Designation: A 648 – 04a

Standard Specification for Steel Wire, Hard Drawn for Prestressing Concrete Pipe[1]

This standard is issued under the fixed designation A 648; 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.

1. Scope*

1.1 This specification covers two classes of uncoated, high-strength, hard-drawn steel wire for use in the manufacture of prestressed concrete pipe. In application, the wire is helically wrapped on the pipe maintaining tension by mechanical means not including drawing dies.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are provided for information only.

1.3 Supplementary requirements describe hydrogen embrittlement resistance test acceptance criteria.

1.4 The following caveat pertains only to the test method portions of this specification, 6.2.3 and 6.4.3: *This standard does not purport to address 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.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

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

A 510 Specification for General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel

A 700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Domestic Shipment

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

2.2 *ANSI Standard:*

C 304 Standard for Design of Prestressed Concrete Cylinder Pipe[3]

3. Ordering Information

3.1 Orders for material to this specification should include the following information:

3.1.1 Quantity (weight),

3.1.2 Name of material (hard-drawn steel wire for prestressing concrete pipe),

3.1.3 Wire diameter (see Table 1),

3.1.4 Class (see Table 1),

3.1.5 Packaging (see Section 11),

3.1.6 ASTM designation and year of issue, and

3.1.7 Special requirements, if any (see Supplementary Requirements).

NOTE 1—A typical ordering description is as follows: 100 000-lb, Hard-Drawn Steel Wire for Prestressing Concrete Pipe, 0.192 in. in diameter, Class III, 1500-lb coils, to ASTM A 648 – _____.

4. Manufacture

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

4.2 The steel shall be free of injurious piping and undue segregation.

4.3 The wire shall be cold drawn to produce the desired mechanical properties. The wire manufacturer shall take dependable precautions during wire drawing to preclude detrimental strain aging of the wire.

NOTE 2—Allowing wire to remain at elevated temperatures, such as 400°F (204°C) for more than 5 s or 360°F (182°C) for more than 20 s, can result in detrimental strain aging of the wire. Detrimentally strain aged wire typically has reduced ductility and increased susceptibility to hydrogen embrittlement.

4.4 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.

[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] Available from American National Standards Institute, 25 W. 43rd St., 4th Floor, New York, NY 10036.

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

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TABLE 1 Tensile Requirements

Wire Gage or Fraction, in.	Decimal Size, in. (mm)	Class II Wire			Class III Wire		
		Minimum Tensile Strength,[A] ksi (MPa)	Breaking Strength, lbf (kN)		Minimum Tensile Strength,[A] ksi (MPa)	Breaking Strength, lbf (kN)	
			min	max		min	max
6	0.192 (4.88)	222 (1530)	6 430 (28.6)	7 300 (32.5)	252 (1740)	7 300 (32.5)	8 170 (36.3)
1/4	0.250 (6.35)	211 (1450)	10 360 (46.1)	11 830 (52.6)	240 (1650)	11 780 (52.4)	13 250 (58.9)
5/16	0.312 (7.92)	201 (1390)	15 370 (68.4)	17 660 (78.6)	221 (1520)	16 900 (75.2)	19 190 (85.4)

[A] Based on nominal wire diameter.

5. Chemical Requirements

5.1 The cast or heat analysis of the steel shall conform to the chemical requirements specified in Table 2.

5.2 An analysis of each cast or heat of steel shall be furnished by the manufacturer showing the percentages of all the elements specified in Table 2. The wire shall be subject to permissible variation for product analysis specified in Specification A 510, Table 7.

6. Mechanical Requirements

NOTE 3—Mechanical requirements are applicable only prior to or during pipe manufacture.

6.1 *Test Specimens*—Wire specimens for tensile and torsion tests shall be taken from either end of a coil but must be representative of that coil's wire drawing conditions with regard to wire temperature.

6.2 *Tension Test*:

6.2.1 *Tensile Requirements* shall conform to those prescribed in Table 1 for the specified size and class.

6.2.2 *Number of Tests*—One test specimen shall be taken from each coil.

6.2.3 *Test Method*—The tension test shall be made in accordance with Test Methods and Definitions A 370, Annex A4. Tension test reports shall include the coil number tested, the measured wire diameter, and the measured breaking strength.

6.2.4 *Reduction of Area Test*—The reduction of area requirement for the specimens used for the tension test in 7.1 shall be a minimum of 35 % for 0.192 in. (4.88 mm) wire and 30 % for larger wire as described and tested in accordance with Test Methods and Definitions A 370, Annex A4.

6.3 *Relaxation Test:*

TABLE 2 Chemical Requirements

NOTE 1—Class I wire has been discontinued.

	Classes II and III
Carbon, %	0.50–0.85
Manganese, %	0.50–1.10
Phosphorus, max, %	0.030
Sulfur, max, %	0.035
Silicon, %	0.10–0.35
Nitrogen, max, %	0.007
Aluminum, %	…
Titanium, %	…
Chromium, %	…
Nickel, %	…
Molybdenum, %	…
Copper, %	…
Vanadium, %	…

Note: Where "…" appear in this table, there is no requirement or limit.

6.3.1 *Number of Tests*—Relaxation test results shall be provided for purposes of qualifying the procedures used to manufacture wire for prestressing pipe. Relaxation test results shall include one sample each from a minimum of three coils of wire from the same or different heats of steel where the wire samples are of the same nominal size, the same class, and manufactured using the same drawing machine and drawing procedures. It shall be permissible to provide the relaxation test results from the wire manufacturer's historical records.

6.3.2 *Test Method*—Wire shall be tested as described in Test Methods E 328.

6.3.3 *Conditions of Tests*—The conditions of the tests are:

6.3.3.1 At least one of the tests performed shall have a duration of 1000 h minimum, and all other tests shall have a duration of at least 200 h. Measurements shall be made and recorded for at least five data points during each time interval of (1) 0 to 10 h, (2) 10 to 100 h, and (3) 100 to 1000 h, except that, if a test is terminated in less than 1000 h, measurements shall be made for at least two data points in the third interval. For tests terminated in less than 1000 h, the expected relaxation of the specimen at 1000 h shall be determined from the linear regression curve of stress loss on a logarithm time scale.

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

6.3.3.3 The test specimen shall not be subjected to loading, including sample straightening, prior to the relaxation test, except that it shall be permissible to straighten the sample ends to fit in the test machine jaws.

6.3.3.4 Loading shall be applied at an essentially constant rate over a period of not less than 3 min and not more than 5 min until the initial load is reached. Thereafter, the gage length shall be maintained constant. Load relaxation readings shall commence 1 min after the initial load has been reached.

6.3.3.5 The initial load shall be 70 % of the specifed minimum breaking strength of the wire. Overstressing of the test specimen to a level greater than 70 % of the specified minimum breaking strength during loading shall not be permitted.

6.3.3.6 The test gage length shall be at least 60 times the nominal diameter of the wire.

6.3.3.7 The result of each relaxation test shall be reported either as the actual percent of stress loss after 1000 h or the extrapolated percent of stress loss after 1000 h as determined from the linear regression curve.

NOTE 4—In accordance with ANSI/AWWA C 304, ordinary prestressed concrete pipe design is based on an assumed maximum wire relaxation of 7.48 % at 1000 h. Wire with higher relaxation can be used, but the higher relaxation loss must be known for consideration in the pipe design.

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6.4 *Torsion Test*:

6.4.1 *Torsion Requirements*—Torsion requirements shall conform to those prescribed in Table 3 for the specified size and class.

6.4.2 *Number of Tests*—One test specimen shall be taken from each coil.

6.4.3 *Test Method*—Conduct the torsion test in accordance with the following:

6.4.3.1 Use a twist rate of 10 to 30 r/min.

6.4.3.2 Load the wire with an axial force of from 0.5 to 2 % of the minimum breaking strength of the wire.

6.4.3.3 Use a test specimen length, defined as the distance between the testing machine jaws, of a minimum of 8 in. (203 mm).

6.4.3.4 Use a minimum number of turns proportional to the length of the test specimen based upon Table 3.

6.4.3.5 The test shall be conducted to fracture, defined as complete separation of the broken ends. The test specimens shall be inspected for primary break shear area and longitudinal (spiral) splitting following completion of the torsion test.

(1) Primary Break Shear—The primary break face of the test specimen shall have a clean, flush, full shear face, perpendicular to the wire axis (see Fig. 1).

(2) Longitudinal (Spiral) Splitting—If the fractured specimen shows evidence of a spiral split, either visible without magnification (see Fig. 2) or by an offset in the wire surfaces (see Fig. 3) detectable with a fingernail, a retest of that coil shall be conducted in accordance with 6.4.3.5 (*3*).

(3) Retest for Splitting in Torsion —The retest specimen shall have a minimum length of 8 in. (203 mm). The retest shall consist of twisting the retest specimen proportionally to three twists per 8 in. (203 mm) specimen length, at which point the twisting shall be stopped and the specimen inspected while still in the torsion machine. A spiral split in this specimen, either visible without magnification or detectable with a fingernail, shall be cause for rejection of the coil.

6.4.3.6 The tested coil number, specimen length, and total number of turns shall be recorded.

6.5 *Mechanical Test Results Report*— The wire manufacturer shall furnish a report listing the tensile, reduction of area, and torsion test results.

7. Dimensions and Permissible Variations

7.1 The diameter of the wire shall not vary from that specified by more than ±0.002 in. (0.05 mm) in diameter nor more than 0.002-in. (0.05-mm) out-of-round.

8. Workmanship, Finish, and Appearance

8.1 The surface of the wire as received shall be smooth and generally free of rust. A light oxidation film that does not cause pitting of the wire surface visible to the unaided eye after wiping or light cleaning, shall not be cause for rejection. Coils of wire with visible pitting shall be rejected.

TABLE 3 Torsion Requirements

Wire Gage or Fraction in.	Decimal Size, in. (mm)	Class II and Class III min turns per 8 in. (203 mm)
6	0.192 (4.88)	10
1/4	0.250 (6.35)	8
5/16	0.312 (7.92)	7



FIG. 1 Acceptable View of the Break Face.

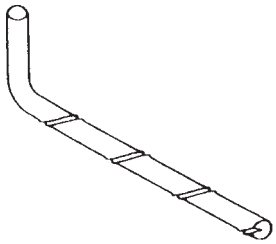


FIG. 2 Visible Longitudinal (Spiral) Splitting After Torsion Testing

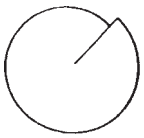


FIG. 3 End View of Offset Longitudinal (Spiral) Split After Torsion Testing

8.2 The wire shall not have detrimental piping, cross checking, torn surfaces, chatter marks, splits, die marks, scratches, pits, or seams.

8.3 The wire shall not be kinked, improperly cast, or show a wavy condition.

8.4 Each coil shall be one continuous length of wire, properly coiled.

8.5 The wire shall not be oiled or greased.

9. Inspection

9.1 The manufacturer shall afford the purchaser's inspector all reasonable facilities to satisfy him that the material is being produced and furnished in accordance with this specification. All tests and inspections may be made at the place of manufacture prior to shipment and shall be so conducted as not to interfere unnecessarily with the operation of the work.

10. Rejection Retesting, and Rehearing

10.1 Failure of any specimen to meet the mechanical requirements of this specification when tested by the manufacturer, except splitting during torsion testing, shall be cause either for rejection of the coil represented by the sample or for retesting two additional specimens from that coil. If either additional specimen fails the retest for the mechanical requirement in which the first specimen failed, the coil in question shall be rejected. Requirements for retesting coils which split during torsion testing are described in 6.4.3.5 (*3*).

10.2 Any rejection based on tests made in accordance with the specification shall be reported to the wire manufacturer within a reasonable period of time. The material must be adequately protected and correctly identified in order that the wire manufacturer may make a proper investigation.

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11. Product Marking and Packaging

11.1 The size of the wire, purchaser's order number, ASTM specification and class number, cast or heat number, coil number, and name or mark of the manufacturer shall be marked on a tag securely attached to each coil of wire.

11.2 Unless otherwise specified, packaging shall be in accordance with the procedures in Practices A 700.

12. Keywords

12.1 prestressed concrete pipe; prestressing; steel wire

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply when specified by the purchaser order or contract.

S1. Hydrogen Embrittlement Test

S1.1 Results–For a single diameter and class of wire, the results of nine hydrogen embrittlement tests performed in accordance with Test Method A 1032 shall be submitted to the purchaser. No test shall result in a time-to-failure of less than 75 hours. The results shall be derived from tests conducted anytime within the previous 12 months on wire of the same diameter and class and made from the same rod source as the wire being furnished. The hydrogen embrittlement test report described in Test Method A 1032 shall be submitted to the purchaser at the time of delivery of wire or as agreed between purchaser and wire manufacturer.

S1.2 Test Specimens–For a single diameter and class of wire, three wire test specimens shall be taken from each of three different rod heats from the same rod source, having chemical analyses that conform to the parameters stated in the purchase order and also falling within Chemical Requirements listed in Table 2. All wire to be tested shall be manufactured using the same wire drawing procedure. Each of the test specimens shall be taken from a different coil of wire.

S1.3 Retests–If time-to-failure for one specimen from any heat is less than 75 hours, retesting of two specimens taken from test units from two additional coils from the same rod heat of steel shall be performed. If both retest specimens have time-to-failure of 75 hours or greater, those two results shall be reported. If either retest has a time-to-failure less than 75 hours, no wire drawn from the failing rod heat of steel shall be supplied to purchase orders or contracts requiring these supplementary requirements. Wire samples representing a fourth heat of steel shall be then submitted for testing.

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last version (A 648 – 04) that may impact the use of this standard. (Approved Sept. 1, 2004.)

(1) Added the Supplementary Requirements.
(2) Added a new section 1.3.
(3) Added 3.1.7.

Committee A01 has identified the location of selected changes to this standard since the last version (A 648 – 95 (2000)) that may impact the use of this standard. (Approved March 1, 2004.)

(1) Revised Table 1 and 5.2.
(2) Revised Table 3 and 6.4.3.5 (1), and added a new Figure 1.

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