
Description Line # 3:
Description Line # 4:
Description Line # 5:
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Description Line # 9:
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