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American Association State
Highway and Transportation Officials Standard
AASHTO No.: M 204

Standard Specification for Uncoated Stress-Relieved Steel Wire for Prestressed Concrete[1]

This standard is issued under the fixed designation A 421/A 421M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope*

1.1 This specification covers two types of uncoated stress-relieved round high-carbon steel wire commonly used in prestressed linear concrete construction, as follows:

1.1.1 *Type BA* wire is used for applications in which cold-end deformation is used for anchoring purposes (Button Anchorage), and

1.1.2 *Type WA* wire is used for application in which the ends are anchored by wedges, and no cold-end deformation of the wire is involved (Wedge Anchorage).

1.2 Supplement I describes low relaxation wire and relaxation testing for that product.

1.3 The values stated in either inch-pound or SI units are to be regarded as standard. Within the text, the inch-pound units are shown in parentheses. The values stated in each system are not exact equivalents; therefore, each system shall be used independently of the other, without combining values in any way.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products

E 30 Test Methods for Chemical Analysis of Steel, Cast Iron, Open-Hearth Iron, and Wrought Iron[3]

E 328 Test Methods for Stess Relaxation Tests for Materials and Structures

2.2 *Military Standards:*

MIL-STD-129 Marking for Shipment and Storage[4]

MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage[4]

2.3 *Federal Standard:*

Fed. Std. No. 123 Marking for Shipments (Civil Agencies)[4]

3. Ordering Information

3.1 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:

3.1.1 Quantity (kg [lb]),

3.1.2 Diameter,

3.1.3 Type of anchorage (BA or WA),

3.1.4 Packaging,

3.1.5 ASTM designation and date of issue, and

3.1.6 Special requirements, if any.

NOTE 1—A typical ordering description is as follows: 10 000 kg of 6.35-mm diameter wire, Type BA in approximately 450 kg 1.5-m diameter coils to ASTM A 421/A 421M– _____(22 000 lb 0.250-in. diameter wire, Type BA in approximately 1000 lb 60-in. diameter coils to ASTM A 421/A 421M–_____).

4. Manufacture

4.1 *Process*—The steel shall be made by the basic-oxygen, open-hearth, or electric-furnace process.

4.2 *Internal Soundness*—A sufficient discard shall be made to ensure freedom from injurious piping and undue segregation.

4.3 *Wire*—The wire shall be cold-drawn to size and suitably stress relieved after cold drawing by a continuous heat treatment to produce the prescribed mechanical properties.

5. Physical Requirements

5.1 *Tensile Strength*—The tensile strength of Type BA wire and Type WA wire shall conform to the requirements prescribed in Table 1, and shall be determined as prescribed in Test Methods and Definitions A 370, including Annex A4.

5.2 *Yield Strength*:

5.2.1 The minimum yield strength for all wire, measured by the 1.0 % extension under load method, shall not be less than 85 % of the specified minimum breaking strength.

[1] This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys, and is the direct responsibility of Subcommittee A01.05 on Steel Reinforcement.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Withdrawn.

[4] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

***A Summary of Changes section appears at the end of this standard.**

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TABLE 1 Tensile Strength Requirements

Nominal Diameter, mm (in.)	Tensile Strength, min, MPa (psi)	
	Type BA	Type WA
4.88 (0.192)	[A]	1725 (250 000)
4.98 (0.196)	1655 (240 000)	1725 (250 000)
6.35 (0.250)	1655 (240 000)	1655 (240 000)
7.01 (0.276)	1620 (235 000)	1620 (235 000)

[A]This size is not commonly furnished in Type BA wire.

5.2.2 The extension under load shall be measured by an extensometer calibrated with the smallest division not larger than 0.0001 mm/mm (0.0001 in./in.) of gage length.

5.2.3 The initial load corresponding to the initial stress prescribed in Table 2 shall be applied to the specimen, at which time the extensometer is attached and adjusted to a reading of 0.001 mm/mm (0.001 in./in.) of gage length. The load shall then be increased until the extensometer indicates an extension of 1 %. The load for this extension shall be recorded. The stress corresponding to this load shall meet the requirements for stress at 1 % extension prescribed in Table 2.

5.3 *Elongation*—The total elongation under load of all wire shall not be less than 4.0 % when measured in a gage length of 250 mm (10 in.). The elongation shall be determined by an extensometer which is placed on the test specimen after a load corresponding to the initial stress prescribed in Table 2 is applied. If the fracture takes place outside of the gage length and the elongation so measured meets the minimum requirements, no further testing shall be required. If the elongation is less than the minimum requirements, the test shall be considered an invalid test and a retest made.

6. Diameter and Permissible Variations

6.1 Wire meeting the requirements of this specification is normally ordered in the diameters shown in Table 1.

6.2 The diameter of the wire shall not vary from the nominal diameter specified by more than ± 0.05 mm (0.002 in.).

6.3 The wire shall not be out-of-round by more than 0.05 mm (0.002 in.).

7. Workmanship and Finish

7.1 *Cast*—A wire sample having a chord length of 1524 mm (60 in.) shall have an offset at the center of the chord of not more than 76 mm (3 in.). This is equivalent to a chord of an arc of a circle not less than 7.6 m (25 ft) in diameter.

7.2 *Type BA Wire*—Type BA wire shall be of suitable quality to permit cold forming of buttons for anchorage. Splitting shall not be considered a cause for rejection if the button anchorage is capable of developing the minimum required tensile strength of the wire.

TABLE 2 Yield Strength Requirements

Nominal Diameter, mm (in.)	Initial Stress, MPa (psi)	Minimum Stress at 1 % Extension, MPa (psi)	
		Type BA	Type WA
4.88 (0.192)	200 (29 000)	[A]	1465 (212 500)
4.98 (0.196)	200 (29 000)	1407 (204 000)	1465 (212 500)
6.35 (0.250)	200 (29 000)	1407 (204 000)	1407 (204 000)
7.01 (0.276)	200 (29 000)	1377 (199 750)	1377 (199 750)

[A]This size is not commonly furnished in Type BA wire.

7.3 The wire shall be free of kinks.

7.4 The wire shall be furnished in firmly tied coils having a minimum inside diameter of 1219 mm (48 in.). Each coil shall be of one continuous length.

7.5 There shall be no welds or joints in the finished wire. Any welds or joints made during manufacture to promote continuity of operations shall be removed.

7.6 The wire shall not be oiled or greased. Slight rusting, provided it is not sufficient to cause pits visible to the naked eye, shall not be cause for rejection.

7.7 Temper colors which result from the stress-relieving operation are considered normal for the finished appearance of this strand.

8. Chemical Requirements

8.1 Variations in manufacturing processes and equipment among wire manufacturers necessitate the individual selection of an appropriate chemical composition at the discretion of the manufacturer.

8.2 Phosphorus and sulfur values shall not exceed the following:

Phosphorus	0.040%
Sulfur	0.050%

8.3 The purchaser shall have the right to make an analysis from finished wire representing each heat of steel. Samples for analysis shall be obtained by milling the wire in such a manner as to obtain a sample representative of the entire cross section. Prior to milling, the surface shall be cleaned to remove all foreign matter. All such individual determinations shall not vary from the limits shown in 8.2 by more than 0.008 %.

8.4 For referee purposes, Methods E 30 shall be applied.

9. Sampling

9.1 Unless otherwise agreed upon between the manufacturer and the purchaser, one test specimen shall be taken from each 10 coils or less in a lot (Note 2) and tested to determine compliance with 5.1, 5.2, 5.3, 6, and 7.1.

NOTE 2—The term "lot" means all the coils of wire of the same nominal wire size contained in an individual shipping release or shipping order.

10. Inspection

10.1 The purchaser shall state at the time of order whether outside inspection is required or waived. If outside inspection is required, the manufacturer shall afford the inspector representing the purchaser all reasonable facilities to satisfy him that the material is being furnished in accordance with this specification. All tests and inspections shall be made at the place of manufacture prior to shipment, unless otherwise agreed upon at the time of purchase, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

11. Rejection

11.1 Unless otherwise specified, any rejection based on tests made in accordance with this specification shall be reported to the manufacturer within a reasonable length of time.

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12. Certification

12.1 If outside inspection is waived, a manufacturer's certification that the material has been tested in accordance with and meets the requirements of this specification shall be the basis of acceptance of the material.

12.2 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 ASTM standard(s) and conform to any existing 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 as invoked here is: EDI is the computer-to-computer exchange of business information in a standard format such as ANSI ASC X12.

13. Packaging and Marking

13.1 The size of the wire, ASTM specification number, heat number, and name or mark of the manufacturer shall be marked on a tag securely attached to each bundle of wire.

13.2 *For Government Procurement Only*— When specified in the contract or order, and for direct procurement by or direct shipment to the 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.

14. Keywords

14.1 cold-drawn wire; prestressed concrete; steel wire (tendon); stress-relieved wire

SUPPLEMENTARY REQUIREMENTS

I. LOW-RELAXATION WIRE

S1. Scope

S1.1 This supplement delineates only those details which are peculiar to low-relaxation wire, and to the method of relaxation testing related to single wire tendons having properties generally as described in Specification A 421.

S2. Referenced Document

S2.1 *ASTM Standard*:

E 328 Methods for Stress-Relaxation Tests for Materials and Structures

S3. Test Method

S3.1 Low-relaxation strand shall be tested as prescribed in Methods E 328.

S4. Relaxation Properties

S4.1 Low-relaxation wire shall meet the physical requirements of this specification, with the added requirement that relaxation after 1000 h under the conditions of Section S5 shall not be more than 2.5 % when initially loaded to 70 % of specific minimum tensile strength or not more than 3½ % when loaded to 80 % of specified minimum tensile strength of the wire.

S5. Yield Strength

S5.1 Yield strength of low-relaxation wire as described in 5.2 shall not be less than 90 % of the specified minimum tensile strength of the wire.

S6. Conditions of Relaxation Test

S6.1 If required, relaxation evidence shall be provided from the manufacturer's records of tests on similarly dimensioned wire of the same grade.

S6.2 The temperature of the test specimen shall be maintained at 20 ± 2°C (68 ± 3.5°F).

S6.3 The test specimen shall not be subjected to any loading prior to the relaxation test.

S6.4 The initial load shall be applied uniformly over a period of not less than 3 min and not more than 5 min, and the gage length shall be maintained constant; load relaxation readings shall commence 1 min after application of the total load.

S6.5 Overstressing of the test specimen during the loading operation shall not be permitted.

S6.6 The duration of the test shall be 1000 h or a shorter computed period extrapolated to 1000 h which can be shown by records to provide similar relaxation values.

S6.7 The test gage length shall be at least 60 times the nominal diameter.

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SUMMARY OF CHANGES

Committee A01 has identified the location of the following changes to this standard since the last issue (A 421/A 421M – 02) that may impact the use of this standard.

*(1)*Sections 3.1, 5.3, 8.3, and S6.5 were revised.

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