# INTERNATIONAL ASSOCIATION OF PLUMBING

**AND MECHANICAL OFFICIALS, UNIFORM EVALUATION SERVICES**

**EVALUATION CRITERIA FOR**

**STEEL COMPOSITE, NON-COMPOSITE AND ROOF DECK CONSTRUCTION**

**EC 007-2020**

**(Proposed March 2020, previously Adopted April 2019, April 2015, September 2013, 2010)**

**1.0 INTRODUCTION**

**1.1 Purpose:** This Evaluation Criteria establishes the requirements for recognition of cold-formed steel composite, non-composite and roof deck construction in an evaluation report under the 2018, 2015 and 2012 International Building Codes (IBC). Basis of recognition are IBC Section 104.11 and Chapter 22.

The objective of this criteria is to expand uses of steel decks, since the prescriptive requirements of Chapters 19 and 22 of the IBC need supplemental procedures for establishing the structural capacities of steel decks utilized as components of diaphragms and composite floors.

**1.2** **Scope:** This Evaluation Criteria applies to cold-formed fluted and cellular sheet steel panels attached to cold-formed or hot-rolled steel support framing with welds, screws, power-actuated fasteners (commonly referred to as pins or nails), or other fastening systems suitable for attaching steel deck. Panel side-laps are connected using welds, screws, friction connections (commonly referred to as button punches), penetrating mechanical interference punches or other fastening systems suitable to engage the side-laps of the steel deck.

The criteria provides guidelines to calculate, test and evaluate diaphragm shear capacities, diaphragm flexibility, composite vertical load capacities, section properties and web crippling capacities and includes optional test and acceptance standards for fire-resistance and acoustic performance.

Evaluation of diaphragm shear capacity for steel deck is limited to the in-plane shear resistance of the steel deck panel or concrete-filled steel deck panel, connection strength of the steel deck to the support framing and connection strength of steel deck-to-steel deck (side-lap), acting as the membrane stressed skin of a floor or roof diaphragm assembly. This Evaluation Criteria does not provide for the development of complete horizontal floor or roof diaphragm system as the term diaphragm is used in IBC Section 202, which would also include support framing, collectors and boundary chords.

**2.0 REFERENCED STANDARDS**

**2.1** **General:** The edition of the Referenced standards shall be as indicated or shall be consistent with the provisions of Chapter 35 of the applicable edition of the IBC upon which compliance is based.

 **American Concrete Institute**

ACI 318 Building Code Requirements for Structural Concrete and Commentary

 **American Institute of Steel Construction**

AISC 360 Specification for Structural Steel Buildings

Copyright © 2020 by International Association of Plumbing and Mechanical Officials. All rights reserved. Printed in the United States. No part of this publication may be reproduced, stored in an electronic retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior written permission of the publisher. Ph: 1-877-4IESRPT • Fax: 909.472.4171 • Web: [www.iapmoes.org](http://www.iapmoes.org) • 5001 East Philadelphia Street • Ontario, California 91761-2816 ––USA

 **American Iron and Steel Institute**

AISI S100-16 AISI Standard North American Specification for the Design of Cold-Formed Steel Structural Member (2018 IBC)

AISI S100-12 AISI Standard North American Specification for the Design of Cold-Formed Steel Structural Members (2015 IBC)

AISI S100-07/S1-09/S2-10 AISI Standard North American Specification for the Design of Cold-Formed Steel Structural Members with Supplements 1 and 2 (2012 IBC)

AISI S310-16\* North American Standard for the Design of Profiled Steel Diaphragm Panels (2018 IBC)

\*with revisions in Annex A of this criteria.

AISI S310-13 North American Standard for the Design of Profiled Steel Diaphragm Panels (2015 and 2012 IBC)

AISI S904-13 Standard Test Methods for Determining the Tensile and Shear Strength of Screws (Optional for the 2018, 2015, and 2012 IBC)

AISI S904-08 Standard Test Methods for Determining the Tensile and Shear Strength of Screws (2018, 2015, and 2012 IBC)

AISI S905-13 Test Methods for Cold-Formed Steel Connections (Optional for the 2018, 2015, and 2012 IBC)

AISI S905-08 Test Methods for Mechanically Fastened Cold-Formed Steel Connections (2018, 2015 IBC, and 2012 IBC)

AISI S907-13 Cantilever Test Method for Cold-Formed Steel Diaphragms (Optional for the 2018, 2015, and 2012 IBC)

AISI S907-08/S1-12 Cantilever Test Method for Cold-Formed Steel Diaphragms (2018, 2015, and 2012 IBC)

AISI S909-13 Standard Test Method for Determining the Web Crippling Strength of Cold-Formed Steel (Optional for the 2018, 2015, and 2012 IBC)

AISI S909-08 Standard Test Method for Determining the Web Crippling Strength of Cold-Formed Steel Beams (2018, 2015, and 2012 IBC)

AISI S922-19 Test Standard for Determining the Strength and Stiffness of Bearing-Friction Interference Connector Assemblies in Profiled Steel Panels.

 **American Society of Civil Engineers**

ASCE 3-91 Standard for the Structural Design of Composite Slabs

ASCE 7 Minimum Design Loads for Buildings and Other Structures

 **ASTM International**

ASTM A370-14 Standard Test Methods and Definitions for Mechanical Testing of Steel Products

ASTM E90 Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements

ASTM E119 Standard Test Methods for Fire Tests of Building Construction and Materials

ASTM E492 Standard Test Method for Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies Using the Tapping Machine

**International Code Council**

2018, 2015, and 2012 IBC International Building Code

**International Organization for Standardization**

ISO/IEC Standard 17020:2012, Conformity assessment -- Requirements for the operation of various types of bodies performing inspection

ISO/IEC Standard 17065:2012, Conformity Assessment – Requirements for bodies certifying products, processes and services

**Steel Deck Institute**

ANSI/SDI C-2017 Standard for Composite Steel Floor Deck-Slabs (2018 IBC)

ANSI/SDI C-2011 Standard for Composite Steel Floor Deck-Slabs (2015 IBC)

ANSI/SDI T-CD-2017 Test Standard for Composite Steel Deck-Slabs (2018 IBC)

ANSI/SDI T-CD-2011 Test Standard for Composite Steel Deck-Slabs (2015 IBC)

ANSI/SDI NC-2017 Standard for Non-Composite Steel Floor Deck (2018 IBC)

ANSI/SDI NC-2010 Standard for Non-Composite Steel Floor Deck (2015 and 2012 IBC)

ANSI/SDI RD-2017 Standard for Steel Roof Deck (2018 IBC)

ANSI/SDI RD-2010 Standard for Steel Roof Deck (2015 and 2012 IBC)

DDM03 Diaphragm Design Manual, 3rd Edition with Appendix VI, VII, VIII, IX Supplements and Errata

ANSI/SDI QA/QC-2017 Standard for Quality Control and Quality Assurance for Installation of Steel Deck

**Underwriters Laboratories**

UL 263 Fire Tests of Building Construction and Materials

ANSI/UL 209-11 Cellular Metal Floor Raceways and Fittings

 **United States Army Corp of Engineers**

TM 5-809-10 Seismic Design for Buildings, 1982 edition

**3.0 DEFINITIONS**

**3.1 General.** Where the following terms appear in this Evaluation Criteria, such terms shall have the meaning as defined in this section.

**Accredited Evaluation Agency**: An organization providing third-party evaluation services for products and materials and operating in accordance with ISO/IEC 17065. The verification of conformance to ISO/IEC 17065 shall be based on accreditation by an accreditation body recognized as conforming to ISO/IEC 17011.

**Accredited Inspection Agency**: An organization providing third-party inspection services and operating in accordance with ISO/IEC 17020. The verification of conformance to ISO/IEC 17020 shall be based on accreditation by an accreditation body recognized as conforming to ISO/IEC 17011.

**Acoustical Deck:** Deck or cellular deck containing holes. Holes either are in discrete locations or throughout the coil width. Acoustic media and other components are often but not always installed behind the holes to improve sound absorption.

**Cellular Deck:** Cold-formed fluted sheet steel panel with a pan sheet or fluted steel panel welded or mechanically attached to the top or bottom of the fluted member.

**Composite Deck**: Steel deck that is used as a component of a composite deck-slab assembly. Composite deck is designed to bond to the concrete in the assembly and to act as tensile reinforcement for the composite deck-slab assembly in positive bending. Prior to the concrete curing, the composite deck acts as a form only. Composite deck may be cellular or not cellular.

**Composite Deck - Slab:** Assembly in which structural normal-weight or lightweight concrete is placed directly on and bonded to the composite deck. The deck acts as the tension reinforcement and the concrete acts as the compression element for positive bending only after the concrete has cured.

**Diaphragm Shear Stiffness:** In-plane shear stiffness of the steel deck panels or concrete-filled steel deck panels as applicable, and the connections of the steel deck panels to supporting members.

**Diaphragm Shear Strength:** In-plane shear resistance of steel deck panels or concrete-filled steel deck panels as applicable, and the connections of the steel deck panels to the supporting members.

**Non-Composite Deck:** Assembly in which structural normal weight or lightweight concrete is placed directly on steel deck or cellular deck but without significant bond. The deck is designed for use only as a form and it is assumed that no composite action is achieved between the concrete and deck.

**Positive Connection:** Connection involving direct bearing or interlock of the members, welds, or dowel type fasteners, including but not limited to screws, bolts, or rivets, in the direction of loading.

**Roof Deck:** Steel deck or cellular deck panel without structural concrete fill.

**Steel Deck**: Cold-formed multi-web sheet steel panel including cellular versions used for composite, non-composite and roof applications.

**4.0 BASIC INFORMATION**

**4.1 General:** Each submittal for product evaluation shall include the information in Sections 4.2 through 4.8 of this criteria.

**4.2 Steel Deck:** For each profile of steel deck, the following basic information shall be provided:

**4.2.1** Deck profile cross section drawings showing dimensions and tolerances.

**4.2.2** Detail drawings of embossments, hanger tabs, vent tabs or holes and perforation patterns as applicable to the deck profile.

**4.2.3** Deck steel specification(s) and grade(s).

**4.2.4** Metallic or paint coatings applied to the steel.

**4.2.5** For cellular decks only, drawings illustrating the fastener pattern and descriptions of the fastenings used to connect the fluted sheet steel panel to the pan sheet steel panel together.

**4.3 Fasteners:** Standards and specifications applicable to the fasteners shall be disclosed to the accredited evaluation service agency and the minimum structural properties of the fasteners shall be specified. Fasteners shall be described in detail, including fastener type, material specifications, size, length, head type and point type (where applicable), coatings, limits on the steel connected by the fastener (drill capacity) including the minimum and maximum steel thickness, location and minimum edge distance(s). Drawings showing support fastener patterns shall be provided where no values are recognized by the IBC or its references, the fasteners shall be recognized in a current evaluation report, a national product standard or shall otherwise be justified to the satisfaction of accredited evaluation service agency in accordance with Section 5.5 or 5.6.4 of this criteria. Fasteners exposed to weather or moisture shall be corrosion-resistant or protected to prevent corrosion, such as stainless steel or galvanized, or covered by corrosion-resistant paint, sealant, or a stainless steel sealing cap. Galvanized steel shall comply with applicable fastener specification. Other metallic coatings shall be permitted to be used on mechanical fasteners if justified to the satisfaction of the accredited evaluation service agency.

**4.4 Concrete:** Properties of concrete used in the deck assemblies shall be reported in accordance with the applicable design and test standards. Minimum information to be reported shall be the density and minimum compressive strength of the concrete.

**4.5 Accessories:** For each accessory type, a drawing shall be provided with basic information including geometry, dimensions and tolerances. Detail drawings of the embossments, stiffeners, holes and perforation patterns shall be provided as applicable. Specifications(s) and grade(s) of the materials(s) shall be provided. Metallic or paint coatings applied shall be described as applicable.

**4.6 Acoustical Deck Assemblies:** For each acoustical deck, a cross section profile shall be provided identifying the type of deck and perforation pattern. The acoustical deck type, size of acoustic materials, type and thickness of acoustic material, type of concrete fill for composite deck or non-composite deck, and cover board or insulation board placed on top of steel roof deck shall be described. Standards and specifications applicable to acoustic materials and cover board or insulation on top of deck used shall be provided. For mineral fiber, fiberglass and similar acoustic batt materials, the density of the batts shall be provided.

**4.7 Engineering Reports:** Engineering reports demonstrating the product capacities in accordance with the design and test standards shall be submitted. Reports shall include calculations, installation/assembly diagrams, recommendations and limitations in sufficient detail to demonstrate that the deck complies with the design and test requirements of this Evaluation Criteria to the satisfaction of the accredited evaluation service agency. Reports shall be signed and sealed by a registered design professional.

**4.8 Test Reports:** Test reports shall contain all information and results required by the applicable test standard. Testing laboratories shall be accredited for the applicable testing procedures in accordance with ISO/IEC 17025 by a recognized accreditation body conforming to ISO/IEC 17011. Testing at a non-accredited laboratory shall be permitted by the accredited evaluation service agency, provided the testing is conducted under the supervision of an accredited laboratory and the supervising laboratory issues the test report.

**5.0 TESTING AND PERFORMANCE REQUIREMENTS**

**5.1 Roof Deck:** Steel roof deck panels shall be designed to comply with the requirements of ANSI/SDI RD-2017 (2018 IBC), ANSI/SDI RD-2010 (2015 IBC and 2012 IBC) and the provisions contained in this Evaluation Criteria.

**5.2 Non-Composite Deck:** Non-composite deck panels shall be designed in accordance with the requirements of ANSI/SDI NC-2017 (2018 IBC), ANSI/SDI NC-2010 (2015 IBC and 2012 IBC) and the provisions contained in this Evaluation Criteria.

**5.3 Composite Deck and Composite Deck-Slabs:** Composite deck and composite deck-slabs shall be designed in accordance with ANSI/SDI C-2017 (2018 IBC) and ANSI/SDI C-2011 (2015 IBC) and the provisions contained in this Evaluation Criteria. Alternatively, capacities of composite deck slabs may be determined in accordance with ASCE 3.

**5.4** **Cellular Decks:** Cellular decks shall be designed in accordance with Section 5.1, 5.2 or 5.3 of this criteria as applicable based on the application of the cellular deck. To develop the full gross and effective section properties of the cellular assembly, the components of the cellular deck shall be interconnected with welds, screws, bolts, rivets, or other mechanical fastening systems sufficient to develop the shear flow at the interface of the components of the cellular deck. Welds, screws, bolts, rivets, and other mechanical fastening systems shall comply with the requirements of AISI S100.

**5.5 Diaphragm Shear Strength and Stiffness:** Diaphragm shear strength and diaphragm shear stiffness shall be determined by analytical calculations or by testing as referenced in Section 6.3 of this criteria.

 For the 2018 IBC, steel deck with and without concrete fill, calculations for diaphragm shear and diaphragm shear stiffness shall be conducted in accordance with the AISI S310-16, except Sections B1.1, D1, and D2 are replaced with revisions in Annex A of this criteria.

For the 2015 and 2012 IBC, steel deck with and without concrete fill, calculations for diaphragm shear and diaphragm shear stiffness shall be conducted in accordance with AISI S310-13; or DDM03, including supplemental information in Appendix VI through IX and errata, based on IAPMO UES EC 007-2015 or previous editions.

For the conversion of allowable diaphragm shear to nominal diaphragm shear in TM 5-809-10, Equation 5-8 shall be multiplied by a safety factor of 3.0 and Equation 5-9 shall be multiplied by a safety factor of 2.0.

 For composite steel deck-slabs with structural concrete fill that is attached to supporting members with welded stud shear connectors, calculation of diaphragm shear strength shall be permitted to be based on the provisions of ACI 318 for the shear capacity of the concrete above the deck and AISC 360 for the shear capacity of the welded stud shear connectors or mechanical connectors complying with IAPMO UES EC-023.

All perimeter and interior connections shall be designed to develop the published diaphragm design strengths in accordance with provisions of AISI S310 or DDM03. Optionally, the evaluation report may indicate that the connections are permitted to be designed to resist the required strength only, such as for connections to shear transfer elements. Unless a special analysis is submitted, the spacing of fasteners connecting panels along longitudinal edges parallel to the deck flutes shall be no greater than the interior side-lap seam fastener spacing to maintain diaphragm stiffness, as set forth in Section 2.6 of DDM03.

**5.6 Vertical Load Capacities:**

**5.6.1 Deck Panels:** Vertical load capacities for roof deck, non-composite deck, and composite deck acting as a form shall be determined in accordance with provisions of this section and the respective standards referenced in Sections 5.1, 5.2, or 5.3 of this criteria.

Vertical uniform load capacities for decks to resist gravity and wind loads shall be based on a rational analysis, analyzing the steel deck as a beam. For uniformly distributed loads, a combination of gross and effective moment of inertia shall be permitted to be used for determining deflection as follows:

 When positive moment governs:

$$I\_{d+} = \frac{2I\_{e+}+ I\_{g}}{3}$$

When negative moment governs:

$$I\_{d-} = \frac{2I\_{e-}+ I\_{g}}{3}$$

Where:

*Id-*= Hybrid negative moment of inertia under uniformly distributed loads, in4 (mm4)

*Id+*= Hybrid positive moment of inertia under uniformly distributed loads, in4 (mm4)

*Ie+* = Effective positive moment of inertia, in4 (mm4)

*Ie-* = Effective negative moment of inertia, in4 (mm4)

*Ig* = Gross moment of inertia, in4 (mm4)

Determination of vertical line load or point load capacities shall be based on a rational analysis, analyzing the steel deck as a beam. It is acceptable to specify a load distribution device, such as a steel plate or bar that will distribute the load perpendicular to the deck flutes. Tributary width of the deck shall not be more than one flute beyond the length of the point or line load distribution perpendicular to the deck unless testing demonstrates otherwise. Web crippling at the line or point load shall be considered where applicable.

**5.6.2 Composite Deck and Composite Deck-Slabs:** Vertical load capacities for concrete-filled composite deck-slabs shall be determined in accordance with the standards referenced in Section 5.3 of this criteria.

 **5.6.3 Web Crippling:** Web crippling for steel decks shall be determined in accordance with the provisions of AISI S100. As an alternative, testing in accordance with Section 6.5 of this criteria shall be permitted to be used to determine web crippling capacities of any panel. For decks with R/t, N/t or N/h ratios that exceed limitations specified in AISI S100, or modified elements, such as perforations, separate tests are mandatory to determine applicable end reactions and interior reactions. The testing shall establish the minimum and maximum bearing widths. Where multiple thicknesses occur in the deck profile, testing conducted in accordance with Section 6.5 of this criteria shall establish the minimum and maximum thicknesses.

 **5.6.4 Fasteners:** Tension strength of fasteners used to resist vertical loads applied to the deck away from the supporting members such as wind uplift, shall be calculated in accordance with AISI S100. As an alternative, testing shall be permitted to be performed in accordance with Section 6.6 of this criteria. Evaluation of combined tension and shear loading is outside the scope of this criteria.

**5.7 Fire-Resistance (Optional):** Fire- resistance ratings shall be determined by tests in accordance with Section 6.7 of this criteria except fire resistance designs issued by approved sources complying with IBC Section 202 as determined by the accredited evaluation service agency are permitted in accordance with IBC Section 703.3.1.

**5.8 Sound Transmission (Optional):** Sound transmission performance of acoustical deck assemblies shall be determined by testing in accordance with Section 6.8 of this criteria.

 **5.9** **Bearing-Friction Interference Connector Assemblies (Optional):** The strength of bearing-friction interference connections to steel deck shall be established by testing in accordance with Section 6.9 of this criteria. Either monotonic or reverse cyclic loading is permitted for positive connections. Reverse cyclic testing shall be required for all load combinations including seismic when connections are not positive, or if yielding, buckling, or other energy dissipation mechanism is used to limit the maximum load transferred by the connection to adjoining members. Resistance factors and safety factors shall be developed from the test results in accordance with AISI S100.

**6.0 TEST METHODS**

**6.1 Product Sampling:** Sampling of the steel deck for tests under this Evaluation Criteria shall be in accordance with the applicable test standard. In the absence of specified sampling, the sampling methods shall be approved by the accredited evaluation service agency.

**6.2 Material Properties:** All steel used for testing shall have mill traceability certifications that clearly identify the grade designation, actual base metal thickness, yield strength, tensile strength and elongation. In absence of any of the required information, each coil of steel used for panel samples shall be tested in accordance with ASTM A370.

**6.3 Diaphragm Shear Strength and Diaphragm Shear Stiffness:** Diaphragm testing and the evaluation of test data and test results shall comply with the requirements of AISI S310.

**6.3.1** For the 2018 IBC, the appropriate safety factors (Ωd) and resistance factors (Φd) for calculating or testing diaphragms shall be used in accordance with Table B1.1 of AISI S310-16 and Annex A of this criteria. If the nominal shear strength is only established by test without defining all limit state thresholds, the Ωd and Φd shall also be limited by the values given in Table B1.1 for connection types and connection-related failure, and the more severe factored limit state shall control the design in accordance with Section B1.1 of AISI S310-16 and Annex A of this criteria. Where a combination of connection types are used within a diaphragm configuration, the more severe factor shall be used in accordance with Section B1.1 of AISI S310-16 and Annex A of this criteria.

**6.3.2 Historic Diaphragm Testing:** Product performance based on testing and evaluation of test results approved by and published in an Evaluation Report prior to April 2015 based on the following requirements in Section 6.3 of this criteria shall be acceptable for the 2015 and 2012 IBC. All new testing and evaluation of test results shall be in accordance with AISI S310.

Diaphragm testing shall comply with the requirements of AISI S100-12, AISI S907-08/S1-12 and this Evaluation Criteria. The test assemblies shall be as intended for end use unless sufficient evidence is submitted and approved by the accredited evaluation service agency for a variance. Boundary elements shall be designed such that the boundary elements do not fail before the diaphragm fails.

 Large scale testing shall be used to establish the diaphragm shear strength and stiffness of a specific assembly when general analytic design equations for diaphragm shear strength and stiffness are outside the scope of DDM03 or TM 5-809-10. Large scale testing shall be performed in accordance with AISI S100-12 using AISI S907-08/S1-12.

 Small scale testing shall be used to develop shear strength and stiffness properties of fasteners. Testing shall be performed in accordance with the requirements of Section 6.6 of this criteria. Shear strength and stiffness values for fasteners developed through small scale testing may be used in combination with the methods in DDM03 to develop diaphragm shear and stiffness values for steel roof deck (with or without structural concrete fills), non-composite floor deck, composite deck, and composite deck-slabs.

 Provisions for analyzing the test data within the test standard shall be acceptable for both large scale and small-scale tests. As an alternative, analytic design equations to describe a range of tested assemblies are permitted to be developed. Provisions of AISI S100-12 Section F1, Tests for Determining Structural Performance, are permitted for development of safety and resistance factors for the analytical method that describes the test results.

Tests shall comply with the requirements for the minimum number of tests and diversity of tests in accordance with the test standard. Where such requirements are not stated, provisions in Section A1.2 and Chapter F of AISI S100-12 shall be applied. Statistical data for determination of resistance factors shall be the most conservative for the connector type(s) used in the test assemblies. Target reliability index, βo shall be in accordance with AISI S100-12 Section D5 and Commentary, which is 2.5 for wind and 3.5 for all other load effects. The professional factor, Pm, shall be the average of the ratio of the test results to the calculated design values predicted by the theoretical design equations (Pm = AVE (Ptest/Pcalc)). Resistance and safety factors developed from this analysis shall be compared to with Table D5 of AISI S100. If the resistance and safety factors are higher than those in AISI S100-12 Table D5, then the higher resistance factors shall be used in conjunction with the products tested. Likewise, if the safety factor developed from this analysis is lower than those in AISI S100-12 Table D5, then the lower safety factor shall be used in conjunction with the products tested.

In all testing, the requirements for evaluation of steel yield and tensile strength shall be considered in accordance with Section F1.1 (b) of AISI S100-12.

**6.4 Composite Deck-Slab Testing:** Testing of vertical load capacities as required by ANSI/SDI C-2011 or ANSI/SDI C-2017 shall be in accordance with ANSI/SDI T-CD-2011 or ANSI/SDI T-CD-2017 respectively, or ASCE 3.

**6.5 Web Crippling:** If required testing for web crippling shall be performed in accordance with AISI S100 using AISI S909.

**6.6 Mechanical Fasteners:** Testing of mechanical fasteners shall be performed in accordance with test methods AISI S904 and AISI S905. Test results are calibrated according to AISI S100.

**6.7** **Fire-Resistance:** Fire-resistance testing shall be in accordance with ASTM E119 or UL 263.

**6.8** **Sound Transmission Testing:** Sound transmission testing shall be conducted in accordance with the following standards: ASTM E90 to determine the sound transmission coefficient (STC); and ASTM E492 for the Impact Insulation Class (IIC).

**6.9 Bearing-Friction Interference Connector Assemblies:** Testing of bearing-friction interference connections to steel deck shall be in accordance with AISI S922. Test results shall be calibrated in accordance with AISI S100.

**7.0 QUALITY CONTROL**

**7.1** **Inspections:** Inspections of manufacturing facilities are required for these products by the accredited evaluation service agency or an accredited inspection agency. Welded cellular steel decks require inspections conducted by an accredited inspection agency. The accredited inspection agency shall be accredited in accordance with ISO/IEC 17020 by a recognized accreditation body conforming to ISO/IEC 17011.

**7.2** **Quality Assurance:** Quality documentation complying with IAPMO UES Minimum Requirements for Listee’s Quality Assurance System (IAPMO UES 010) or equivalent shall be submitted.

**7.3** **Cellular Decks:** This section applies to cellular decks, where individual sheets are connected by welds. Deck welds shall be tested and comply Sections 11 and 12 of ANSI/UL 209.

**7.4 Installation:** Quality control during installation shall comply with ANSI/SDI QA/QC.

**8.0 EVALUATION REPORT RECOGNITION**

**8.1** **Product Identification**: Evaluation reports shall include information on mandatory visible product identification labels for each bundle of panels. Labels shall include the manufacturer’s name and address, evaluation report number, deck type, steel specification and base metal thickness and gage.

**8.2** **Section Properties.** Mandatory items listed in Table 1, Section Properties, shall be included and the optional items may be included in the evaluation report. Other items shall be permitted to be included as determined appropriate by the accredited evaluation service agency.

**8.3** Concrete Admixtures. Admixtures containing calcium chloride, chloride from other sources or other substances that are corrosive or otherwise deleterious to the steel deck and embedded items shall not be permitted.

**8.4** **Deflection Equations (Optional).** Table 2, Diaphragm Shear Web Deflection Equations,may be included in the evaluation report to aid designers in determining the shear deflection based on the shear stiffness of the steel deck.

**8.5** **Diaphragm Design.** Evaluation reports shall contain the following or equivalent statements:

*When steel deck panels are used as the stressed skin shear carrying element of a horizontal or sloped diaphragm**as defined in Section 1602 of the IBC, the diaphragm length and width shall be limited by one of the following: engineering mechanics; applied loads; shear capacity of the diaphragm; diaphragm shear deflection limited by the requirements of ASCE 7 in Sections 12.8.6 entitled, “Story Drift Determination”; or Section 12.12 entitled, “Drift and Deformation”.*

*Shear deflection shall be based on the shear stiffness for the steel deck diaphragm and equations of mechanics. Common shear deflection equations as shown in Table 2 may be used as an option*.

The use of steel deck diaphragms for vertical diaphragms (shear walls) is beyond the scope of this report.

**8.6** **Partial Panels,** **Openings, Holes or Penetrations Through Steel Deck:** The registered design professional may submit design calculations and details to the building official for approval based on the principles of mechanics for partial panels, openings, holes or penetrations. For lateral force resisting systems, the calculations shall consider the effects of partial panels, openings, holes, or penetrations on the overall strength and stiffness of the diaphragm. Proprietary penetrations, holes, and openings shall be permitted and listed in the report if testing or calculations are submitted to the satisfaction of the accredited evaluation service agency.

**8.7 Fatigue Loads:** Evaluation reports shall indicate that the steel deck shall not be used in conditions subject to loads that are predominately cyclic in nature unless a licensed design professional submits substantiating calculations to the Building Official in accordance with AISI S100 Chapter G.

**8.8 Supporting Members Materials:** Evaluation reports shall require that supporting steel members shall be of materials complying with the requirements of AISC 360 or AISI S100.

**8.9 Concrete Fill:** In accordance with ACI 318-14 26.4.1.4.1(c) or ACI 318-11 3.6.4, calcium chloride or admixtures containing chloride from sources other than impurities in admixture ingredients are prohibited from use in concrete cast against stay-in-place galvanized steel deck.

**8.10 Fire-Resistance Ratings:** Evaluation reports with fire-resistance ratings shall provide guidelines for classification as a restrained or unrestrained assembly. If no fire-resistance rating evidence is submitted, then the evaluation report shall indicate that use within fire-resistive assemblies is beyond the scope of the report.

**8.11 Sound Transmission Performance:** Evaluation reports with tested values for sound transmission coefficient (STC) or Impact Insulation Class (IIC) shall include those values and specify the testing standard used to establish them. When no acoustical performance evidence is submitted, then the evaluation report shall indicate that acoustic performance is beyond the scope of the report.

**8.12 Special Inspection:** Evaluation reports shall indicate that special inspection is required in accordance with IBC Section 1705.2.2 for steel deck and welding and IBC Section 1705.3 for concrete. Quality assurance for deck installation shall comply with ANSI/SDI QA/QC, where the special inspector duties are as set forth for the quality assurance inspector (QAI).

**TABLE 1: SECTION PROPERTIES**

|  |  |  |
| --- | --- | --- |
| Mandatory | Optional | Item |
|  |  | **Code Reference** |
|  | X | Nominal, allowable or factored moment or shear strengths  |
|  |  | **Properties** |
| X |  | Cross section diagram(s) of panels and basic dimensions |
| X |  | Fastener attachment pattern diagram(s) |
| X |  | Perforation pattern(s), if applicable |
|  |  | **Fasteners** |
| X |  | Nominal, allowable or factored shear capacities and stiffness |
|  | X | Nominal, allowable or factored withdrawal capacities |
|  | X | Nominal, allowable or factored pull-over capacities |
|  |  | **Properties** |
| X |  | Design base metal thickness per gage callout |
| X |  | Grade(s) of steel, yield and tensile strengths |
|  | X | Average weight per unit area |
|  | X | Gross cross section area |
|  | X | Gross moment of inertia |
|  | X | Distance to neutral axis |
|  | X | Gross positive section modulus |
|  | X | Gross negative section Modulus |
|  | X | Effective area |
|  | X | Effective positive moment of inertia |
|  | X | Distance to neutral axis for positive bending |
| X |  | Effective positive section modulus |
|  | X | Effective negative moment of inertia |
|  | X | Distance to neutral axis for negative bending |
| X |  | Effective negative section modulus |
|  | X | Positive hybrid moment of inertia for uniform load deflection |
|  | X | Negative hybrid moment of inertia for uniform load deflection |
| X |  | Lesser of positive or negative hybrid moment of inertia for uniform load deflection |
|  |  | **Diaphragm** |
| X |  | Nominal, allowable or factored diaphragm shear strengths. If nominal strengths are reported, safety factors and resistance factors also shall be provided, based on the referenced standard or from calibration of the test data per Section 6.3 of this criteria. The safety factors shall be greater than or equal to and the resistance factors shall be less than or equal to the values in Table D5 of AISI S100. |
| X |  | Diaphragm flexibility factor or stiffness factor |
|  |  | **Web crippling** |
| X |  | Web crippling for end and interior supports  |
|  | X | Web crippling for other conditions |
|  |  | **Out-Of-Plane Capacities** |
|  | X | Distributed load tables for strength and deflection |
|  | X | Point load tables for strength and deflection |

**TABLE 2: DIAPHRAGM SHEAR WEB DEFLECTION EQUATIONS**

 Type of Loading Loading Condition Shear Deflection

Simple Beam at Center Uniform Load, w 

Simple Beam at L1 Uniform Load, w 

Simple Beam at center Point Load, P 

Simple Beam at 1/3 points Point Loads, P 

Cantilever Beam at End Uniform Load, w 

Cantilever Beam at End Point Load, P 

Relationship between flexibility

factor and stiffness factor

b = Depth of diaphragm (ft)

f = Flexibility factor (micro in/lbs)

G’ = Stiffness factor (kips/in)

L = Diaphragm Length (ft)

L1 = Distance to point were deflection is calculated (ft)

P = Concentrated load (lbs)

qave = Average diaphragm shear (lbs/ft)

w = Uniform load (lbs/ft)

Δw = Web deflection (in.)

**Annex A**

**REVISIONS TO AISI STANDARD S310-16**

**B1.1 Floor, Roof, or Wall Steel Diaphragm Construction**

The in-plane *diaphragm nominal shear strength* [*resistance*], Sn, shall be established by calculation or test. The *safety factors* and *resistance factors* for *diaphragms* given in Table B1.1 shall apply to calculations or tests. The *safety factors* and *resistance factors* for tests shall be determined in accordance with Section E1.2.2 or Section E2.2 of this *Standard*, as applicable. However, the more severe factor from calibration and Table B1.1 shall be used unless noted otherwise in the *Standard*. If the *nominal shear strength* [*resistance*] is only established by test without defining all limit state thresholds, the *safety factors* and *resistance factors* shall also be limited by the values given in Table B1.1 for *connection* types and *connection*-related failure modes. The more severe factored limit state shall control the design. Where a combination of connection types are used within a *diaphragm configuration*, the more severe factor shall be used.

d = As specified in Table B1.1 (*ASD*)

d = As specified in Table B1.1 (*LRFD* and *LSD*)

**Table B1.1**

**Safety Factors and Resistance Factors for Diaphragms**

|  |  |  |
| --- | --- | --- |
| Load Type orCombinationsIncluding | Connection Type | Limit State |
| Connection-Related | Stability Related |
| d(*ASD*) | d(*LRFD*) | d(*LSD*) | d(*ASD*) | d(*LRFD*) | d(*LSD*) |
| Wind | Welds | 2.15 | 0.75 | 0.60 | 2.00 | 0.80 | 0.75 |
| Screws | 2.00 | 0.80 | 0.75 |
| Earthquake andAll Others | Welds | 3.00 | 0.55 | 0.40 |
| Screws | 2.30 | 0.70 | 0.55 |

For mechanical fasteners other than screws:

1. d shall not be less than the Table B1.1 values for screws, and
2. d shall not be greater than the Table B1.1 values for screws.

In addition, the value of d and d using mechanical fasteners other than screws shall be limited by the  and  values established through calibration of the individual fastener shear strength in accordance with Section D1.1.5, unless sufficient data exist to establish a *diaphragm* system effect in accordance with Section E1.2. Fastener shear strength calibration shall include the *diaphragm* material type.

If the *nominal shear strength* [*resistance*] per unit length of the *diaphragm* is established by test in accordance with AISI S907 or a *connection strength* of the *diaphragm* is established by test in accordance with AISI S905, the *safety* and *resistance factors* shall be determined in accordance with Section E1.2.2 or Section E2.2 of this *Standard*, as applicable. The test assembly shall be such that the tested failure mode is representative of the design. The

impact of the *thickness* of the supporting material on the failure mode shall be included in the test, if applicable.

**User Note:**

Stability is discussed in the Commentary of Section D2.

Mechanical fasteners include screws, power-actuated fasteners, or other mechanical connections. Diaphragm system effect is established through tests in accordance with AISI S907.

**D1 Diaphragm Shear Strength per Unit Length Controlled by Connection Strength, Snf**

The *nominal shear strength* [*resistance*] per unit length of a *diaphragm* or *wall diaphragm*

controlled by connection strength, Snf, shall be the smallest of Sni, Snc, Sne, and Snp.

Sni = [2A(λ - 1) + β]$\frac{P\_{nf}}{L}$ (*Eq.* D1-1)

Snc = $\left(\frac{N^{2}β^{2}}{L^{2}N^{2}+β^{2}}\right)^{0.5}$Pnf (*Eq*. D1-2)

 (*Eq.* D1-3)

 $S\_{np}=n\_{d}P\_{nf}\frac{α}{w\_{t}}$ (For Fluted *Panels*) (*Eq*. D1-4a)

 = NPnf (For *Cellular Deck*) (*Eq*. D1-4b) where

Sni = *Nominal shear strength* [*resistance*] per unit length of *diaphragm* or *wall diaphragm*

 controlled by *connections* at *interior panels* or *edge panels*

Snc = *Nominal shear strength* [*resistance*] per unit length of *diaphragm* or *wall diaphragm*

controlled by *support connections* at the corners of *interior panels* or *edge panels*

Sne = *Nominal shear strength* [*resistance*] per unit length of *diaphragm* or *wall diaphragm* controlled by *connections* along the edge parallel to the *panel* span in an *edge panel* and located at a *diaphragm* reaction line

Snp = *Nominal shear strength* [*resistance*] per unit length of *diaphragm* or *wall diaphragm* controlled by *connections* along the ends of *interior* or *edge panels* and into *exterior supports*

A = Number of *exterior support connections* per flute located at the *side-lap* at an *interior panel* or *edge panel* end

 *Connection* strength reduction factor at corner fastener, unitless

=  for U.S. Customary units (*Eq*. D1-5a)

 =  for SI units (*Eq*. D1-5b)

where

Dd = Depth of *panel*, in. (mm). See Figure D2.1-1

Lv = Span of *panel* between supports with fasteners, ft. (m) t = Base metal *thickness* of the *panel*, in. (mm)

β = Factor defining *connection* contribution and interaction to *diaphragm* shear strength per unit length

 nss  2npp2 + 4e2 (*Eq*. D1-6)

Where

ns = Number of *side-lap connections* along a total *panel* length, L, and not into supports

s = (*Eq*. D1-7)

 Pnf = *Nominal shear strength* [*resistance*] of a *support connection* per fastener

 Pns = *Nominal shear strength* [*resistance*] of a *side-lap connection* per fastener

 np = Number of *interior supports* along a total *panel* length, L

p2 = Analogous section modulus of *panel interior support connection* group in an *interior* or *edge panel*

=  (*Eq*. D1-8)

w = *Panel* cover width

xp = Distance from *panel* center line to an *interior support structural connection* in a

*panel*

2 = Analogous section modulus of *panel exterior support* fastener group in an *interior* or

e

*edge panel*

=  (*Eq*. D1-9)

xe = Distance from *panel* center line to an *exterior support structural connection* in a *panel*

L = Total *panel* length

= (np  1)L v for equal spans (*Eq*. D1-10)

N = Number of support fasteners per unit width at an *interior* or *edge panel’s* end

1 = Measure of *exterior support* fastener group distribution across a *panel* width, we, at an

*edge panel*

 = (*Eq*. D1-11)

xee = Distance from *panel* center line to an *exterior support structural connection* in an *edge panel*

we = *Panel* cover width at the *edge panel*

2 = Measure of *interior support* fastener group distribution across a *panel* width, we, at an

*edge panel*

= (*Eq*. D1-12)

xpe = Distance from *panel* center line to an *interior support structural connection* in an

*edge panel*

ne = Number of edge *support connections* between transverse supports and along an *edge panel* length, L

Pnfs= *Nominal shear strength* [*resistance*] of an *edge support connection* installed parallel with an *edge panel* span and between transverse supports

nd = Number of *support connections* at any given flute bottom flat along the ends of

*interior* or *edge panels* and into *exterior supports*

wt **=** Greatest tributary width to any given bottom flute with *support connection(s)* along the end perpendicular to the *panel* span and located at *exterior support*

**User Note:**

Commentary Figure C-D2-1 provides examples on determination of nd and wt.

See Figure D1-1 for an illustration of the parameters in Section D1. Support fastener spacing shall not exceed 18 in. (460 mm).

For Lv > 5.00 ft (1.52 m), the spacing of *side-lap connections* between supports shall not exceed

* 1. ft (0.914 m), and the spacing of edge fasteners between supports shall not exceed 3.00 ft (0.914 m).

Pnf shall be determined in accordance with Section D1.1, and Pns shall be determined in accordance with Section D1.2. If the *support connection* is subjected to combined shear and tension, Pnf shall be reduced in accordance with Section D3.

Pnfs used to determine Sne in accordance with Eq. D1-3 shall be calculated as follows:

* + 1. Pnfs is determined in accordance with Section D1.1 where the *connection* is through the bottom flat of a *panel* with the gap between the *panel* bottom and the edge support less than or equal to 3/8 in. (9.53 mm), and
		2. Pnfs = 0.0 for *connections* through the top flat of a *panel* or through the bottom flat of a panelwhere the gap between the *panel* bottom and the edge support is greater than 3/8 in. (9.53 mm).

**User Note:**

Some *connection* installation does not allow a gap. Consult the fastener manufacturer’s recommendations or refer to AWS D1.3, as applicable.

Where Pnfs would otherwise be negligible (Pnfs = 0.0), the designer should provide a detail that is capable of transferring the *diaphragm* shear force (reaction) from the *edge panel* to the edge support at the *lateral force-resisting system* line. If the *diaphragm* shear force per unit length can flow across a potential *lateral force*-*resisting system* to another *lateral force-resisting system* without exceeding the *available strength* [*factored resistance*] of the *diaphragm* system, the detail can be avoided.

A reaction line is where *diaphragm* shear force per unit length transfers to a *lateral force-resisting system*. The *panel* width, we, is the distance from the adjacent *interior panel side-lap* to the reaction line in determining the *nominal diaphragm shear strength* [*resistance*] per unit length at an *edge panel*, Snf (smallest of Sni, Snc, Sne, and Snp).

Installations with insulation between the *panel* and the edge support are discussed in Section D1.3 and are consistent with the Section D1 requirements.

**User Note:**

Snx and Sny, as shown in Figure D1-1, indicate a possible shear flow along the orthogonal axes x and y and clarify that the required Sn can be a variable along the *diaphragm* span, Ld, between *lateral force-resisting systems*.

Appendix 2 presents a particular case of Snc with *loads* delivered through perimeter *connections*. The *nominal diaphragm shear strengths* [*resistances*] per unit length, Sni, Snc, Sne, and Snp, are subsets of Snf, and the *safety* and *resistance factors* controlled by *connections* apply to each subset for the applicable connections. See Table B1.1 in Section B1.

Eqs*.* D1-1, D1-2, or D1-4a or D1-4b can control *nominal shear strength* [*resistance*] per unit length at either an *edge* or *interior panel*. Both *panel* locations must be investigated when the fastener pattern or *panel* width varies between the *interior* and *edge panels*. Eq*.* D1-3 only applies at locations of *load* transfer along *lateral force-resisting system* lines or along *load* delivery members (*struts*).

When *diaphragm* shear per unit length is flowing from two sides into a *lateral force-resisting system*, the *required strength* [reaction] per unit length rather than the maximum shear per unit length in the panel is compared with the *available shear strength* [*factored resistance*] per unit length. A*vailable shear strength* [*factored resistance*] is Sne/ for *ASD* and Sne for *LRFD* or *LSD*, where Sne is determined in accordance with Eq. D1-3.

To develop edge *support connection resistance* at each of the ne fasteners between *panel* supports, the designer must require edge supports between the perpendicular supports. The edge supports are generally parallel with the *panel* span or the building edge and must be in the *diaphragm* support plane to allow attachment.

**D2 Diaphragm Shear Strength per Unit Length Controlled by Stability, Snb**

The *nominal shear strength* [*resistance*] per unit length of a *diaphragm* or wall *diaphragm* controlled by *panel* stability, Snb, for either *acoustic* or non-*acoustic* fluted *panels* shall be the smallest of Sno and Sn, calculated in accordance with Eq. D2-1 and D2-2, respectively.

Sno =  (*Eq*. D2-1)

 (*Eq*. D2-2)

where

Sno = *Nominal diaphragm shear strength* [*resistance*] per unit length controlled by *panel out- of-plane buckling*, kip/ft (kN/m)

Sn = *Nominal diaphragm shear strength* [*resistance*] per unit length controlled by *local web buckling* of *panel* over *exterior support*

f1 = Conversion factor for units

 = 1 for U.S. customary units

 = 1879 for SI units

f2 = Conversion factor for units

 = 12 for U.S. customary units

 = 1000 for SI units

Lv = Span of *panel* between supports with fasteners, ft (m)

Ixg = Moment of inertia of fully effective *panel* per unit width, in.4/ft (m4/mm)

t = Base steel *thickness* of *panel*, in. (mm)

d = *Panel* corrugation *pitch*, in. (mm)

e = One-half the bottom flat width of *panel* measured between points of intercept as illustrated in Figure D2-1, in. (mm)

Dd = Depth of *panel* illustrated in Figure D2-1, in. (mm)

Pnw= *Nominal web crippling strength* [*resistance*] per web

= (*Eq.* D2-3)

where

Fy = Design *yield stress* as determined in accordance with AISI S100 Section A3.3.1

θ = Angle between plane of web and plane of bearing surface, 45° ≤ θ ≤ 90

R = Inside bend radius

Next = Bearing length at *exterior support* (3/4 in. (19 mm) minimum)

h = Flat dimension of web measured in plane of web

qs = Perforated web adjustment factor

= 1 for panels with solid webs

= (*Eq.* D2-4)

where

k = Ratio of perforated element stiffness to that of a solid element of the same thickness, t, determined in accordance with Appendix 1, Eq. 1.6-5

wp = Width of perforation band in the web flat of width,

 s = Developed flute width per *pitch*, in. (mm)

 = 2(e + w) + f (*Eq*. D2-5)

 where

 w = *Web* flat width of *panel* measured between points of intercept illustrated in Figure D2-1, in. (mm)

 f = Top flat width of *panel* measured between points of intercept illustrated in Figure D2-1, in. (mm)

For fluted *acoustic panels*, the following shall apply:

1. The developed flute width, s, is determined in accordance with Eq. D2-5 using the modified element lengths in Appendix 1 Section 1.6 by setting e = ep, w = wp, and f = fp,
2. The modified *panel* moment of inertia, Ixg, is obtained from the manufacturer, and
3. Other parameters in Eq. D2-1 are not modified.

f

Dd

w

e

e

d

**Figure D2-1 Panel Configuration**