Designation: A1032 – 15

Standard Test Method for Hydrogen Embrittlement Resistance for Steel Wire Hard-Drawn Used for Prestressed Concrete Pipe[1]

This standard is issued under the fixed designation A1032; 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 test method describes procedures to determine the hydrogen embrittlement (HE) resistance of hard-drawn steel wire used for prestressed concrete pipe.

1.2 HE resistance is reported as time-to-failure of specimens tested in a laboratory.

1.3 The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered standard.

1.4 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A648 Specification for Steel Wire, Hard-Drawn for Prestressed Concrete Pipe

D1193 Specification for Reagent Water

3. Summary of Test Method

3.1 Characterization of HE resistance of hard-drawn steel wire is accomplished by determining the time-to-failure of a wire specimen under a maintained constant tensile force, while immersed in a heated solution of ammonium thiocyanate (NH_4SCN). The tensile force, the solution temperature, and length of time in the test are continuously monitored.

4. Significance and Use

4.1 Hard-drawn steel wire as used in prestressed concrete pipe may be exposed to elemental hydrogen favorable to hydrogen induced embrittlement and cracking. Resistance to hydrogen embrittlement is necessary for prestressing wire to provide long-term performance to installed pipe.

4.2 The length of time that a stressed wire specimen resists failure while exposed to a heated solution of NH_4SCN, is an indication of the specimen's resistance to hydrogen embrittlement.

5. Apparatus

5.1 *Test Cell*—The test cell shall contain the test solution and the wire specimen and be constructed of material which is inert to NH_4SCN (as shown in Fig. 1). The test cell shall be cylindrical with an inside diameter sufficient to provide a minimum of 5 mL of solution per 100 mm^2 (2 $in.^3$ per $in.^2$) of wire specimen surface area in contact with the solution. The test cell length shall allow the exposure of a minimum test specimen length of 150 mm (6 in.) to the test solution. The test cell shall be so designed that the wire specimen passes through it and is sufficiently exposed outside the end of the cell as to allow application of a tensile force to the specimen.

5.2 *Chronometer*—A chronometer with a precision of at least ± 1 min. and capable of being stopped automatically on fracture of the specimen shall be used.

5.3 *Tensile Force Frame*—A closed stiff frame, in either horizontal or vertical orientation, shall be used to position the test cell such that a constant tensile force shall be applied to the test specimen and maintained. The tensile force shall be applied through use of a dead weight, or hydraulic loading system equipped with a force indicator.

6. Reagents and Materials

6.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

6.2 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean reagent water as defined by Type 4 of Specification D1193.

[1] This test method 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.

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

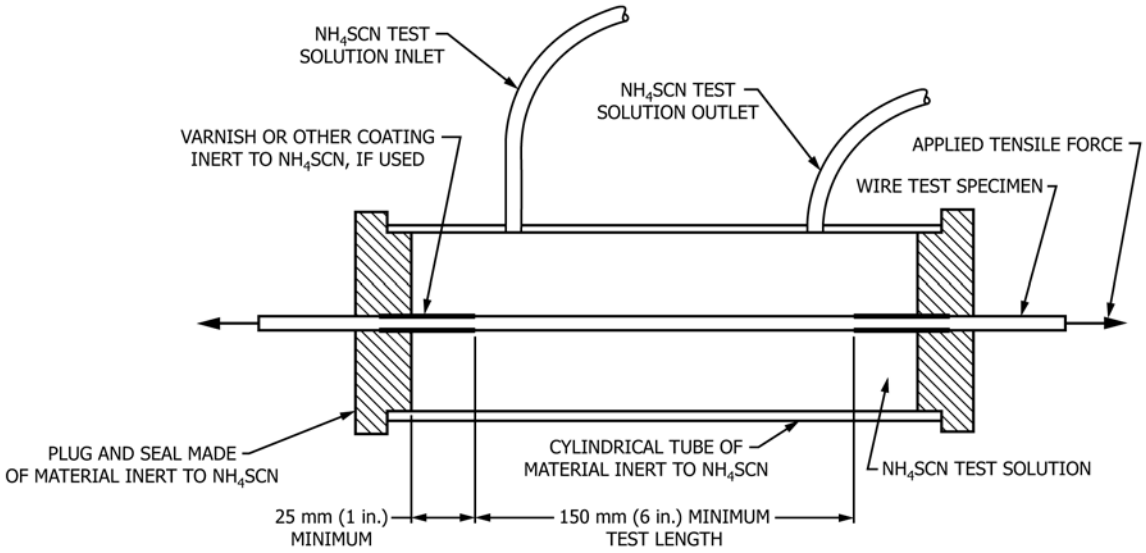

FIG. 1 Test Cell

6.3 *Ammonium Thiocyanate*—NH_4SCN solution shall be prepared by dissolving 250 g of NH_4SCN (98.5 % pure) per 1.0 L (0.52 lb of NH_4SCN per 1.0 qt) of water.

7. Sampling, Test Specimens, and Test Units

7.1 *Hard-Drawn Steel Wire*—The wire shall comply with Specification A648.

7.2 A test unit shall consist of 1500 mm (60 in.), or such length as specified by the testing laboratory, of wire from a coil of wire. Specimens shall be identified with size, class, rod heat number, manufactured wire coil number, and name of wire and rod manufacturer.

7.2.1 The mechanical properties shall have been determined in accordance with applicable sections of Specification A648 and a certified mill test report for the test unit shall be provided.

7.3 *Test Specimen*—A test specimen shall be cut from the wire test unit, of such length that a minimum length of 150 mm (6 in.) will be exposed to the test solution, plus sufficient length to connect to a tension loading device. The test specimen shall be identified as required in 7.2.

7.3.1 The test specimen shall be cleaned by wiping with a soft cloth and degreased in acetone, or in trichlorethylene, then dried in air.

7.3.2 To prevent false negative results, the test specimen may be coated with an insulating material such as varnish, up to 25 mm (1 in.) into the test cell at each end. The 25 mm length of coating at each end within the cell shall not be considered part of the length required in 7.3.

8. Procedure

8.1 *Preparation*—Place the test specimen into the empty test cell and seal the ends of the cell. Place the test cell into the tensile force frame.

8.2 *Tensile Force Application*—Apply a tensile force to the wire specimen until 70 % of the Specification A648 minimum tensile strength for the wire diameter and class being tested is developed. Maintain the tensile force to within ±2.0 % for the duration of the test. The tensile force application shall be completed within 5 min of loading initiation.

8.3 *Fill Test Cell*—Upon completion of tensile force application, fill the test cell with NH_4SCN test solution, preheated to a temperature of 50 ± 1°C (122 ± 2°F). Filling of the test cell shall be completed within 1 minute.

8.4 *Tensile Force and Temperature*—The tensile force and the solution temperature shall be monitored and maintained within the force requirements of 8.2 and the temperature requirements of 8.3, for the duration of the test.

8.5 *Time to Failure*—With a full test cell, set the chronometer to zero and record time to failure to the nearest 1 min. Terminate test after 100 h of exposure if failure has not occurred.

9. Report

9.1 *Report Contents*—A report of HE test results from each specimen shall be made and shall include:

9.1.1 Date of test and date of report.

9.1.2 Identification of the test specimen.

9.1.3 Wire diameter and class.

9.1.4 Manufacturer of wire and manufacturer of rod.

9.1.5 Wire coil number and rod heat number.

9.1.6 Mechanical properties determined in accordance with Specification A648.

9.1.7 Chemical composition in accordance with Specification A648.

9.1.8 Number of hours-to-failure, or number of hours to test termination.

9.1.9 Description of the test apparatus and testing procedures.

10. Precision and Bias

10.1 *Precision*—No statement is made on the precision of this test method since the test results indicate only whether there is conformance to given criteria and no generally accepted method for determining precision of this test method

is currently available. General guidelines provided herein for the specimens, instrumentation, and procedures make the results intractable to calculation of meaningful values by statistical analysis for precision at this time.

10.2 *Bias*—Since there is no accepted reference material suitable for determining the bias in this test method, no statement on bias is made.

11. Keywords

11.1 cracking; hydrogen embrittlement; prestressed concrete pipe; prestressing; hard-drawn steel wire

SUMMARY OF CHANGES

Committee A01 has identified the location of selected changes to this standard since the last issue (A1032 – 04 (2010)) that may impact the use of this standard. (Approved May 1, 2015.)

(1) Various editorial changes in the title, 1.1, 3.1, 4.1, 5.1, 5.2, 5.3, 8.2, 8.4, 9.1, and 9.1.9.