Designation: D1036 – 99 (Reapproved 2005)

Standard Test Methods of Static Tests of Wood Poles[1]

This standard is issued under the fixed designation D1036; 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.

INTRODUCTION

One of the important factors involved in the design and economical use of poles for the support of aerial communication and power lines is the value of the maximum fiber stress for the different species of timber used for poles. In order to gain information on this characteristic, mechanical tests on pole size specimens have been made by numerous investigators. These tests have been made in various manners, such as the use of a testing machine, holding the pole butt horizontally in a crib and applying the load at the tip, setting poles in the earth and applying the load at the tip, and so forth. The amount of seasoning the test poles have received and the type of preservative treatment applied to the poles are additional variables. The result is that it is difficult, if not impossible, to obtain sufficient information pertaining to the various tests to permit accurate comparisons.

It is the purpose of these test methods to cover testing procedures in sufficient detail so that the results of tests made in accordance with the test methods defined will be comparable. It is, of course, not intended that using other test methods that may be better adapted to a particular investigation should be discouraged. However, experience gained from tests of several hundred poles has indicated the test methods specified are entirely practicable.

The data forms presented have been found to be convenient for recording the test data and for making the calculations necessary for the proper analysis of the test results.

1. Scope

1.1 These test methods cover determination of the bending strength and stiffness of wood poles. Knowledge of these properties is used in providing for reliable and economical design with poles of different species, size, or grade.

1.2 Two test methods are included: the cantilever test method and the machine test method.

1.3 Provision is also made for extracting small clear specimens from the butt section and determining static bending and compression parallel to grain strength values in accordance with Test Methods D143.

1.4 The procedures specified in these test methods apply to tests of either treated or untreated material.

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

1.6 *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]

D143 Test Methods for Small Clear Specimens of Timber

D198 Test Methods of Static Tests of Lumber in Structural Sizes

2.2 *ANSI Standard:*[3]

O5.1 Specifications and Dimensions for Wood Poles

[1] These test methods are under the jurisdiction of ASTM Committee D07 on Wood and are the direct responsibility of Subcommittee D07.04 on Pole and Pile Products.

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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 (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

3. Summary of Test Method

3.1 *Major Tests*:

3.1.1 In the cantilever test method, the pole is supported securely from butt to ground line in a horizontal position, and a load is applied near the pole tip by means of a pulling line.

3.1.2 In the machine test method, the pole is supported near the butt and tip, and a load is applied at the ground line by the moving head of a mechanical testing machine.

3.1.3 Determinations of age, rate of growth, moisture, and density are also made.

3.2 *Minor Tests*:

3.2.1 Small clear specimens are taken from the butt section of the tested poles for the determination of strength values such as static bending, compression parallel to grain, toughness, compression perpendicular to grain, and hardness. The overall objectives of the program will determine which of these tests are desired.

4. Significance and Use

4.1 Tests of wood poles are made to determine:

4.1.1 Data for use in establishing allowable stresses,

4.1.2 Data upon which to base economical pole line design,

4.1.3 Data on the strength properties of different species in pole sizes,

4.1.4 Data as to the influence of defects on the strength properties of poles,

4.1.5 Data as to the effect of preservatives and preservative treatments on the strength properties of poles, and

4.1.6 Data for correlating the strength properties of full-size poles with those of small clear specimens of the same species.

4.2 Treating procedures to which poles have been subjected may introduce variables that prohibit direct comparisons between different groups of data. Complete information on the treating techniques shall form a part of the test records.

COLLECTION OF MATERIAL

5. Identification

5.1 The material for test shall be selected by one qualified to identify the species.

6. Number of Major Specimens

6.1 For each species under investigation it is desirable that a minimum of 50 specimens be selected for test. The poles shall be carefully chosen as representative of the commercial product being supplied.

NOTE 1—Tests may be conducted to study the effect of some particular characteristic and in such cases the selection of test specimens shall be made in such a manner as to ensure that the range of the characteristic under study has been adequately sampled.

7. Field Notes

7.1 Field notes fully describing the material shall be carefully made by the collector. These notes shall, so far as possible, supply data outlined as follows and shall be incorporated into the test records:

FIELD NOTES

Project No.
Locality cut
County
Slope ... Elevation
Undergrowth
Crown
Soil
Shipment No.
Species
Date cut
Seedling or sprout
How and when transported from woods
Age of tree in years
Treatment
Seasoning
Preservative retention
Age in service (if pole had been in service)
Age of pole since treatment
Source of pole (supplier, region, and climate), if pole had been in service
Classification standard
Condition of pole (decay, woodpecker holes, splits), if pole had been in service

8. Field Marking

8.1 Each specimen shall be legibly marked on the butt with its length, class, and source of supply, in accordance with the requirements of ANSI O5.1, using such symbols as may apply to each specimen.

CONDITIONING AND MEASURING OF SPECIMENS FOR TESTING

9. Conditioning

9.1 Two basic procedures for conditioning and moisture content are provided as follows:

9.1.1 *Test Method A*, providing for air seasoning and butt soaking of poles prior to test.

9.1.2 *Test Method B*, providing for tests of poles in the full-length green condition.

NOTE 2—Test Method A, providing for butt soaking of poles after seasoning, has been used as a preconditioning test method when it is desired to provide tests simulating, as nearly as possible, actual field use under certain climatic conditions.

Test Method B, providing for tests of poles in the green condition, has been used where the stability of moisture-strength relationships thus established is particularly desired for comparison between species, grades, and testing procedures, and for establishing relationship of strength between full-size poles and that of small clear specimens taken from the pole material.

10. Alternative Conditioning Requirements

10.1 *Test Method A*—All poles tested shall be air-seasoned on skids at least 2 ft (600 mm) above the ground. Prior to testing, the butt sections (from the groundline to the butt) shall be soaked in water in order to bring the moisture content of this section equal to or above the fiber saturation point. Butt soaking shall be conducted in a manner to prevent decay and with the poles in a vertical position. Moisture determinations of the butt section shall be made by means of increment borings. The determinations shall be made by using the portions of the borings nearest the pole surface with a length of boring equal to one-half the pole radius.

NOTE 3—For the purposes of these test methods, poles will be considered air-seasoned when two successive determinations made one week apart indicate the moisture content of the pole to have reached a practically constant value at or below 22 %.

10.2 *Test Method B*—All poles to be tested shall be selected in the green condition and shall be tested before any seasoning has taken place. If there is any delay in testing that would result in seasoning, this shall be prevented by proper storage, preferably by full-length immersion in water. If other methods of maintaining the green condition are employed, care shall be exercised to prevent the development of stain or decay. Special moisture determinations of the test sections are not required prior to test (Section 25).

11. Initial Measurements

11.1 Before placing a pole in the testing apparatus, a record shall be made of the following items:

11.1.1 Weight,

11.1.2 Length to the nearest 1 in. (25 mm),

11.1.3 Class,

11.1.4 Circumference at butt, at tip, and at the ground line to the nearest 1⁄16 in. (1.5 mm),

11.1.5 Diameter of each knot over ½ in. (13 mm) in diameter and its location on the surface of the pole relative to the butt and to the longitudinal center line of the face of the pole, and

11.1.6 Any possible strength reducing defects observed other than knots, such as sweep, crook, checks, shakes, spiral grain, insect damage, and the like.

STATIC BENDING TESTS OF POLES

Cantilever Test Method

12. Apparatus

12.1 A schematic drawing of the testing apparatus and field layout for conducting the tests is shown in Fig. 1. For convenience of reference, the principal features of the layout are denoted on the drawing by capital letters. The pole to be tested shall be held securely from the butt to the ground line in the crib *A*. The crib shall be built in such a manner that there will be no significant movement of the pole butt during the test. The design of the crib and holding devices shall be such that all vertical and rotational motion of the pole shall be prevented.

12.2 A support *B* shall be provided at a point about three quarters of the distance from the ground line to the point of load application to minimize vertical movement at that point and reduce the stress from the weight of the pole. This support shall be such that any friction associated with the deflection of the pole under load shall not be a significant portion of the measured load on the pole.

12.3 As a pole is placed in the testing apparatus, it shall be rotated to align the pole so as to minimize out-of-plane shear stresses due to torque. The pole shall be shifted longitudinally until its ground line coincides with the front face of the crib, and then it shall be secured firmly in place (see 12.1). A wooden saddle *C*, Fig. 1, with a concave surface on the pole side and rounded edges, shall be placed against the pole to

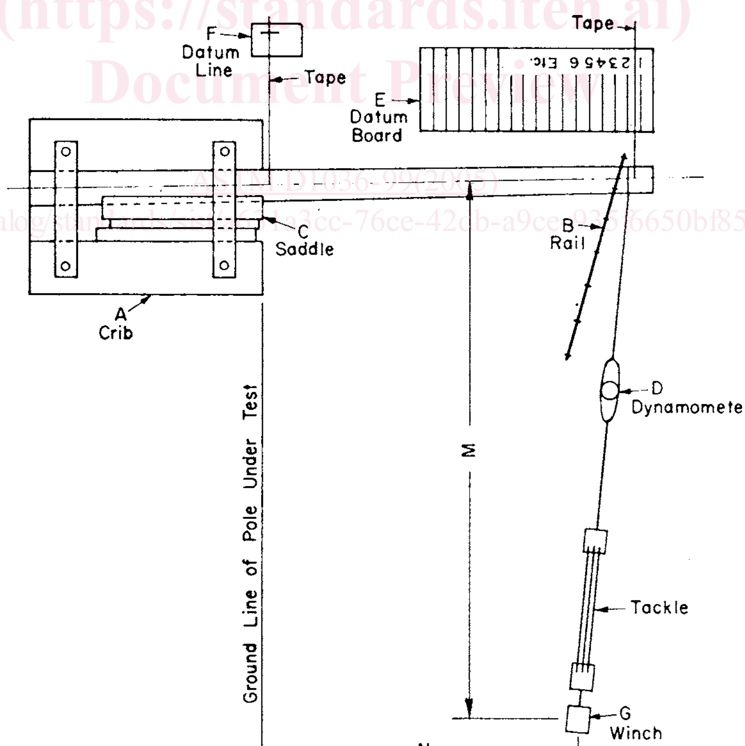


FIG. 1 Schematic Layout of Field Mechanical Tests of Wooden Poles

prevent injury to the ground-line section. This saddle shall be made of wood at least as soft as the pole under test and shall have dimensions as shown in Fig. 2.

13. Load

13.1 The load shall be applied at a point 2 ft (600 mm) from the tip of the pole by a power winch, or other means of sufficient capacity and capable of pulling at a constant rate of speed. The pulling line shall be kept level between the winch position and the point where load is applied to the pole. The load shall be applied continuously until the pole fails, and at such a rate of speed as to cause a deflection at the point of load of N in./min (mm/min), as determined by the equation:

$$N = 2\pi Z L^2 / 3C_t \tag{1}$$

where:

N = rate of deflection, in./min (mm/min),
Z = rate of fiber strain, in./in.·min (mm/mm·min) = 0.0010, the value specified in Test Methods D198,
L = lever arm, in. (mm), and
C_t = circumference at point of load application, in. (mm).

14. Pulling Line

14.1 The pulling line shall be secured around the pole at the load point. The load measuring device shall be placed in series with the pulling line and the line to the winch with a free-running swivel on each side of it.

15. Winch Positions

15.1 If the winch G, Fig. 1, is set far enough away from the pole to make the angle between the initial and final positions of the pulling line small, the error in assuming that the pull is always perpendicular to the original direction of the pole axis will be negligible. The winch shall be located at the positions given in Table 1.

16. Load Measurement

16.1 Load shall be measured by a suitable measuring device placed in series in the pulling line. The recommended method is a calibrated metal tension bar fitted with calibrated electric-type strain gages, suitably wrapped or housed for protection against shock when the pole breaks. This method permits remote reading of loads and minimizes the possibility of personal injury during test. Alternatively, where electric-type strain gaging equipment is not available, load may be measured by a dynamometer of suitable capacity, graduated in 50-lb (200-N) divisions. Calibration of the dynamometer shall be checked at frequent intervals during the tests. The load-measuring device shall be supported on a sled or cradle moving on a suitable platform or level space. The sled or cradle and the surface on which it moves shall be such that the force required to pull it shall not add materially to the measured load on the pole.

TABLE 1 Winch Positions

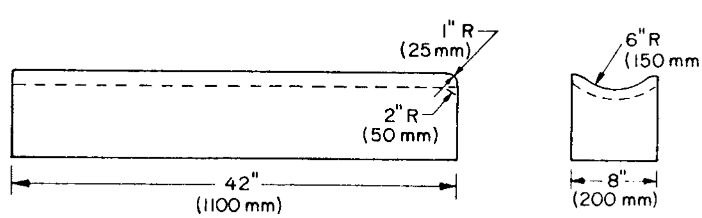
Pole Length, ft (m)	Distance M from Pole Axis, ft (m)[A]	Distance N from Ground Line, ft (m)[A]
20 (6.1)	100 (30.5)	13.5 (4.1)
22 (6.7)	110 (33.5)	15.5 (4.7)
25 (7.6)	125 (38.1)	17.5 (5.3)
30 (9.1)	150 (45.7)	22.0 (6.7)
35 (10.7)	175 (53.3)	26.5 (8.1)
40 (12.2)	200 (61.0)	31.0 (9.4)
45 (13.7)	225 (68.6)	35.5 (10.8)
50 (15.2)	250 (76.2)	40.0 (12.2)
55 (16.8)	275 (83.8)	44.5 (13.6)
60 (18.3)	300 (91.4)	49.0 (14.9)

[A] See Fig. 1 for location of distances M and N.

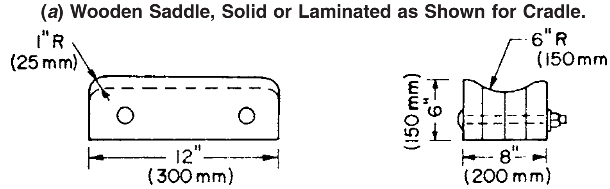
17. Deflections

17.1 The deflection of the pole at the point of load shall be measured at such intervals of load as to provide not less than 15 simultaneous readings of load and deflection. A greater number of readings (25 to 40) is preferred. The measurement of the deflection of the load point shall be made in a direction perpendicular to the unloaded position of the pole axis. A measurement of the movement of the load point toward the butt resulting from the deflection shall also be made at each increment of load.

NOTE 4—These measurements may be facilitated if a piece of plywood (datum board), E, Fig. 1, is ruled with lines perpendicular to the unloaded axis of the pole and spaced 1 in. (25 mm) apart. The edge of the plywood board away from the pole may be used as the datum line from which the



(*a*) Wooden Saddle, Solid or Laminated as Shown for Cradle.



(*a*) Wooden Saddle, Solid or Laminated as Shown for Cradle.

FIG. 2 Saddle and Cradle

deflection is measured. Then as the pole is deflected under load, the tape by which the deflection is measured is kept parallel to the ruled lines and its motion toward the butt may be measured by noting the line to which the tape is parallel when the deflection is measured.

17.2 A second datum line shall be established at *F*, Fig. 1, from which movement of the ground line shall be measured.

17.3 Alternatively, the deflection of the pole may be measured with respect to a wire tightly stretched along the upper surface of the pole between the load point and a point 1 ft (300 mm) from the butt. The movement of the wire relative to the position of the pole at the ground line can be observed by means of a suitable horizontal scale attached to the upper surface of the pole.

18. Procedure

18.1 Before any load is applied to the pole, take zero readings for the following and enter in the appropriate columns of Table 2 (Data Sheet 1):

18.1.1 On the tape that measures the deflection of the load point to the edge of the datum board, *t*,

18.1.2 On the datum board the line to which the tape of 18.1.1 is parallel, *s*,

18.1.3 On the tape for measuring ground line movement, *g*, and

18.1.4 On the horizontal scale at the ground line of the pole when the wire is used.

18.2 At this time also make the following measurements and record them in the appropriate place in Table 2 (Data Sheet 1):

18.2.1 Actual distance from butt of test pole to ground line (that is, point of support),

18.2.2 The distance from ground line to point of load,

18.2.3 Circumference at ground line and at point of load,

18.2.4 Species of timber,

18.2.5 Source of pole,

18.2.6 Preservative treatment if any, and

18.2.7 Test number.

18.3 Make the circumference measurements to the nearest 0.1 in. (2 mm).

18.4 The difference between the zero and any subsequent *t* readings measures the movement of the point of load in a direction perpendicular to the unloaded position of the pole axis. Similarly, the difference between the zero and subsequent *s* readings measures the movement of the point of load toward the pole butt in a direction parallel to the unloaded position of the pole axis. The data relative to the ground line movement, *g* readings, will be needed only for correction of the deflection readings and for a calculation of the modulus of elasticity if this characteristic is desired.

18.5 Apply the load continuously and at a uniform rate until the pole fails. At each increment in the load, as indicated by the load measuring device, make simultaneous readings of *t, s,* and *g* and record them in Table 2 (Data Sheet 1) until failure occurs in the pole. Record the maximum load shown by the load measuring device. After failure, estimate the break location and measure and record the distance from this location to the point of load.

19. Test Results

19.1 *Load Correction*—Record the corrected load reading in the appropriate column of Table 3 (Data Sheet 2). Determine these corrected readings from calibration curves of the load measuring device.

19.2 *Lever Arm Correction*—The difference between the *t* and *s* readings and the zero readings made during each test are, respectively, measures of the movement of the point of load in a direction perpendicular to and parallel to the unloaded position of the pole axis. Deduct the difference between the zero and final *s* readings from the distance from point of load to ground line and from the distance from point of load to point of break, to obtain the true lever arm for the calculation of the fiber stress at the ground line and at the breaking point, respectively.

19.3 *Load-Deflection Curve*—Plot a load-deflection curve for each pole tested.

19.4 *Calculations*—Calculate the maximum fiber stress at the ground line as follows:

$$F = 32\pi^2 P(L - \Delta_L)/C^3 \tag{2}$$

where:

F = maximum fiber stress at ground line, psi (MPa),
P = load at failure (corrected), lbf (N),
L = distance from ground line to point of load, in. (mm),
Δ_L = longitudinal deflection of the load point at the maximum load, in. (mm), and
C = circumference at ground line, in. (cm).

If the maximum fiber stress at break is desired, calculate it as follows:

$$F_b = 32\pi^2 P(a - \Delta a)/C_a{}^3 \tag{3}$$

where:

F_b = maximum fiber stress, psi (MPa),
P = load at failure (corrected), lbf (N),
a' = distance from break to point of load, in. (mm),
Δ_a' = longitudinal deflection of break point at maximum load, a lever arm correction for stress at point of break, accounting for the lever arm shortening between the point of break and point of load, in. (mm), calculated as:

$$\Delta_a' = \Delta_L[1 - (b/L)^3] \tag{4}$$

where:

L = distance from ground line to point of load, in. (mm),
b = distance from ground line to point of break, in. (mm),
Δ_L = longitudinal deflection of the load point at the maximum load, a lever arm correction for maximum ground line stress, accounting for the lever arm shortening between ground line and point of load, in. (mm), and
C_a = circumference at point of break, in. (mm).

TABLE 2 Sample Data Sheet 1

Pole Strength Tests — Test Pole No: 26

Species: So. Pine — Class and Length 6-30 — Weight, lb.:

Plant and Treatment: Spartanburg - Salt

CIRCUMFERENCES (Inches)

GL*: 26.9 — Load Point: 19.1 — Tip: 18.5

LENGTHS (Feet-Inches)

Butt to GL*: 5′-5 3/4″ — GL* to Load Point: 22′-6″ — Load Point to Break: 16′-6 1/2″

Observed Dynamometer Reading, lb.	t*		s*, in.	g*, in.	Remarks
	Feet	Inches			
0	10	8 3/4	5	0	
200	11	1/2	5 5/8	0	
400	11	3 7/8	6 1/4	1/16 −	
600	11	9 1/4	6 1/4	1/16 +	
800	12	1	6 3/8	1/8	
1000	12	6	6 5/8	3/16	Start time
1200	12	10 3/8	6 3/4	3/16	
1400	13	4 1/8	7 1/8	1/4	
1600	13	11 1/2	7 3/8	5/16	3 m 4 s
1800	14	8 7/8	7 1/2	3/8	
2000	(14.95 =	Est.	(g =	Est.)	1840 Max.
2200			10.0		Short break at knot whorl
2400			(9.8 min.)		
2600					
2800					
3000					
3200					
3400					
3600					
3800					
4000					Total s = 5

*GL (Ground Line) = Point of support.
t = Perpendicular distance from tip datum to load point.
s = Distance load point moves toward butt.
g = Distance pole moves at ground line.

Initials of Recorder: R.C.E.
Date: 9-5-39

NOTE 1—This data sheet is an example using inch-pound units. If the metric equivalents were being used, the quantities would be measured as follows:

circumferences—mm
lengths—m, s—mm
dynamometer readings—N g—mm
t—m

The modulus of elasticity may be calculated as follows: