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

## Standard Specification for Stress-Relieved Steel Wire for Prestressed Concrete<sup>1</sup>

This standard is issued under the fixed designation A421/A421M; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

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

### 1. Scope\*

1.1 This specification covers two types of stress-relieved round high-carbon steel wire commonly used in prestressed 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 A supplementary requirement (S1) is provided for use where low-relaxation wire and relaxation testing for that product is required by the purchaser. The supplementary requirement applies only when specified in the purchase order, order or contract.

1.3 This specification is applicable for orders in either inch-pounds units (as Specification A421) or in SI units (as Specification A421M).

1.4 The values stated in either inch-pound or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the specification.

1.5 The text of this specification references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables) shall not be considered as requirements of the specification.

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

<sup>1</sup> 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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\*A Summary of Changes section appears at the end of this standard

## 2. Referenced Documents

### 2.1 *ASTM Standards:*<sup>2</sup>

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

A751 Test Methods and Practices for Chemical Analysis of Steel Products

E328 Test Methods for Stress Relaxation for Materials and Structures

### 2.2 *Military Standard:*<sup>3</sup>

MIL-STD-129 Marking for Shipment and Storage

### 2.3 *Federal Standard:*<sup>3</sup>

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

## 3. Ordering Information

3.1 Orders for stress-relieved steel wire under this specification shall contain the following information:

3.1.1 Quantity (feet [metres]),

3.1.2 Nominal diameter (inches [millimetres]),

3.1.3 Type BA or WA wire, and

3.1.4 ASTM designation A421 [A421M] and year of issue.

~~3.2 The purchaser 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~~ have the option to specify additional requirements, including but not limited to, the following:

~~3.1.1 Quantity lb [kg],~~

~~3.1.2 Nominal diameter,~~

~~3.2.1 Name of material (uncoated stress-relieved Sampling—number of test specimens (9.1) steel wire for prestressed concrete, Type BA or WA wire),~~

~~3.2.2 If outside inspection is required Requirements for inspection (10.1),~~

~~3.2.3 Packaging, Package marking (13.2),~~

~~3.2.4 Supplementary Requirement S1 (if desired), Relaxation evidence on similarly dimensioned wire of the same grade (S1.5.1), and~~

~~3.2.5 ASTM designation and date of issue. Other special requirements, if any.~~

## 4. Manufacture

4.1 *Process*—The steel shall be made by any commercially accepted 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.

<sup>2</sup> 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.

<sup>3</sup> Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, http://dodssp.daps.dla.mil.

## 5. Mechanical Property 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 **A370**, 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 tensile strength.

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

5.2.3 The initial load corresponding to the initial stress prescribed in **Table 2** shall be applied to the test specimen, at which time the extensometer is attached and adjusted to a reading of 0.001 in./in. [0.001 mm/mm] of gage gauge 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 gauge length of 10 in. [250 mm]. 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 gauge 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 nominal diameters shown in **Table 1**.

6.2 The diameter of the wire shall not vary from the nominal diameter specified by more than  $\pm 0.002$  in. [ $\pm 0.05$  mm].

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

## 7. Workmanship and Finish

7.1 *Cast*—A wire sample test specimen having a chord length of 60 in. [1500 mm] shall have an offset at the center of the chord of not more than 3 in. [75 mm]. This is equivalent to a chord of an arc of a circle not less than 25 ft [7.6 m] in diameter.

7.2 *Type BA Wire*—Type BA wire shall be of suitable quality to permit cold forming of button heads for anchorage. Splitting shall not be considered a cause for rejection if the button anchorage is capable of developing the specified minimum required tensile strength of the 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 48 in. [1200 mm]. Each coil shall be of one continuous length.

**TABLE 1 Tensile Strength Requirements**

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

<sup>A</sup> This size is not commonly furnished in Type BA wire.



TABLE 2 Yield Strength Requirements

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

<sup>A</sup> This size is not commonly furnished in Type BA wire.

7.5 There shall be no welds or joints in the finished wire. Any welds or joints made during manufacture to enable 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 a person with normal or corrected vision, 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 the finished wire.

## 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 %

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<https://standards.iteh.ai/catalog/standards/sist/08769738-13b6-41d1-a73b-37d2def205cb/astm-a421-a421m-21>

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, Test Methods, Practices, and Terminology A751 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 1) and tested to determine compliance with Sections 5-15, 5-2, 5-3, 6, and 7-17.

NOTE 1—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. If outside inspection is required, the manufacturer shall afford the inspector representing the purchaser all reasonable facilities to satisfy the inspector 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 without unnecessarily interfering with manufacturing operations. Inspection of the stress-relieved steel wire shall be agreed upon between the purchaser and the manufacturer as part of the purchase order or contract.