IAPMO ES

Cover Sheet

Evaluation Criteria of

COLD-FORMED STEEL FRAMING MEMBERS—INTERIOR NONLOAD-BEARING WALL ASSEMBLIES

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International Association of Plumbing and Mechanical Officials

Evaluation Criteria of

COLD-FORMED STEEL FRAMING MEMBERS—INTERIOR NONLOAD-BEARING WALL ASSEMBLIES

EC 004-XXXX

1.0 INTRODUCTION

1.1 Purpose: An IAPMO ES Evaluation Criteria that defines the evaluating and testing procedure for structural performance of vertical cold-formed steel framing members (studs) used in non-loaded-bearing, interior wall assemblies along with establishing wall height limits for recognition in IAPMO Evaluation Service, L.L.C. evaluation reports under the 2006 *International Building Code*® (IBC), the 2006 *International Residential Building Code*® (IRC), and 2007 *California Building Code* (CBC), Bases of recognition are IBC Section 104.11, IRC Section R104.11 and CBC Section 108.7.

Based on stiffness and strength characteristics of interior non load-bearing wall assemblies, consisting of cold-formed steel studs and gypsum panel products installed on one or both sides of the wall such that the wall responds to transverse loading as an assembly, this criteria establishes an empirical method of determining wall height limits. This method is an alternate to the sheathing-braced design defined in the building codes for cold-formed steel stud wall assemblies resisting transverse loads.

1.2 Scope: This criteria is applicable to the design of field-fabricated interior non loading-bearing walls when using the Allowable Stress Design (ASD) method where the superimposed axial design load is zero pounds and the transverse design loads are limited to 5, 7 ½, 10, and 15 psf (240, 360, 480, and 720 Pa.

1.3 Codes and Referenced Standards:

1.3.1 2006 *International Building Code*® (IBC) International Code Council.

1.3.2 2006 *International Residential Code*® (IRC), International Code Council.

1.3.3 2007 California Building Code® (CBC)

1.3.4 AISI General-04, Standard for Cold-formed Steel Framing---General Provisions, American Iron and Steel Institute.

1.3.5 AISI WSD-04, Standard for Cold-formed Steel Framing---wall Stud Design, American Iron and Steel Institute.

1.3.6 AISI NAS-01, North American Specification for the Design of Cold-formed Steel Framing, including 2004 Supplement, American Iron and Steel Institute.

1.3.7 ASTM A 370-05, Standard Test Methods and Definitions for Mechanical Testing of Steel Products, ASTM International.

1.3.8 ASTM C 473-03, Standard Test Methods for Physical Testing of Gypsum Panel Products, ASTM International.

1.3.9 ASTM C 1178-04, Standard Specification for Coated Glass Mat Water-Resistant Gypsum Backing Panel, ASTM International.

1.3.10 ASTM C 1278-03, Standard Specification for Fiber-Reinforced Gypsum Panel, ASTM International.

1.3.11 ASTM C 1396-02, Standard Specification for Gypsum Board, ASTM International.

1.3.12 ASTM E 72-02, Standard Test Methods of Conducting Strength Tests of Panels for Building Construction, ASTM International.

1.4 Definitions:

1.4.1 Interior Non loading-bearing Wall Assembly:

A field-fabricated wall assembly of vertical cold-formed steel framing members (studs) separated a maximum of 24 inches (610 mm) on center. Gypsum panel products are sheathed on one or both sides of the wall assembly. Where the superimposed axial load is zero pounds installation of the wall assemblies in a structure shall be limited to interior application.

1.4.2 Gypsum Panel Products: The name for a family of sheet products consisting essentially of gypsum.

1.4.3 Stud: A vertical cold-formed steel I framing member in a wall assembly.

1.4.4 Set Deflection: The deflection reading recorded five minutes after the application or release of test loads.

2.0 BASIC INFORMATION

2.1 General:

2.1.1 Description: Each component of the wall assembly shall be described by dimensions, material specifications, and compliance with applicable standards or evaluation or acceptance criteria.

2.1.1.1 Cold-formed steel framing members shall conform to the quality control requirements and field identification required by an accredited evaluation agency. IAPMO ES. sheet steel materials used in the steel wall stud construction shall comply with the requirements in Section 2210.4 of the IBC and Section 2210.4 of CBC.

2.1.1.2 Gypsum panel products shall comply with ASTM C 1396, C 1278, or C 1178, as applicable.

2.1.1.3 Fasteners shall comply with applicable standards, specifications, or evaluation criteria.

2.1.2 Identification: Products shall be marked, as applicable, in accordance with the ASTM specification or relevant criteria, or both. A description of the method of field identification of the components of the interior non load-bearing wall assembly evaluated in accordance with this evaluation criteria shall be provided..

2.1.3 Installation Instructions: Installation instructions shall be submitted, detailing the attachment of gypsum panel products to the steel studs (orientation of panel products), the thickness and type of the gypsum panel product, location of panel joints, size and type of panel fasteners, fastening schedule, joint and face treatments and attachment of steel studs to tracks.

2.2 Testing Laboratories: Testing laboratories shall comply the requirements as noted by ISO/IEC standard 17025.

2.3 Test Reports: Test reports, submitted for approval, shall consist of:

2.3.1 A description of the test procedures, test results, observations, calculations deriving limiting wall heights based on stiffness and strength test data of tested assemblies, deflection and load measurements, and photographs of typical wall assembly test specimens and typical failures.

2.3.2 A description of the test specimens. fastener type and size, and a fastener schedule. Installation specifications and details of the gypsum panel products, and cold-formed steel framing members. The description of gypsum panel products and studs shall also be supported by test data on the tensile strength and yield of the cold-formed studs, the flexural strength of the gypsum panel products, when required, and bare-metal thickness of the steel studs. The description of the test specimens shall also include the location of panel joints and orientation of panel products.

2.3.3 A description of the gypsum panel, panel thickness, product name, product type, and when required the manufacturer's name (Refer to Section 3.1.4).

2.4 Product Sampling and Preparation of Test Assemblies: Sampling of the components of interior non loading-bearing walls for tests under the criteria shall be approved by IAPMO ES.

3.0 TEST AND PERFORMANCE REQUIREMENTS

3.1 General: The allowable height of an interior non loading-bearing wall assembly shall be the lesser of the limiting height based on wall assembly stiffness in accordance with Section 3.2 or the limiting height based on wall assembly strength in accordance with

Section 3.3.

3.1.1 Test specimens shall be truly representative of the wall construction for which recognition in an evaluation report is desired, in regards to their detailing materials, workmanship, and orientation of gypsum panel products and location of panel joints. Joints and fasteners shall not be treated.

3.1.2 One representative steel sample shall be obtained from each tested wall assembly to verify steel thickness both before and after removal of the galvanized coating. To substitute when the manufacturing process of cold forms steel to a shape makes taking thickness measurements impossible, a minimum of ten samples cut from flat sheets taken from the same coil of steel used to cold from the steel studs shall be used.

3.1.3Tensile strength, yield strength, and elongation shall be verified using ASTM A 370 test procedures. Only yield strength needs to be verified when the maximum allowable transverse load specified in the evaluation report for the interior non loading-bearing wall assembly is limited to 5 psf (240 Pa), only.

3.1.4 The type and product name of the gypsum panel product does not need to be identified in the evaluation report or the span tables, when the flexural strength of the gypsum panel products used in the tests does not exceed the minimum values set forth in the applicable ASTM standard by more than 15 percent.

When the flexural strength of the gypsum panel product used in the tests is greater than 15% of the ASTM standard and less than or equal to 50% of the ASTM standard, then its type, thickness, manufacture, and product name shall be specified in the condition of approval section of the ES report.

When the flexural capacity exceeds 15% of the ASTM standard, but is not greater than 50% of the ASTM standard, a limiting span table is required for each manufacture. Combining separate manufacture limiting span tables is permitted provided the spans are based on either the most conservative flexural strength or span values.

The gypsum panel product shall be evaluated independently in accordance with ASTM C 473. At least three panels from each shipment received by the test agency shall be selected for physical property testing, provided they constitute a truly representative sample for the purpose of wall assembly tests. The test data shall be included in the test report for the wall assemblies None of the single test values shall be discarded.

3.1.5 Unsymmetrical wall systems shall be tested in the most flexible and weakest direction.

3.2 Limiting Heights Based on Wall Assembly Stiffness: Testing shall be in accordance with Section 4.1 of this criteria and the analysis of test data shall be in accordance with Section 3.2.1 through 3.2.5.

3.2.1 Wall assembly bending stiffness, *EI*, shall be based on the equation for midspan deflection of a simply supported beam with uniformly distributed loading over its entire span. An *EI* value for each midspan deflection target shall be calculated based on the incremental deflection from previous set deflection after release of load to the current set deflection after application of load. Average *EI* values shall be determined from the test results for each test assembly height. For a specific test specimen, the arithmetical average of the EI values derived for each deflection target shall be used when the deviation of any individual deflection target *EI* value does not exceed ±15 percent of the specimen's average *EI* value. If such a deviation from the average value exceeds 15 percent for any test assembly, then the *EI* values for each specific deflection target of all specimens shall be averaged. The deflection-target-specific *EI* values shall be used to calculate the limiting heights for that test assembly height.

3.2.2 The wall assembly's controlling *EI* value derived in accordance with Section 3.2.1 shall be used to calculate limiting wall heights for deflection target values L/360, L/240 and L/120 (if a L/120 deflection level cannot be obtained, it shall be permitted to use L/180 in place of L/120); and transverse design loads of 5, 7 ½, 10, and 15 psf (240,360, 480, and 720 Pa), provided:

3.2.2.1 When steel samples are obtained from each tested wall assembly to verify steel thickness, the measured uncoated steel thickness of the studs in each test assembly does not vary from the specified (design) thickness by ±5 percent.

3.2.2.2 When it is not possible to measure steel thickness of studs in each test assembly because the manufacturing processes that cold forms steel to a shape makes taking measurements impossible, the measured uncoated steel thickness of samples cut from flat sheets taken from coil steel shall not vary from the coil steel thickness specified in the quality documentation by ±5 percent.

3.2.2.3 The unloaded set deflection is less than 20 percent of the loaded set deflection.

3.2.3 Limiting wall heights may be derived by linear interpolation between the derived limiting height value (H_1) from one test span and the derived limiting height value (H_2) from the next taller test span:

$$L_{LH} = \frac{(L_1 \times H_2) - (L_2 \times H_1)}{H_2 - H_1 - L_2 - L_1}$$

Where:

L_{LH} = *Interpolated limiting wall height, ft. (m).*

L_1 = *Actual span of short test assembly, ft (m).*

L_2 = *Actual span of all tall test assembly, ft (m).*

H_1 = *Derived limiting height for a specific deflection target and design load based on the controlling EI value from short-span wall test data, ft (m).*

H_2 = *Derived limiting height for a specific deflection target and design load based on the controlling EI value from long-span wall test data, ft (m).*

3.2.3.1 The calculated limiting height based on the taller test assemblies shall be used rather than an interpolated value, if the calculated limiting heights derived from the shorter test assemblies are greater than twice the height of the taller assemblies..

3.2.3.2 If for any specific design load and deflection target combination, a calculated limiting wall height based on the shorter test assemblies is less than the actual test span. The calculated height value shall be discarded and the wall assembly will not be permitted to resist that specific design load and deflection target.

3.2.3.3 The interpolated value L_{LH}, in no case shall, be greater than the mean value between calculated vales H_1, and H_2.

3.2.4 Linear extrapolation of the controlling *EI* value may be used to determine limiting wall heights greater than those tested. Extrapolated heights are permitted to twice that of the tested assemblies.

3.2.5 A controlling *EI* value shall only be used to calculate limiting wall heights for target deflection values that are included in the derivation of the controlling *EI* value for the test wall assembly.

3.3 Limiting Heights Based on Wall Assembly Strength: The design of cold-formed steel studs for interior non load-bearing wall assemblies shall be in accordance with AISI-WSD. Limiting wall heights based on strength characteristics of the wall assembly may be derived in accordance with the provisions of this section when the wall assembly construction deviates from AISI-WSD provisions. Flexural and end-reaction testing shall be in accordance with Section 4.1 and 4.2, respectively, and the analysis of the test data shall be in accordance with Section 3.3.1 and 3.3.2..

3.3.1 Wall assembly limiting height based on flexural strength shall be derived using the following formula:

$$L_f = \sqrt{\frac{R_s P L_t^2}{SW}}$$

Where:

L_f = *Limiting height based in flexural strength, ft(m).*

R_s = *Adjustment factor (refer to Section 3.3.1.1).*

P = *Controlling peak test load (refer to Section 3.3.1.2), psf(Pa).*

L_t = *Span of test assembly, ft(m).*

S = *Safety factor (refer to Section 3.3.1.3).*

W = *Design load (refer to Section 3.3.1.4), psf (Pa).*

3.3.1.1 In cases where the yield point of the steel from which the studs are formed is larger than the specified minimum value, or the thickness of the steel is greater than the specified (design) thickness, or both, the controlling test peak load shall be scaled by an adjustment factor, R_s:

$$Rs = \left[\frac{F_{y}\text{- specified}}{F_{y}\text{- tested}}\right] x \left[\frac{t_{specified}}{t_{tested}}\right] \leq 1.0$$

Where:

$F_{y\text{ - specified}}$ = *Specified yield stress of the steel, psi(MPa).*

$F_{y\text{ –tested}}$ = *Measured yield stress of the steel, psi(MPa).*

$t_{specified}$ = *Design steel thickness specified in the evaluated report or the coil steel thickness specified in the quality documentation, as applicable, inch (mm).*

t_{tested} = *Measured steel thickness, inch (mm).*

3.3.1.2 The controlling peak test load of a set of wall assemblies of the same height shall be in accordance with Section 4.1.

3.3.1.3 Safety factor, Ω, shall be in accordance with Section F1.2 of AISI-NAS. The following variables for the resistance factor equation in Chapter F of AISI-NAS (Eq. F1.1-2) shall be used, unless data justifying other variables are submitted:

β_o = Target reliability index = 1.6

Mm = Mean value of the material factor = 1.0

V_u = COV of the material factor = 0.10

V_f = COV of the fabrication factor = 0.05

3.3.1.4 The transverse design loads, W, shall be limited 5, 7 ½, 10, and 15 psf (240,360,480, and 720 Pa). Not to be multiplied by 0.75 or any other factor associated with short-term loading.

3.3.1.5 Linear interpolation between the multiple test heights is permitted. To derive limiting heights based on flexural strength between sets of wall assemblies having different heights.

3.3.1.6 Linear extrapolation of flexural strength data may be used to derive limiting wall heights greater than those tested, up to twice the height of the tested assemblies.

3.3.2 Wall assembly limiting height based on end reaction strength shall be derived using the following formula:

$$L_r = \frac{R_s B L_t}{\Omega W}$$

Where:

L_r = *Limiting height based on end reaction, ft (m).*

R_s = *Adjustment factor (refer to Section 3.3.1.1).*

B = *Controlling peak test, psf (Pa), in accordance with Section 4.2 of this criteria.*

L_t = *Actual span of the nominal 4- foot test assembly, ft (m).*

Ω = *Safety factor in accordance with Section F1.2 of AISI-NAS.*

W = *Transverse design load (refer to Section 3.3.1.4), psf (Pa).*

4.0 TEST METHODS

4.1 Transverse Load Testing:

4.1.1 Wall assemblies shall be tested at two different heights. The taller set of wall test assemblies can be one-half the maximum allowable height of the wall assembly sought for recognition in an IAPMO-ES evaluation report.

4.1.2 A set of wall assembly test specimens will define each combination of variables that affects the performance of the wall assembly: uncoated minimum steel thickness, stud depth, , minimum and maximum stud spacing where the maximum spacing shall be 24 inches (610 mm) on center, thickness and type of gypsum panel products, panel orientation, and location of panel joints, size and type of fasteners, and fastener schedule. Only walls with maximum

spaced studs need to be tested, if it can be shown that the test data for walls with minimum spaced studs is within 15 percent of the test data for walls with maximum spaced studs.

4.1.3 Consisting of not fewer than three identical specimens, a set of wall assembly test specimens, will be tested provided deviation of any individual test result from the average value does not exceed ±15 percent. More tests of the same kind shall be conducted when a deviation from the average value exceeds ±15 percent or until the deviation of any individual test result from the average value obtained from all the tests does not exceed ±15 percent, or until at least three additional tests have been conducted.

4.1.4 Complying with ASTM E 72, transverse load testing shall, use uniform air pressure loading on minimum 4-foot wide (1220 mm) wall assembly test specimens placed in a vertical position as described in Section 12 of ASTM E 72, and Section 4.1.4.1 through 4.1.4.7 of this criteria.

4.1.4.1 An initial load, or preload, is permitted to be applied to seat the assembly and not exceed 10 percent of the average load associated with an L/120 deflection target value.

4.1.4.2, Cylindrical roller support shall be used to reduce rotational restraint at both ends of the assembly, as shown in the vertical test setup in Figure 3 of ASTM E 72 and as described in Section 12.3 of ASTM E 72. The top and bottom tracks of the wall test specimen shall not be fastened or attached to supports.

4.1.4.3 The gypsum panel products shall be cantilevered at the edges of the wall assembly at a distance representative of the tributary load area for the steel studs. A maximum 4 inch-long (102mm) steel tracks or wood blocks, having the same depth and width as the wall assembly's steel studs, shall be placed at the unsupported edges of the gypsum panel products to prevent premature failure of the cantilevered edges of the gypsum panel products in the test assemblies. These supports shall be spaced 24 inches (610 mm) on center and located 12 inches (305mm) from the ends of the wall assembly. , Provided the method of attachment does not increase the wall assembly's stiffness, gypsum panel products may be attached with a screw on one side of the assembly.

4.1.4.4 The chamber method of loading shall be used with an airtight frame surrounding the specimen. A polyethylene sheet or equivalent shall cover the specimen. It should overlap the frame, and be sealed to the wall of the test facility so that it is effectively airtight. Such that it does not contribute to the stiffness of the assembly, the polyethylene sheet or equivalent shall be applied loosely.. To reduce air pressure within the chamber behind the assembly, a vacuum pump shall be used. . The difference between the ambient pressure and chamber pressure shall be recorded.

4.1.4.5 Mid-height lateral deflections shall be measured using dial gages or electronic instruments. The gages or instruments are to be aligned with at least two steel studs in the wall assembly and are mounted on a reference frame. These two gages or instruments shall determine the mid-height deflection of the test assembly at each loading increment, the arithmetical average of the deflection readings shall be used. A single deflection gage is permitted at the center of the test assembly provided as an alternate, aligned midway between the steel studs.

4.1.4.6 At each designated deflection target of L/360, L/240, and L/120, successive incremental loadings shall be applied for five minutes. . After five minutes of set deflections shall be measured at the initial application of each load increment, , after release of the load increment, and after five minutes of set. Additional deflection targets or alternative deflection targets may be considered. Based on the specific assembly response characteristics where at least three target levels are investigated.

4.1.4.7 Test assemblies are to be be loaded to failure following the incremental loadings, where failure is defined as when the maximum pressure cannot be sustained without the sudden or continuous movement of the test assembly. The assembly shall be visually inspected for buckling or permanent deformation of the steel studs, fastener pullout or pullthrough, and gypsum panel failure after the conclusion of each test, The measured load at failure and mode of failure will be reported for each test assembly.

4.2 Wall End Reaction Load Testing:

4.2.1 A series of three identical tests, as a minimum, shall be performed for each combination of variables that affect the performance of the assembly, provided deviation of any individual test result from the average value does not exceed ±15 percent. More tests of the same kind shall be conducted if such a deviation from the average value exceeds ±15 percent until the deviation of any individual test result from the average value obtained from all the tests does not exceed ±15 percent, or until at least three additional tests have been conducted. Variables affecting performance include spacing, stud depth, uncoated minimum base metal thickness, track configuration and uncoated minimum base metal thickness; fastener type, size, schedule used to construct the assemblies, type and thickness of gypsum panel products; and fasteners used to attach the track to the supporting construction. The worst case configuration may be tested, if various wall configurations are sought for evaluation,. the additional configurations shall be tested, if higher ratings are sought for stronger configurations.

4.2.2 Transverse load testing shall comply with ASTM E 72. Transverse load testing using uniform air pressure loading on nominally 4-foot tall-by-4-foot-wide (1220 mm by 1220 mm) wall assemblies placed in a horizontal or vertical position, as described in Section 11 or Section 12 of ASTM E 72, respectively; and Sections 4.2.2.1 through 4.2.2.5 of the criteria.

4.2.2.1 An initial load, or preload, is permitted to be applied to seat the assembly. This preload shall not exceed 10 percent of the peak load.

4.2.2.2 Cold-formed steel studs shall be spaced as designed for actual construction, except the maximum spacing shall be 24 inches (1220 mm) on center. Track sections shall be placed at the ends of the studs, and the wall assembly shall be sheathed with gypsum panel products to simulated actual top and bottom wall construction. The minimum end distance of web holes of studs shall be considered in the test specimen wall construction.

4.2.2.3 The cleat shall be set against a rigid support of the test fixture. One end of the wall assembly may bear against a cylindrical roller, and the other end shall be attached to a wood or steel cleat in such a manner that is representative of actual construction.

4.2.2.4 The gypsum panel products shall be cantilevered at the edges of the wall assembly a distance representative of the tributary load area for the steel studs. A maximum 4 inch-long (102 mm) steel tracks or wood blocks, having the same depth and width as the wall assembly's steel studs, shall be placed at the unsupported edges of the gypsum panel products to prevent premature failure of the cantilevered edges of the gypsum panel products in the test assemblies, These supports shall be located 12 inches (305 mm) from the ends of the wall assembly.

4.2.2.5 Test assemblies shall be loaded to failure. Failure is defined as when the maximum pressure cannot be sustained without the sudden or continuous movement of the test assembly. Each test assembly shall be visually inspected for fastener pullout or pull through, gypsum panel failure, or buckling or permanent deformation of the steel studs or track. The measured load at failure and mode of failure shall be reported for each test assembly.

5.0 QUALITY CONTROL

5.1 Quality documentation complying with the IAPMO-ES Evaluation Criteria for Quality Documentation (EC010) shall be submitted.

5.2 Third-party follow-up inspections are not required under this criteria.

5.3 ES reports based on this EC require yearly re-evaluations.

6.0 EVALUATION REPORT RECOGNITION

6.1 The evaluation report for interior non load-bearing walls that comply with this criteria shall include:

6.1.1 Manufacturer's name and products name of proprietary components.

6.1.2 Description of the wall assembly, material specifications for all wall assembly components, , and applicable fastener type and fastener schedule for interconnection of framing members and attachment of gypsum panel to cold-formed steel framing members.

6.1.3 Tabulated limiting wall heights for wall assemblies resisting transverse design loads limited to 5, 7 ½ , 10, and 15 psf (240,360 ,480, and 720 Pa)

at deflection limits of L/360, L/240, and either L/180 or L/120 (see Section 3.2.2 revision). Tabulated limiting wall heights governed by wall assembly strength shall be so identified.

6.1.4 A condition of use stating the following: “The interior non load-bearing wall assemblies shall be limited to interior installations where the superimposed axial load is zero pounds.”