INTERNATIONAL ASSOCIATION OF PLUMBING AND MECHANICAL OFFICIALS, EVALUATION SERVICES

EVALUATION CRITERIA FOR STEEL ROOF DECK

EC 007-2010 e1

1.0 INTRODUCTION

1.1 Purpose: This criteria establishes the requirements for recognition by IAPMO Evaluation Services (IAPMO ES) of steel roof deck construction evaluation report under the 2009 *International Building Code* (IBC), and the 2006 *International Building Code* (IBC), and the 2007 *California Building Code* (CBC). The basis of recognition is IBC Section 104.11.

The development of this criteria is to provide guidelines for calculating and testing the performance of steel roof deck for building and non-building structures, based on code provisions and the requirements in this evaluation criteria for conditions where the codes do not address the necessary requirements.

1.2 Scope: This criterion provides a basis for calculating, testing and evaluating diaphragm shear capacity, diaphragm flexibility, section properties, and web crippling capacities for steel roof deck to meet the requirements section of Section 2209 of the IBC and CBC. Fire and acoustical performance of steel decks shall be addressed where supplemental evidence is submitted and listed in the Evaluation Report Evidence Submitted section, otherwise a finding shall be included in the evaluation report that acoustical, and fire performance is not within the scope of the report.

The development of capacities for steel decks with structural concrete fill including composite and non-composite steel deck assemblies exceed the scope of this criteria and shall not be evaluated under this criteria. In addition, the report shall state that topped diaphragms do not comply with the flexibility assumptions of ASCE 7-05 section 12.3.1.1 and IBC 1613.6 unless appropriate flexibility coefficients are developed and suitable deflection methodology is used to calculate the stiffness and deflection. The stiffness and deflection calculations shall be submitted to the building official.

1.2.1 The report shall indicate that use of the deck as a transfer diaphragm, categorized as an out-of-plane offset vertical irregularity, per ASCE 7-05 Table 12.3-1 (4), within a seismic force resisting system is beyond the scope of the report.

1.3. REFERENCED STANDARDS

1.3 Standards referenced in this criteria shall be applied consistently with the specific model code(s) in which the Evaluation Report is evaluated to.

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2009 IBC	International Building Code®
2006 IBC	International Building Code®
2007 CBC	California Building Code
ASCE7-05	Minimum Design Loads for Buildings and Other Structures
ANSI RD1.0-06	Standard for Steel Roof Deck (SDI)
ANSI/COS/NASPEC-01 with '04 Supplement	AISI Standard North American Specification for the Design of Cold-Formed Steel Structural Members, American Iron and Steel Institute.
AISI S100-07	AISI Standard North American Specification for the Design of Cold-Formed Steel Structural Members, American Iron and Steel Institute.
AISC 360-05	Specification for Structural Steel Buildings, American Institute of Steel Construction.
AISI TS-4-02 (S904-08)	Standard Test Methods for Determining the Tensile and Shear Strength of Screws.
AISI TS-5-02 (S905-08)	Test Methods for Mechanically Fastened Cold-Formed Steel Connections, American Iron and Steel Institute.
AISI TS-7-02 (S907-08)	Cantilever Test Method for Cold-Formed Steel Diaphragms, American Iron and Steel Institute.
AISI TS-9-05 (S909-08)	Standard Test Method for Determining the Web Crippling Strength of Cold-Formed Steel Beams, American Iron and Steel Institute.
ASTM A370-09	Standard Test Methods and Definitions for Mechanical Testing of Steel Products
ASTM A792-09	Standard Specification for Steel Sheet, 55% Aluminum-Zinc Alloy-Coated by the Hot-Dip Process
ASTM A924-09	Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process.
DDM03	Diaphragm Design Manual, 3rd Edition, Steel Deck Institute with Appendix VI Supplement and Errata.
MOC02	SDI Manual of Construction with Steel Deck 2nd Edition, Steel Deck Institute.

3.0 DEFINITIONS

3.1 Acoustical Deck: A roof deck or cellular roof deck in which the panel or pan is perforated to allow for sound to pass through and be trapped in acoustical absorbing material on the top side of the steel deck or within the cavity of the cellular deck.

3.2 Cellular Roof Deck: A cold-formed fluted sheet steel panel with a steel pan, flat sheet welded or mechanically attached to the top or bottom of the fluted member.

3.3 Roof Deck: A cold-formed fluted sheet steel panel.

4.0 BASIC INFORMATION

4.1 General: Each submittal shall include the following information for an evaluation report:

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4.1.1 Steel Roof Deck shall meet the requirements of the NASPEC, AISI-S100, ANSI RD1.0 as referenced in this evaluation criteria. Roof deck designs that exceed the scope of standards shall meet the requirements of this evaluation criteria.

4.1.2 The steel roof deck shall be cold-formed fluted sheet steel panels. The panels shall be attached to supporting members with welds, screws, power driven pins/nails or other approved fastening systems, reference section 4.1.5. The evaluation report shall specify the material type, minimum & maximum thickness, and grade of the supporting framing required to develop the shear and flexibility of the fasteners listed. The panel side laps shall be permitted to be connected using welds, screws, friction connections (commonly referred to as button punches), penetrating mechanical interference punches or other fastening systems recognized in a current valid evaluation report.

4.1.3 Steel Roof Deck Panels Materials: The steel deck panels that comprise the diaphragm shall be manufactured from structural quality steel in accordance with the NASPEC and AISI-S100. Roof deck panel finishes shall comply with ANSI RD1.0-2006. In addition to the coating referenced in ANSI RD1.0, zinc-aluminum coated steel in accordance with ASTM A792 shall be an acceptable alternate coating to galvanized coatings.

4.1.4 Supporting Members Materials: Supporting steel members shall be of materials meeting the requirements of AISC 360, NASPEC or AISI-S100.

4.1.5 Fasteners: The standards and specifications applicable to the fasteners shall be disclosed to IAPMO-ES, and the minimum structural properties of the fasteners shall be specified. Fasteners shall be described in detail, including fastener type, size, length, location and edge distance(s). Where no values are recognized by the applicable code, the fasteners shall be recognized in a current evaluation report, a national product standard, or shall otherwise be justified to the satisfaction of IAPMO-ES in accordance with section 5.11. Fasteners exposed to weather shall be corrosion resistant or protected to prevent corrosion, such as, stainless steel, galvanized and covered by: corrosion-resistant paint, sealant, or a stainless steel sealing cap. Galvanized steel shall comply with ASTM A924 Other metallic coatings shall be permitted to be used on mechanical fasteners if justified to the satisfaction of IAPMO-ES.

4.2 Testing Laboratories: Testing laboratories shall meet the requirements for compliance with the ISO/IEC Standards 17025 or an accredited independent agency, recognized by the International Laboratory Accreditation Cooperation Mutual Recognition Arrangement or ANSI. Testing at a non-accredited laboratory shall be permitted by IAPMO-ES, provided the testing is conducted under the supervision of an accredited laboratory and the supervising laboratory issues the test report.

4.3 Test Reports: Test reports shall be submitted to IAPMO-ES for generation of evaluation reports.

4.4 Product Sampling: Sampling of the cold-formed steel diaphragm components for tests under this criteria shall be approved by IAPMO-ES.

5.0 TESTING AND PERFORMANCE REQUIREMENTS

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5.1 Openings, Holes or Penetrations through diaphragm: The report shall incorporate the diaphragm penetration, hole, and opening guidelines in accordance with the SDI Manual for Construction with Steel Deck. Alternately for penetrations, holes, and openings that exceed the scope of the SDI Manual of Construction with Steel Deck the registered design professional may submit design calculations and opening details to the building official based on the principals of mechanics. Proprietary penetrations, holes, and openings shall be permitted and listed in the report if testing or calculations are submitted to the satisfaction of IAPMO-ES.

5.2 **Interpolation of Tables**: The report shall state that interpolation of table shear and flexibility data for intermediate support spacing's is permissible, provided the higher tested value does not exceed the lower tested value by more than 50 percent, unless justified otherwise to the satisfaction of IAPMO-ES. Interpolation and extrapolation beyond the above stated shall not be allowed unless justified to the satisfaction of IAPMO-ES.

5.3 **Fatigue Loads:** The report shall indicate that the roof deck shall not be used in conditions subject to loads that are predominately cyclic in nature. The report shall be permitted to indicate that fatigue loading shall be permitted to be allowed provided a licensed design professional submits substantiating calculations to the Building Official in accordance with NASPEC and AISI-S100 Chapter G.

5.4 **Fire Ratings:** Fire ratings shall be in accordance with Underwriters Laboratories, Factory Mutual or an approved agency recognized by IAPMO-ES. If no fire rating evidence is submitted, then the report shall indicate that the deck is not fire rated and use within fire-resistive assemblies is beyond the scope of the report.

5.4.1 If non-structural light weight insulating concrete is included in a fire-rated assembly, the report shall indicate that the insulating concrete shall be treated as dead load that the roof deck must support, and provide guidelines for classification as a restrained or unrestrained assembly.

5.5 **Acoustical Performance:** Acoustical performance shall be submitted using a test method and laboratory approved by IAPMO-ES. If acoustical products are listed in the IAPMO-ES report and no acoustical performance evidence is submitted, then the report shall indicate that the acoustical performance is not rated by IAPMO-ES and acoustic performance is beyond the scope of the report.

5.6 **Section Properties:** Section properties shall be calculated in accordance with the NASPEC and AISI-S100.

5.7 **Diaphragm Shear and Flexibility:** Diaphragm shear and flexibility shall be determined by analytical calculations or by testing. Reference Section 6.2 for the testing methods.

5.7.1 Calculations for diaphragm shear and flexibility shall be done in accordance with the DDM03 including Appendix IV. Shear and flexibility tables, for general design of buildings, shall be based on a 3 span deck condition as recommended by SDI in DDM03.

5.7.2 Safety and resistance factors applied to the nominal diaphragm shear values calculated in accordance with DDM03 shall be as listed in Table D5 of the NASPEC or AISI-S100.

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5.8 Web Crippling: Web crippling for multi-web steel decks shall be determined in accordance with the provisions of NASPEC or AISI-S100. Alternately, any panel including those that exceed the limitations of the methods in the NASPEC and AISI-S100, testing shall be used to determine web crippling capacities. Reference Section 6.3 for the testing methods.

5.9 Vertical Uniform Load Capacities: Determination of capacities for vertical uniform loads from gravity and wind shall be based on a rational analysis, analyzing the steel deck as a beam. The licensed design professional shall provide calculations that justify the deck to the supporting members connection is capable of transferring the wind uplift loads, reference Section 5.11.2. The resisting capacities of the steel deck shall be based on NASPEC or AISI S100. For uniformly distributed loads a combination of gross and effective moment of inertia shall be permitted to be used for determining deflection as follows:

$$I_{uniform} = \frac{2I_{eff} + I_g}{3}$$

5.10 Vertical Line Load or Point load Capacities: Determination of vertical line load or point load capacities shall be based on a rational analysis, analyzing the steel deck as a beam. The resisting capacities of the steel deck shall be based on NASPEC or AISI S100. Many point loads will require a load distribution device, such as a steel plate or bar that will distribute the load perpendicular to the deck flutes. The tributary width of the deck shall not be more than one flute beyond the length of the load distribution perpendicular to the deck. Web crippling at the line or point load shall be considered if applicable.

5.11 Fastener Capacities: Fastener capacities shall be based on model code accepted standards. In the absence of model code accepted standards, capacities shall be based on testing. Reference Section 6.4 for the testing methods.

5.11.1 Shear capacities for fasteners used in steel diaphragms shall be calculated in accordance with DDM03. For fasteners not included in DDM03 provisions of the NASPEC and AISI-S100 may be used to calculate shear capacities. For fasteners that exceed the scope of the standard testing shall be run in accordance with Section 6.4.

5.11.2 Tension: Tension of fasteners shall be calculated in accordance with the NASPEC and AISI-S100. For fasteners exceeding the scope of the standards, testing shall be performed in accordance with Section 6.4.

6.0 TEST METHODS

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

6.2 Diaphragm: Diaphragm testing shall comply with the requirements of the NASPEC, AISI-S100, and requirements in this criteria. The testing assembly shall represent the field condition unless sufficient evidence is submitted and approved by IAPMO-ES for a

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variance. Boundary elements shall be designed such that the boundary elements do not fail before the diaphragm fails.

6.2.1 Full scale testing shall be used to establish the shear and flexibility of a specific assembly when general analytic design equations for diaphragm shear and flexibility are outside the scope of DDM03. Full Scale Testing shall be performed in accordance with the NASPEC and AISI-S100 using AISI TS-7-02 (S907-08) Cantilever Test Method for Cold-Formed Steel Diaphragms.

6.2.2 Small Scale Testing shall be used to develop shear strength and flexibility properties of fasteners. The testing shall be performed in accordance with the requirements of section 6.4. The use of shear and stiffness for fasteners developed through small scale testing may be used in combination with the methods in DDM03 to develop shear and stiffness for steel roof decks. The fastener shear strength (Qs) and flexibility (S_s) is limited to the ±5 percent of a DDM03 listed fasteners shear strength and flexibility.

6.2.3 Acceptance of testing for both full scale and small scale tests shall be as follows:

The provisions for analyzing the test data within the test standard shall be acceptable. As an alternate to the test standard criteria analytic design equations to describe a range of tested assemblies are permitted to be developed.

The provisions of Section F Tests for Special Cases in the NASPEC and AISI-S100, shall be permitted to be used to develop safety and resistance factors for the analytical method that describes the test results. Tests shall follow the requirements for the minimum number of tests and diversity of test in accordance with the test standard. The statistical data for determination of resistance factors shall be the most conservative for the connector type(s) used in the tested assembly. The target reliability index, β_o shall be in accordance with the commentary associated with the NASPEC commentary section D5 and AISI-S100, 2.5 for wind and 3.5 for all other load effects. The professional factor, P_m, 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)). The resistance and safety factors developed from this analysis shall not be less conservative than those in Table D5 of the NASPEC and AISI-S100. If the resistance factors are more conservative than those in table D5 then the more conservative resistance factors shall be used in conjunction with the products tested.

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

6.3 Web Crippling: Testing for web crippling shall be performed in accordance with NASPEC and AISI-S100 using AISI TS-9-05 Standard Test Method for Determining the Web Crippling Strength of Cold-Formed Steel Beams.

6.4 Mechanical Fasteners: Testing of mechanical fasteners shall be performed in accordance with the NASPEC and AISI-S100 using AISI TS-4-02 (S904-08) or AISI TS-5-02 (S905-08)Test Methods for Mechanically Fastened cold-Formed Steel Connections.

7.0 QUALITY CONTROL

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7.1 IAPMO-ES approved inspections of manufacturing facilities are required for this product.

7.2 Quality documentation complying with IAPMO-ES Minimum Requirements for Listee's Quality Assurance System (IAPMO-ES 010) shall be submitted.

8.0 EVALUATION REPORT RECOGNITION

8.1 A visible product identification label shall be on each bundle of panels. The label shall include the manufacturer's name and address, the evaluation report number as required by IAPMO-ES. The label shall clearly identify the roof deck type, steel specification by ASTM or other recognized specification, and steel gauge as listed in the IAPMO-ES report.

8.2 In addition to those items that IAPMO-ES determined necessary for inclusion in the report, the mandatory items listed in Attachment A shall be included and the optional items shall be permitted to be included in the report. Other items shall be permitted to be included as determine appropriate by IAPMO- ES.

8.3 The report shall state the following:

The diaphragm length and width shall be limited by; 1) engineering mechanics 2) the applied loads, 3) shear capacity of the diaphragm, 4) the diaphragm shear deflection limited by the requirements of ASCE 7 in Sections 12.8.6 entitled, "Story Drift Determination" and Section 12.12 entitled, "Drift and Deformation". The shear deflection is based on the stiffness or flexibility factors for the diaphragm and equations of mechanics. The shear deflection equations of mechanics, diagrams, notations, and symbols in Attachment B shall be included in the evaluation report as an aid to designers in determining the diaphragm deflection. The total diaphragm deflection is comprised of both the flexural and shear web deflection. Beam theory may be used to determine the flexural deflection and the equations in attachment B may be used to determine the shear web deflection.

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ATTACHMENT A

Mandatory	Optional	Item
		Code Reference
X		Statement that Special Inspections is required in accordance with CBC and IBC section 1704.3, Steel Construction.
X		Statement that Structural Observations is required in accordance chapter 1709 of the IBC and CBC.
X		If nominal strengths are given Table D5 of the NASPEC must be referenced for safety factors and resistance factors.
		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
	X	Nominal, allowable of factored withdrawal capacities
	X	Nominal, allowable of factored pull-over capacities
		Properties
X		Design base metal thickness per gauge callout
X		Grade(s) of steel, yield and tensile
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 hybrid moment of inertia for uniform load deflection
		Diaphragm
X		Nominal, allowable or factored diaphragm shear
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
X		Product Description
X		Site storage recommendations
X		Product installation requirements.

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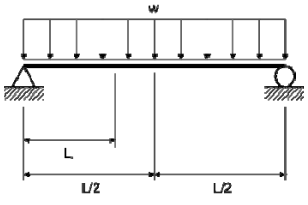
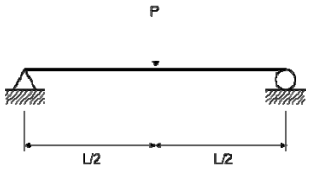
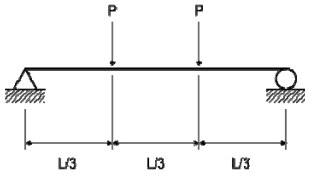
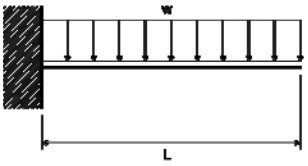
ATTACHMENT B

Diaphragm Shear Web Deflection Equations

Type of Loading	Loading Condition	Shear Deflection	
Simple Beam at Center	Uniform Load, w	$\Delta_w = \frac{wL^2}{8bG'}$	
Simple Beam at L_1	Uniform Load, w	$\Delta_w = \frac{q_{ave}L_1}{G'}$	
Simple Beam at center	Point Load, P	$\Delta_w = \frac{PL}{4bG'}$	
Simple Beam at 1/3 points	Point Loads, P	$\Delta_w = \frac{PL}{3bG'}$	
Cantilever Beam at End	Uniform Load, w	$\Delta_w = \frac{WL^2}{2bG'}$	
Cantilever Beam at End	Point Load, P	$\Delta_w = \frac{PL}{bG'}$	
Relations ship between flexibility factor and stiffness factor		$f = \frac{1000}{G'}$	

b = Depth of diaphragm (ft)
f = Flexibility factor (micro in/lbs)
G' = Stiffness factor (kips/in)
L = Diaphragm Length (ft)
L_1 = Distance to point were deflection is calculated (ft)
P = Concentrated load (lbs)
q_{ave} = Average diaphragm shear (lbs/ft)
w = Uniform load (lbs/ft)
Δ_w = Web deflection (in.)

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