Designation: A421/A421M – 21

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

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

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 (ε) 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 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 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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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:*[3]

MIL-STD-129 Marking for Shipment and Storage

2.3 *Federal Standard:*[3]

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 have the option to specify additional requirements, including but not limited to, the following:

3.2.1 Sampling—number of test specimens (9.1),

3.2.2 Requirements for inspection (10.1),

3.2.3 Package marking (13.2),

3.2.4 Relaxation evidence on similarly dimensioned wire of the same grade (S1.5.1), and

3.2.5 Other special requirements, if any.

4. Manufacture

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

[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.

Current edition approved May 1, 2021. Published May 2021. Originally approved in 1958. Last previous edition approved in 2015 as A421/A421M – 15. DOI: 10.1520/A0421_A0421M-21.

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

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

TABLE 1 Tensile Strength Requirements

Nominal Diameter, in. [mm]	Tensile Strength, min, psi [MPa]	
	Type BA	Type WA
0.192 [4.88]	[A]	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]

[A] 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]	[A]	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]

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

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. 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 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 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 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 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 ±0.002 in. [±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 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 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.

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 appearance of 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 %

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, 6, and 7.

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 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.

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.

12. Certification

12.1 At the time of shipment, the purchaser shall be furnished with a written certification that specimens representing each lot of wire have been either tested or inspected as required in this specification and the requirements have been satisfied. The certification shall include ASTM designation A421 [A421M], year of issue, and revision letter, if any.

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 shall meet the requirements of the invoked ASTM standard(s) and conform to any existing EDI agreement between the purchaser and the manufacturer. Notwithstanding the absence of a signature, the organization submitting the EDI transmission is responsible for the content of the report.

NOTE 2—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 Package Marking

13.1 The type of wire, size of the wire, ASTM designation A421 [A421M], heat number, and name of the manufacturer shall be marked on a tag securely attached to each coil of wire.

13.2 When specified in the purchase order or contract, and for direct procurement by or direct shipment to the U.S. Government, marking for shipment 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; low-relaxation wire; prestressed concrete; steel wire (tendon); stress-relieved wire

SUPPLEMENTARY REQUIREMENTS

S1. LOW-RELAXATION WIRE AND RELAXATION TESTING

The following supplementary requirement shall apply only when specified in the purchase order or contract.

S1.1 Scope

S1.1.1 This supplementary requirement 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 A421/A421M.

S1.2 Test Method

S1.2.1 Low-relaxation wire shall be tested as prescribed in Test Methods E328.

S1.3 Relaxation Properties

S1.3.1 Low-relaxation wire shall meet the mechanical property requirements of this specification, with the added requirement that relaxation after 1000 h under the conditions of Section S1.5 shall not be more than 2.5 % when initially loaded to 70 % of specified minimum tensile strength or not more than 3.5 % when loaded to 80 % of specified minimum tensile strength of the wire.

S1.4 Yield Strength

S1.4.1 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.

S1.5 Conditions of Relaxation Test

S1.5.1 If required, relaxation evidence shall be provided from the manufacturer's records of tests on similarly dimensioned wire of the same grade.

S1.5.2 The temperature of the test specimen shall be maintained at 68 ± 3.5°F [20 ± 2°C].

S1.5.3 The test specimen shall not be subjected to any loading prior to the relaxation test.

S1.5.4 The initial load shall be applied uniformly over a period of not less than 3 minutes and not more than 5 minutes, and the gauge length shall be maintained constant; load relaxation readings shall commence 1 minute after application of the total load.

S1.5.5 Overstressing of the test specimen during the loading operation shall not be permitted.

S1.5.6 The duration of the test shall be 1000 h or a shorter period extrapolated to 1000 h which can be shown by records to provide similar relaxation values.

S1.5.7 The test gauge length shall be at least 60 times the nominal diameter.