



AISI S905-17



**American
Iron and Steel
Institute**

AISI STANDARD

Test Standard for Determining the Strength and Deformation Characteristics of Cold-Formed Steel Connections

2017 Edition



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Approved by
the AISI Committee on Specifications for the Design of
Cold-Formed Steel Structural Members

The material contained herein has been developed by the American Iron and Steel Institute (AISI) Committee on Specifications for the Design of Cold-Formed Steel Structural Members. The organization and the Committee have made a diligent effort to present accurate, reliable, and useful information on testing of cold-formed steel members, components or structures. The Committee acknowledges and is grateful for the contributions of the numerous researchers, engineers, and others who have contributed to the body of knowledge on the subject. With anticipated improvements in understanding of the behavior of cold-formed steel and the continuing development of new technology, this material will become dated. It is anticipated that future editions of this test procedure will update this material as new information becomes available, but this cannot be guaranteed.

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PREFACE

The American Iron and Steel Institute Committee on Specifications developed this Standard to provide test methods for determining strength and deformation characteristics of mechanically fastened and welded connections for cold-formed steel building components.

The Committee acknowledges and is grateful for the contribution of the numerous engineers, researchers, producers and others who have contributed to the body of knowledge on this subject.

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of Cold-Formed Steel Structural Members**

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AISI S905-17
TEST STANDARD FOR
DETERMINING THE STRENGTH AND DEFORMATION
CHARACTERISTICS OF COLD-FORMED STEEL CONNECTIONS

1. Scope

1.1 This Standard applies to test methods to determine the strength and deformation characteristics of mechanically fastened and welded *connections* for cold-formed steel building components. *Connections* that are stressed in shear (loads applied perpendicular to the shank or cross-section of the fastener, or in plane with the *connection* faying surfaces) and *connections* that are stressed in tension (loads applied parallel to the shank or cross-section of the *fastener*, or perpendicular to the *connection* faying surfaces) and the interaction effects on *connections* are included. The objective is to evaluate field *connections* using standard test specimens and fixtures as provided in Section 7.

1.2 For circumstances in which *connection* configurations exclude the use of the standard tests, alternate tests are permitted. Requirements for both standard tests and alternate tests are provided.

1.3 *Connections* of thin components (such as exterior building steel sheet) to relatively thick components (such as structural frame supports) are considered as well as *connections* between two or more thin components.

1.4 Mechanical *fasteners* include screw *fasteners*, power-actuated *fasteners*, bolts, rivets, clinch joining *connections*, mechanically formed *connections* and button punches.

1.5 Welded *connections* include groove welds in butt joints, arc spot welds, arc seam welds, top arc seam welds, fillet welds and flare groove welds as described in AISI S100 and AWS D1.3.

1.6 The subject test methods are also applicable in determining the strength and flexibility characteristics of *connections* for use in cold-formed steel *diaphragms*.

1.7 The test methods are suitable for hydraulic or screw-operated testing machines using force or displacement control.

User Note:

Fastener fracture can occur in tests, but other test standards are designed to determine these limits (e.g., screws are defined in AISI S904).

1.8 This test does not apply to hold-downs and joint hangers attached to cold-formed steel structural framing. Those devices shall be tested in accordance with AISI S913 and AISI S914, respectively.

1.9 This Standard does not preclude the use of other materials, assemblies, structures or designs if the other materials, assemblies, structures or designs demonstrate equivalent performance for the intended use to those specified in this Standard.

User Note:

This test Standard may also be used for alternate material supports such as concrete or wood.

1.10 This Standard is composed of Sections 1 through 11 inclusive.

2. Referenced Documents

The following documents or portions thereof are referenced within this Standard and shall be considered as part of the requirements of this document.

- a. American Iron and Steel Institute (AISI), Washington, DC:
 - S100-16, *North American Specification for the Design of Cold-Formed Steel Structural Members*
 - S310-16, *North American Standard for the Design of Profiled Steel Diaphragm Panels*
 - S913-17, *Test Standard for Determining the Strength and Deformation Behavior of Hold-Downs Attached to Cold-Formed Steel Structural Framing*
 - S914-17, *Test Standard for Determining the Strength and Deformation Behavior of Joist Connectors Attached to Cold-Formed Steel Structural Framing*
- b. American Welding Society (AWS), Miami, FL:
 - AWS D1.3/D1.3M: 2008, *Structural Welding Code—Sheet Steel*
- c. ASTM International (ASTM), West Conshohocken, PA:
 - A370-16, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*
 - E6-15, *Standard Terminology Relating to Methods of Mechanical Testing*
 - E1190-11, *Standard Test Methods for Strength of Power-Actuated Fasteners Installed in Structural Members*
 - IEEE/ASTM SI10-10, *American National Standard for Metric Practice*

3. Terminology

Where the following terms appear in this Standard, they shall have the meaning as defined herein. Terms not defined in Section 3 of this Standard, AISI S100, or ASTM E6 shall have the ordinary accepted meaning for the context for which they are intended.

Characteristic Connection Strength per Fastener. A statistically adjusted value for the mean maximum load per fastener measured for the test unit.

Connection. Combination of structural elements and joints used to transmit forces between two or more members.

Fastener. A mechanical device, weld, crimp or other similar method or device used to connect two or more elements.

Diaphragm. Roof, floor, or other horizontal or nearly horizontal membrane or bracing system that transfers in-plane forces to the lateral force resisting system.

Gross Distortion. A failure mode where a steel sheet or support member undergoes very large permanent deformation prior to fastener failure.

Load-Deformation Curve per Fastener. The load-deformation curve for the test connection with the load values divided by the number of fasteners.

Maximum Load per Connection. The maximum load recorded during a test.

Maximum Load per Fastener. The maximum connection load divided by the number of fasteners in the connection.

Pull-Over. A failure mode where a steel sheet is pulled over the fastener head (the fastener head is pulled through the sheet steel) or around the weld contour. Also referred to as pull-through.

Pull-Out. A failure mode where fasteners are pulled free from the support member.

Sidelap Connection. A connection formed by attaching adjacent panels to each other along the panel edges between the support members.

Standing Rib Sidelap Connection. A connection formed by a vertical sheet leg (edge stiffener of deck) inside an overlapping sheet hem, or by vertical sheet legs back-to-back.

Structural Fastener. A fastener attaching one or more steel sheets to a support member.

Top Arc Seam Sidelap Weld. Arc seam weld applied at the top *sidelap connection*.

Top Sidelap Connection. A connection formed by a vertical sheet leg (edge stiffener of deck) inside an overlapping sheet hem, or by vertical sheet legs back-to-back.

Top Overlapping Sidelap Connection. Welded, screwed, mechanically formed or crimped connection located at or near the top of an overlapping sidelap.

Wall Diaphragm. A wall, bearing or non-bearing, designed to resist forces acting in the plane of the wall (commonly referred to as a “vertical diaphragm” or “shear wall”).

4. Symbols

The following notations shall apply to this Standard:

- A = Elongation in tension test
- a = Width of end supports in alternate tension tests
- a_s = Shear deformation or slip
- a_t = Deformation in tension test
- b = Width of troughs or flats in profiled sheet
- C = Number of *fasteners* used in shear test setup
 - = 2 for test setups illustrated in Figures 1(a) and 1(b)
 - = 4 for test setup illustrated in Figure 1(c)
 - = 1 if one *fastener* is used in test setup in Figure 1(a) but with one *fastener*
- d = Nominal diameter of mechanical *fastener*
 - = Visible diameter of outer surface of arc spot weld or width of arc seam weld
- e_1 = End distance of *fastener* in standard test specimen
- e_2 = *Fastener* gage distance in standard test specimen
- e_3 = *Fastener* edge distance in standard test specimen
- e_4 = *Fastener* edge distance in alternate test specimen
- F_y = Yield stress of steel
- F_u = Tensile strength of steel
- F_{xx} = Tensile strength of electrode classification
- h_{st} = Height of stiffening ribs in profiled sheet
- L = Length of mechanically formed *connection*
- L_w = Length of groove weld in butt joint, length of arc-seam weld (not including circular ends), length of top arc-seam sidelap weld, length of fillet weld or length of flare groove weld
- L_s = Free strap length in standard shear test specimen
- L_a = Test span for alternate tension test specimen

- ℓ_g = Extensometer gage length in shear test
 M_n = Nominal moment resistance per flute determined using AISI S100 Section F3
 M_u = Maximum bending moment per stiffening rib
 n = Number of valid tests in test unit
 p = *Fastener* spacing or pitch
 P = Estimated maximum *connection* load per *fastener*
 P_K = *Characteristic connection strength per fastener*
 P_m = Mean *connection* strength per *fastener*
 P_{not} = Structural *fastener* nominal *pull-out* strength [resistance] from support member
 P_{nov} = Structural *fastener* nominal *pull-over* strength [resistance] for sheet to support member
 P_u = Maximum applied load
 Q_f = Structural *connection* strength for sheet to support member
 Q_s = Stitch *connection* strength for sheet to sheet steel
 S_f = Structural *connection* flexibility for sheet to support member
 S_s = Stitch *connection* flexibility for sheet to sheet steel
 t = Base metal sheet thickness
 = Thickness of support material (Table 3)
 u_s = Shear flexibility per *fastener*
 u_t = Tensile (uplift) flexibility per *fastener*
 w = Width of the shear test specimen
 w_1, w_2 = Leg of fillet weld
 α = Coefficient to convert the measured elongation, Δ_g , to individual elongation at *fastener*
 = 1 for setups illustrated in Figures 1(a) and (c) or for test setups with one *fastener*
 = 2 for setup illustrated in Figure 1(b)
 Δ_g = Total elongation of extensometer gage length, ℓ_g , at 40 percent of P_u in standard or alternate shear test
 σ = Standard deviation

5. Units of Symbols and Terms

Any compatible system of measurement units is permitted to be used with this Standard, except where explicitly stated otherwise. The unit systems considered for use with this Standard shall include U.S. customary units (force in kips and length in inches) and SI units (force in Newtons and length in millimeters) in accordance with IEEE/ASTM SI10. SI units are provided in parentheses.

6. Measurement Precision

6.1 The rate of loading shall be controlled, constant loads shall be maintained, and the applied load shall be measured accurately to within ± 1 percent of the full range of the measuring device.

User Note:

The capacity (range) of the load-measuring device should be appropriate to the expected maximum tested load. The use of a measuring device with a calibrated capacity greatly exceeding the anticipated load is inappropriate. A target ratio of the load-measuring device capacity to specimen strength of no greater than three is recommended.

The tests should be conducted on a testing machine that complies with the requirements of ASTM E4-16, *Standard Practices for Force Verification of Testing Machines*.

6.2 The test specimen support fixtures and testing machine grips shall have the capability of maintaining a constant loading direction throughout the test.

6.3 The devices used to measure deformation shall provide a precision of ± 0.001 in. (0.02 mm) for shear tests and ± 0.002 in. (0.05 mm) for tension tests.

6.4 The devices used to measure the dimensions of the test specimens shall be accurate to within ± 0.0005 in. (0.01 mm) for sheet base metal thickness, ± 0.05 in. (1 mm) for sheet profile dimensions, and ± 0.005 in. (0.1 mm) for *fastener* dimensions.

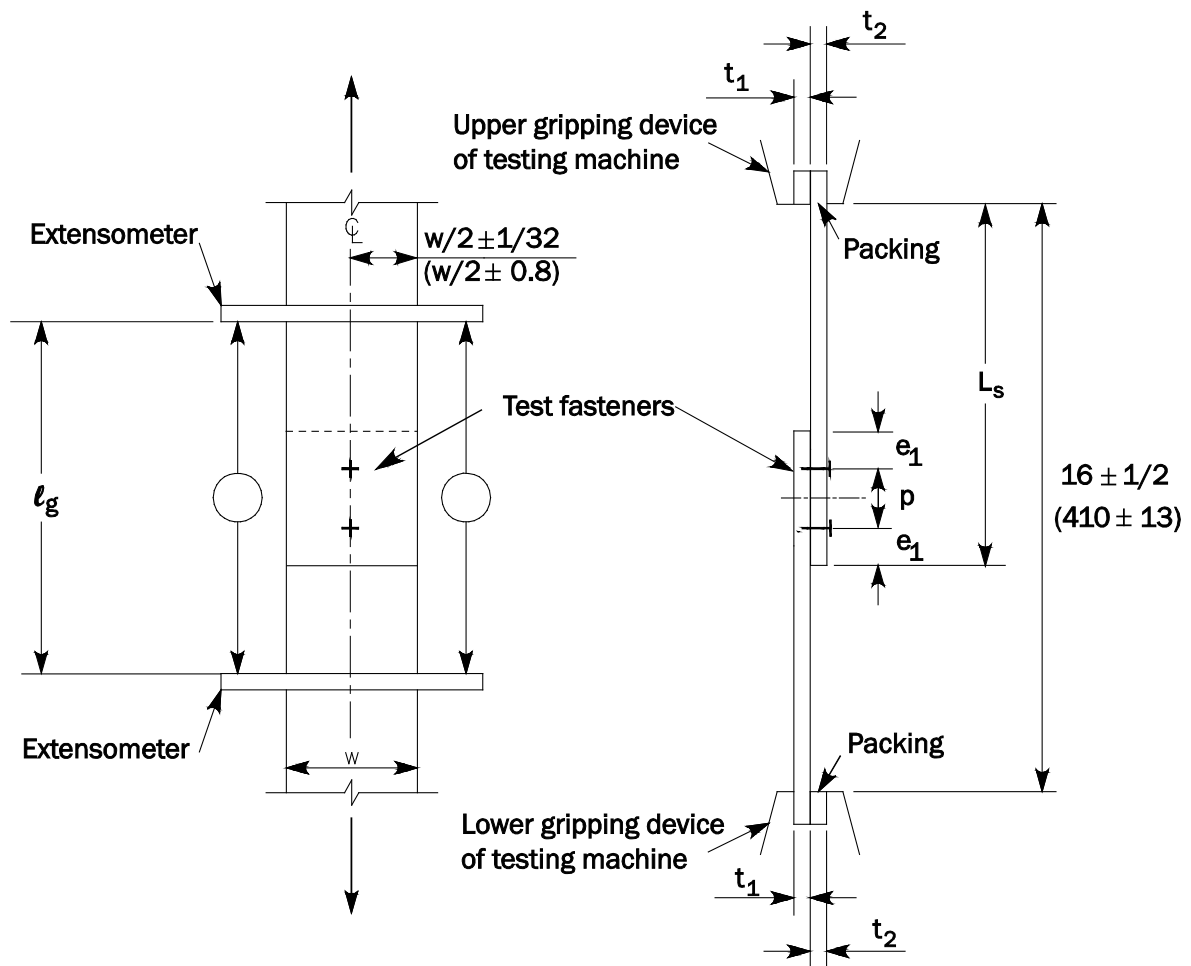
7. Test Fixtures

7.1 Test Fixtures – Lap-Joint Shear Tests

Standard and alternate shear test fixture diagrams are permitted to be used for the investigation of shear strength and stiffness of cold-formed steel *connections* described in Section 1.3. Shear test deformations shall be obtained from extensometer measurements across the lap-joint to the precision as specified in Section 6.3.

User Note:

Shear test deformations may be measured using crosshead movement of the testing machine if any gripping device slip, specimen elongation and any eccentricity are accounted for.



(a) Lap Shear Setup for Two Fasteners per Specimen

Figure 1 Standard Lap-Joint Shear Test, units – in. (mm)
(Continue)

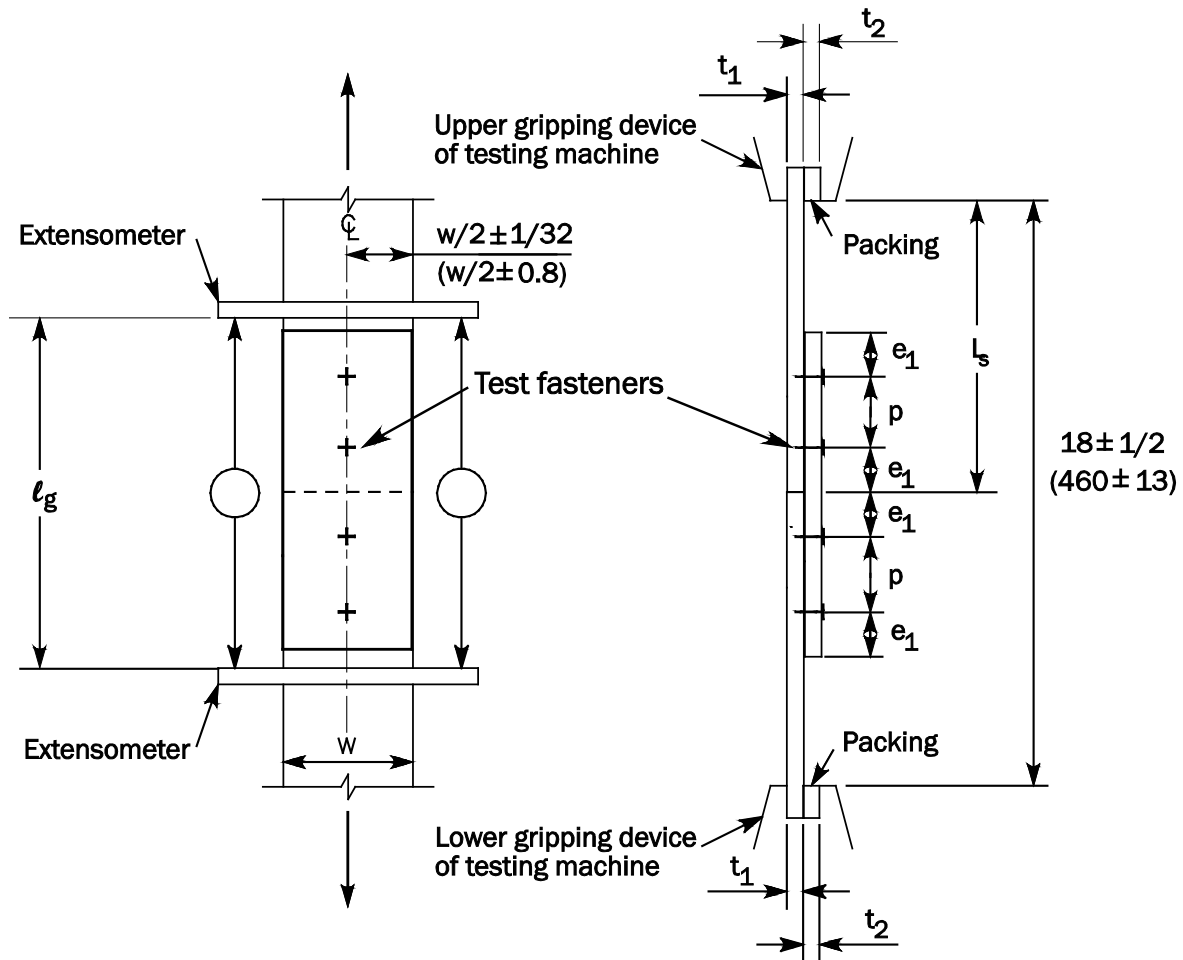


Figure 1 Standard Lap-Joint Shear Test, units – in. (mm)
(Continue)



Figure 1 Standard Lap-Joint Shear Test, units – in. (mm)

Pinned *connections* to the test machine may be used in lieu of mechanical gripping devices provided that bearing of the steel specimen against the pin does not adversely affect the results.

7.1.1 Standard Lap-Joint Shear Tests

Standard shear test specimens shall be a single-lap joint using two flat steel components connected with two *fasteners* (See Figure 1(a)). The test fixture setup shown in Figure 1(b) is permitted if one sheet steel component is connected to two *connection* plates or support members in a lap-joint *connection* with four *fasteners*. The test fixture setup shown in Figure 1(c) shall be used for edge distance investigations. Geometrical proportions of the shear test specimens shall be as given in Table 1, and edge dimension, e_3 , shall be greater than or equal to $1.5d$ and less than $2d$, except for tests investigating other special edge distance and spacing conditions where dimensions are permitted to be modified.

Lap-joint shear tests are intended to develop the strength and stiffness of individual *fasteners* and not for group effects. There may be instances when it is rational to modify test setups in order to verify group effects or other influences on *fastener* strength and stiffness.