Designation: E 489 – 92 (Reapproved 1997)

Standard Test Method for Tensile Strength Properties of Metal Connector Plates[1]

This standard is issued under the fixed designation E 489; 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

The use of prepunched metal connector plates with and without integral projecting teeth as well as solid metal connector plates, usually fabricated from structural quality sheet coils, such as described in Specification A 446/A 446M, to fasten wood members together, is a widely accepted practice. In many applications, these plates must resist tensile forces. During manufacture and subsequent loading of these plates, stress concentrations develop around holes that were punched (or drilled) during manufacture or during fabrication of the connection. These stress concentrations limit the accuracy of strength predictions based solely on metal and net-section properties. This test method provides a simple alternative to the development of complex analytical models required to deal with these stress concentrations.

If a section taken through the width of a metal connector plate differs in geometric character from a section through its length, the strength ratio of this plate is a function of its orientation. If this is the case, the plate shall be evaluated for net section across its length as well as its width under the methods presented here. However, if a plate is identical in both directions, only testing across its width shall be necessary and the resulting strength ratio is applicable to both orientations of the plate.

1. Scope *

1.1 This test method provides a basic procedure for evaluating the tensile strength properties of the net section of finished metal connector plates.

1.2 This test method serves as a basis for determining the comparative performance of different types and sizes of metal connector plates in tension.

1.3 A companion test method, Test Method E 767, covers the performances tests on these plates in shear.

1.4 Test Methods D 1761 cover the performance of the teeth and nails in wood members during the use of metal connector plates (see Note 1).

NOTE 1—The maximum design load in tension, an indication of the effectiveness of the net cross section of the perforated metal connector plate, is not necessarily a criterion of the effectiveness of the plate in transmitting the load from wood member to wood member, since that property is influenced by a number of factors, including the effectiveness of the nails or that of the integral plate projections, or a combination thereof, used in the wood species under consideration, and tested in accordance with Test Methods D 1761.

1.5 This test method does not provide for the corrosion testing of metal connector plates exposed to long-term adverse environmental conditions where plate deterioration occurs as a result of exposure. Under such conditions, special provisions shall be introduced for the testing for corrosion resistance.

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:*

A 446/A 446M Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Structural (Physical) Quality[2]

A 525 Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process[2]

A 591/A 591M Specification for Steel Sheet, Electrolytic Zinc-Coated, for Light Coating Mass Applications[3]

D 1761 Test Methods for Mechanical Fasteners in Wood[4]

E 4 Practices for Force Verification of Testing Machines[5]

E 8 Test Methods for Tension Testing of Metallic Materials[5]

E 575 Practice for Reporting Data from Structural Tests of

[1] This test method is under the jurisdiction of ASTM Committee E-6 on Performance of Buildings and is the direct responsibility of Subcommittee E06.13 on Structural Performance of Connections in Building Construction.

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[2] Discontinued; see *1994 Annual Book of ASTM Standards*, Vol 01.06. Replaced by A653.

[3] *Annual Book of ASTM Standards*, Vol 01.06.

[4] *Annual Book of ASTM Standards*, Vol 04.10.

[5] *Annual Book of ASTM Standards*, Vol 03.01.

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

Building Constructions, Elements, Connections, and Assemblies[6]
E 631 Terminology of Building Constructions[6]
E 767 Test Method for Shear Strength Properties of Metal Connector Plates[6]
F 680 Test Methods for Nails[7]

3. Terminology

3.1 *Definitions*—For general definitions of terms used in this test method, see Terminology E 631.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *gross cross-sectional connector plate area*—cross-sectional area of metal connector plate determined by multiplying gross thickness of plate (see 9.3) by gross dimension of plate perpendicular to direction of load application.

3.2.2 *length of metal connector plate*—dimension of metal connector plate parallel to longitudinal axis of coiled metal strip from which plate was sheared during plate fabrication (see Figs. 1 and 2).

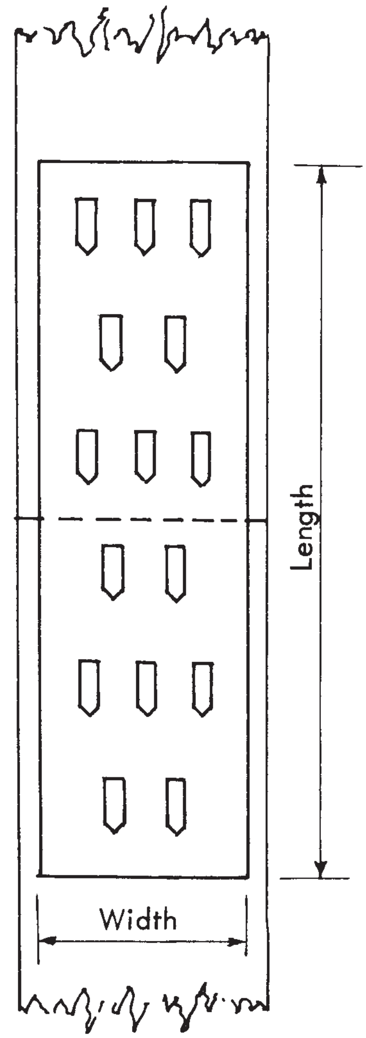
3.2.3 *metal connector plate*—in the context of this test method and with reference to coiled strips of structural quality sheet metal from which metal connector plates are manufactured, finished (coated, galvanized) metal connector plate with or without integral plate projections or nail holes, or a combination of both, with projections sheared from a solid plate during its fabrication and projecting from the plate in a single direction or both directions perpendicular to the plate surface area; plate of specified thickness (gage), usually including the following as well as intermediate thicknesses, to which appropriate tolerances apply:

mm	in.	Washburn and Moen Steel Gage	Specification A 525 (Table 17) Galvanized Sheet, in.
0.9	0.035	20	0.0396
1.0	0.041	19	0.0456
1.2	0.047	18	0.0516
1.4	0.054	17	0.0575
1.6	0.063	16	0.0635
1.8	0.072	15	0.0710
2.0	0.080	14	0.0785

Produced in various sizes, that is, lengths and widths; and designed to connect wood members and to transmit forces from one wood member (or section) to another member (or section). Other common terms include plate, truss plate, and metal plate, but preferably termed metal connector plate.

3.2.4 *nail hole*—round perforation in metal connector plate through which a nail can be driven to fasten plate to wood member (or section) and to transmit shear loads; providing predetermined location for appropriately locating nail to be driven (see plate hole).

3.2.5 *nail-on plate*—solid or prepunched (or predrilled) metal connector plate of specified thickness (gage), manufactured to various sizes, that is, lengths and widths, designed to be fastened with nails (or staples) to wood members and to transmit forces from one wood member (or section) to another member (or section).



NOTE 1—Metal connector plate failure will not necessarily occur along the dashed line, which indicates the separation of the butted wood members.

FIG. 1 Metal Connector Plate—Width Perpendicular to Grain of Wood Member

3.2.6 *plate*—in context of this test method, metal connector plate.

3.2.7 *plate hole*—opening in metal connector plate, resulting from shearing integral plate projections during plate fabrication (see nail hole).

3.2.8 *solid metal-coupon control specimen*—solid metal connector plate sample (see Fig. 3) of same material as metal connector plate under scrutiny; of dimensions meeting the requirements of Test Methods E 8; without nail and plate holes or integral plate projections.

3.2.9 *strength ratio*—ratio of ultimate tensile strength of metal connector plate to ultimate tensile strength of matched solid metal-coupon control specimen of same size; also called effectiveness ratio and efficiency ratio.

3.2.10 *tooth*—in context of this test method, integral projection of metal connector plate formed in direction perpendicular to plate surface during stamping process; also called prong, barb, plug, and nail.

[6] *Annual Book of ASTM Standards,* Vol 04.07.
[7] *Annual Book of ASTM Standards,* Vol 15.08.

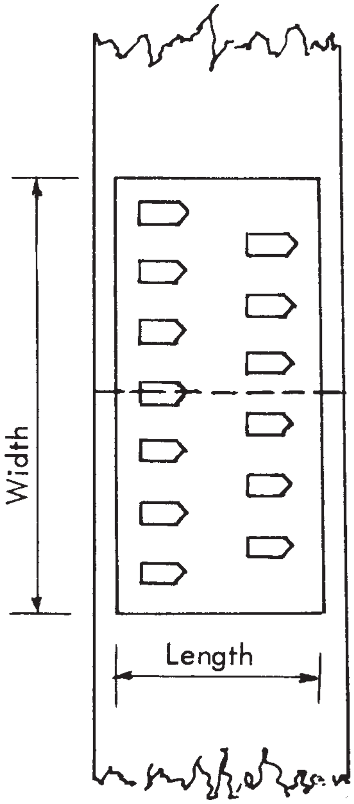


FIG. 2 Metal Connector Plate—Length Perpendicular to Grain of Wood Member

3.2.11 *test specimen*—in context of this test method, connection to be tested, fabricated by connecting two butted wood members with metal connector plates placed symmetrically at opposite sides along the ends of the butted wood members.

3.2.12 *truss plate*—see *metal connector plate.*

3.2.13 *typical metal connector plate*—in context of this test method, metal connector plate representative of single shipment of plate to be tested, with plate manufacturing procedure used simulating actual conditions encountered during plate fabrication as well as simulating actual conditions encountered during member and component assembly.

3.2.14 *ultimate stress*—maximum resistance to internal force developed by application of external force or load that a material, member, component, or assembly can withstand without failure; expressed in terms of unit of force per unit of cross area, MPa (lbf/in.^{2}, psi), even if this area is infinitesimally small. See *yield stress*.

3.2.15 *width of metal connector plate*—dimension of metal connector plate perpendicular to longitudinal axis of coiled metal strip from which plate was sheared during its fabrication (see Figs. 1 and 2).

3.2.16 *wood member*—in context of this test method section of lumber to be connected to similar section of lumber with metal connector plates placed symmetrically on opposite sides across butted member ends (see Figs. 1 and 2).

3.2.17 *yield stress*—resistance to internal force developed by application of external force or load, expressed in terms of unit of force per unit of area, MPa (lbf/in.^{2}, psi), that a material, member, component, or assembly can withstand when the initially constant (linear) rate of deformation increases faster than the rate of force application; that is, when a material, member, component, or assembly exhibits a specified limited deviation from the initial proportionality of stress to strain. When the initial rate of force application is nonlinear, an agreed on convention shall apply.

3.3 *Symbols: Specific to This Standard:*

3.3.1 $A_1 + A_2$—gross cross-sectional area (width $\times$ gross thickness) of both plates on opposite sides of test specimen.

3.3.2 A_t—base-metal cross-sectional area (width $\times$ base-metal thickness) of solid metal-coupon control specimen.

3.3.3 F—ultimate tensile stress resisted by test specimen.

3.3.4 F_t—ultimate tensile stress resisted by solid metal-coupon control specimen.

3.3.5 P—ultimate tensile force resisted by test specimen.

3.3.6 R—tensile strength ratio for each test specimen.

3.3.7 T—ultimate tensile force resisted by solid metal-coupon control specimen.

4. Summary of Test Method

4.1 This test method provides procedures for (*1*) tension tests of metal connector plates, (*2*) tension tests of solid metal-coupon control specimens of the same material used in the manufacture of the metal connector plates, and (*3*) a comparison of the metal connector plates with the control specimens in terms of effectiveness.

5. Significance and Use

5.1 The resistance of a metal connector plate to tensile forces is one measure of its ability to fasten wood members together, where tensile forces must be transferred through the metal connector plates from one member to another. Disregarding the effects of any plate projections, separately applied nails, and the wood members, the following factors affecting the tensile performance of a metal connector plate shall be considered when using this test method: length, width, and thickness of plate; location, spacing, orientation, size, and shape of holes in plate; edge and end distances of holes in plate; stress concentrations around perforations and projections of plate; and basic properties of plate metal. In the case of nail-on plates, their performance is also influenced by the type, size, quantity, and quality of the nails used for load transfer as well as the method of installing the plates and their fasteners.

6. Apparatus

6.1 *Testing Machine*—A testing machine capable of applying tensile loads, at a specific rate, having an accuracy of ± 1 % of the applied load, and calibrated in accordance with Practices E 4.

6.2 *Grips*—Self-centering gripping devices for each specimen end. These grips shall permit accurate specimen positioning, uniform axial load application, and complete rotational freedom, and shall safely hold the specimen during the test and after failure has occurred.

7. Test Material

7.1 *Metal Connector Plates*—The metal connector plates shall be typical of production and shall be manufactured in accordance with the design and of materials specified by the

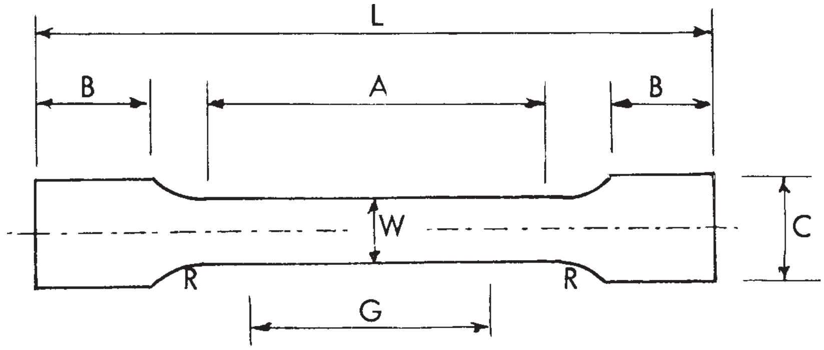


FIG. 3 Solid Metal-Coupon Control Specimen (for Dimensions, see Test Methods E 8)

plate manufacturer. The coil metal used for production of metal connector plates shall meet minimum specified grade properties, including the elongation for a 50-mm (2.0-in.) gage length to be at least 16 % for specified Grade C steel with minimum 275-MPa (40-ksi) yield point and a minimum 380-MPa (55-ksi) ultimate tensile stress in accordance with Specification A 446/A 446M.

7.2 *Solid Metal-Coupon Control Specimens*—The solid metal-coupon control specimens shall originate from the same coil from which the metal connector plates were fabricated.

7.3 *Wood Members*—The wood members of the connection shall be of such density and moisture content to ensure that failure occurs in the metal connector plates and not in the wood, teeth, or nails.

7.4 *Nails*—Any nails, used for fastening the metal connector plates to the wood members, shall be typical of those used in the field and fully comply with the applicable design provisions for transferring the structural forces from member to member. For the definition of nails, see Terminology E 631 and for testing of nails, see Test Methods F 680.

8. Sampling

8.1 Sampling of metal coils and metal connector plates shall provide for selection, on an objective and unbiased basis, of representative test specimens typical of plate production and shall cover the different widths, thicknesses, and configurations of plates to be tested.

8.2 For tests across the metal connector plate width, with the load applied parallel to the plate length, use a minimum of six test specimens for each of two different plate widths.

8.3 For tests across the metal connector plate length, with the load applied perpendicular to the plate length, use a minimum of six test specimens for a single plate length.

NOTE 2—The justification for testing only a single metal connector plate length, whereas two plate widths are specified, lies in the method of manufacture. As plates are formed in a continuously fed stamping operation, their length module is repetitive and uniform. Hence, the edge distance of holes is constant regardless of plate length. However, the width of the plate can be varied in manufacture so that the edge distance is not constant for all different plate widths.

8.4 Test a minimum of three solid metal-coupon control specimens from each coil utilized to fabricate the metal connector plates required in 8.2 and 8.3. When feasible, obtain control specimens from the coil adjacent to the section from which test plates were manufactured.

9. Test Specimen

9.1 *Plates*—The plates shall be of sufficient length to induce a tearing or tensile failure in the plates, rather than a withdrawal failure of the teeth in the plate-wood interface. Alternatively, clamp the plates a minimum of 50 mm (2 in.) from the member ends, or otherwise firmly fasten, to prevent tooth withdrawal, provided such clamping or fastening does not affect the tensile resistance of the plates. The connection dimensions shall be sufficient in size for the plates not to extend beyond the sides of the wood members, and of such size not to result in failure of the wood members.

9.1.1 *Net Section Normal to Plate Length*—Firmly embed the metal connector plates chosen for evaluation of the net section across the plate width in a standard tensile connection, in accordance with Fig. 1. Place the plate on both connection sides without removal of any projections from the plate, in such a manner that the plate width is perpendicular to the grain of the wood members and the minimum cross section occurs at the butted connection (see Fig. 1). Press the plate projections into the wood until the projection side of the plate is flush with the surface of the wood. Do not overpress the plates. The embedment procedure shall be consistent with the method of embedding the plates in the fabrication process of the plate-assembled components, that is, by pressing or rolling. In the case of nail-on plates, the method of attachment shall be in accordance with the field conditions.

9.1.2 *Net Section Normal to Plate Width*—Similarly embed the metal connector plate chosen for evaluation across the plate length except that the plate length shall be perpendicular to the grain of the wood members with a minimum plate cross section occurring at the butted connection (see Fig. 2).

9.2 *Control Specimens*—Machine the solid metal-coupon control specimens into standard test specimens (see Fig. 3) to fulfill the requirements of Test Methods E 8.

9.3 *Coating Thickness*—Unless otherwise specifically required in the applicable documents, deduct the following coating thicknesses from the measured gross thickness of metal connector plates with such coatings as described as follows:

For A 525 G 90coating: 0.038 mm (0.0015 in.)
For A 525 G 60 coating: 0.025 mm (0.0010 in.)
For A 591 electrolytic coating class C: 0.007 mm (0.0003 in.)

10. Procedure

10.1 *General*—Before assembling the test specimens, measure all plates to determine their gross width at least to the nearest 0.75 mm (0.03 in.) and their gross thickness to the nearest 0.002 mm (0.0001 in.). Take measurements at least at three different locations on each plate, using the average of the three readings for the record. Deduct the thickness of any coating, in accordance with Specifications A 525 and A 591/A 591M for the type of coating used and indicated in 9.3, so that all calculations are made using the base-metal thickness.

10.2 *Testing*:

10.2.1 Place test specimen (see Figs. 1 and 2) between the grips of the testing machine. Apply the uniaxial tensile load throughout the test at a uniform rate of the moveable cross-head of the testing machine, so that the ultimate test load is reached in not less than 1.0 min.

10.2.2 Conduct tests on solid metal-coupon control specimens in accordance with Test Methods E 8. Ensure uniform stress distribution and prevent premature failure of the specimen in the grips of the testing machine. Where required, to preclude failure at the grips or slippage, use special grips. Apply the load throughout the test at a uniform rate of separation of the platens of the testing machine in such a way that the ultimate test load is reached in not less than 1.0 min.

10.3 *Data Required*—For the metal connector plates and the solid metal-coupon control specimens, record the yield and ultimate loads in newtons (N) or pounds-force (lbf). Take readings with a precision corresponding with the smallest graduation of the smallest practical load-range scale of the testing machine used.

11. Calculation

11.1 Calculate the yield and ultimate stresses (F_t) for each solid metal-coupon control specimen by dividing the yield and ultimate loads (T), in N (lbf), by the base-metal cross-sectional area (A_t), with $F_t = T/A_t$. Determine average yield and ultimate stresses for each coil of steel from which solid metal-coupon control specimens were taken.

11.2 Calculate the yield and ultimate stresses (F) for the metal connector plates by dividing the yield and ultimate loads (P), in N (lbf), for each test specimen by the sum of the gross cross-sectional area ($A_1 + A_2$) of the two plates from that test specimen, with $F = P/(A_1 + A_2)$. Determine average yield and ultimate stresses for each size and orientation of plate tested.

11.3 Calculate tensile stress ratios (R) for each test specimen by dividing the yield and ultimate stresses (F) for that test specimen by the average yield and ultimate stresses (F_t) for the corresponding steel coil from which the two plates on that test specimen were manufactured, with $R = F/F_t$. Determine average tensile yield and ultimate strength ratios for each size and orientation of plate tested.

12. Report

12.1 The report shall follow the outline of Practice E 575 and shall specifically include the following information:

12.1.1 Date of test and date of report,

12.1.2 Test sponsor and test agency,

12.1.3 Identification of metal connector plate: manufacturer, model, type, material, finish, shape, dimensions, number and shape of teeth, and other pertinent information, such as cracks and other characteristics. The material specifications for the plate shall include minimum specified yield and ultimate stresses of the metal. If separately applied fasteners are used with the metal connector plates, provide identification of fasteners, such as type, size, quantity, and quality as well as the method of installing the plates and their fasteners, including the nail-hole description,

12.1.4 Detailed drawings or photographs of test specimens before and after testing, if not fully described otherwise,

12.1.5 Complete description of test method and loading procedure used, if there are any deviations from the methods prescribed in this test method. Indicate reasons for such deviations.

12.1.6 Number of specimens tested,

12.1.7 Rate of load application,

12.1.8 Elapsed time of testing,

12.1.9 All test data, including means, range of test values, and standard deviations,

12.1.10 Strength ratios for each individual test specimen, and means for all identical test specimens,

12.1.11 Description of types and paths of failure,

12.1.12 Summary of findings,

12.1.13 Certification of calibration of testing machine used,

12.1.14 Mill certification data for heat number of the metal coil(s) from which the plates were fabricated, and

12.1.15 List of observers, and, if required, signatures of responsible persons and the professional seal of the responsible individual.

13. Precision and Bias

13.1 *Precision*—It is not possible to specify the precision of the procedure in this test method because the precision of this procedure within or between laboratories has not been established.

13.2 *Bias*—No justifiable statement can be made on the bias of the procedure in this test method because the bias of this procedure within or between laboratories has not been established.

14. Keywords

14.1 metal connector plates; metal truss plates; sampling; solid metal-coupon control specimens; steel truss plates; tensile strength properties; test material; test methods

SUMMARY OF CHANGES

The major changes in this revision are as follows:

(1) Change of the term steel truss plates to metal connector plates.

(2) Clarification of terminology, material selection, sampling, and test procedure.