ICC EVALUATION SERVICE

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August 7, 2009

TO: **PARTIES INTERESTED IN EVALUATION REPORTS ON CONTINUOUS ROD TIE-DOWN ASSEMBLIES FOR LIGHT-FRAME CONSTRUCTION**

SUBJECT: Proposed Revisions to the Acceptance Criteria for Continuous Rod Tie-Down Assemblies, Subject AC391-0809-R1 (BG/WM)

Dear Madam or Sir:

The revisions proposed to the subject acceptance criteria, as presented with the enclosed June 22, 2009, letter from Simpson Strong-Tie Co., Inc. (Simpson), a June 8, 2009, email from Commins Manufacturing are being posted on the ICC-ES web site to allow for public comment.

The ICC-ES has reviewed the proposed changes from Simpson and have the following comments, which are keyed to the attached proposal:

1. **Sections 1.1, 1.2.1:** The proposal would limit the use of the tie-down assemblies to vertical wind (uplift) restraint only. The reason given by Simpson was that "continuous rod tie-down systems to resist overturning force are completely different from rod tie-down systems for wind uplift **. . .**" It is unclear how these systems are different and why systems used to resist overturning forces should not be included in AC391.

2. **Section 1.2.1:** The statement requiring the continuous tie-down assemblies to be considered as independent was stricken. In addition, a statement was added indicating the uplift resisting performance needs to consider other aspects outside the continuous tie-down assemblies such as wood shrinkage, compression framing design, and flexural member design. The testing proposed in Section 4.2.2 would be used to confirm performance of a wall with the continuous tie-down assemblies. This revision would require a relatively prescriptive application in the evaluation report. Some earlier comments on AC391indicated adequate information existed to permit design for a specific project. Therefore a question arises to whether a prescriptive installation should be included, which may serve the needs where structural design is not always done, such as dwelling construction, whether a design by a professional should be maintained or whether both approaches can be utilized.

3. **Section 1.2.3.4:** This section is proposed for deletion. It is not clear whether the deletion is intended to allow cable or rope as acomponent or whether the deletion is to remove a supposed redundancy with the scope and definition, which limit the assemblies to threaded rod.

4. **Section 1.4.2:** It will be informative to understand the reasons why the steel rod length has been taken as greater than one-half the story height.

5. **Section 3.1:** There appears to a conflict in the proposed revision. The first sentence indicates testing is permitted, provided the test-based values do not exceed calculated values. The second sentence allows for testing where assemblage values cannot be readily confirmed by calculation. If calculations cannot be easily utilized as stated in the second sentence, this premise conflicts with the first sentence, which expects calculations to be done in order set the limits on capacity.

6. **Section 3.2.1.1:** It appears that any steel component may be subject to strength adjusted as proposed. However, the definitions for $F_{u(spec)}$ and $F_{u(test)}$ limit applicability to steel bolts.

7. **Section 3.3.1:** Section 3.3.1 was intended to provide a global requirement for factors of safety, except for threaded rod couplers, which are addressed in Section 3.3.2. The proposed change revises this section to apply to the threaded rods only and other components along with assembly performance have been omitted from consideration.

8. **Section 3.4.1:** The criteria needs to be reviewed to fully allow for LRFD design, including determination of factors of safety for tested assemblies and components.

9. **Section 3.4.6:** This revision proposes that a double plate may act as a structural composite in resisting bending. This composite would be determined by testing. Connections between the two plates should laminate the two members together and be connected across splices for added flexural tension resistance.

10. **Section 4.1.1:** As with Section 3.3.1, this revision implies that testing of the rod only is permitted and not other components. This change conflicts with Section 3.1 where testing is allowed for a component that does not comply with the codes or available acceptance criteria.

11. **Section 6.2.2.2:** It is unclear on the reasons why shrinkage compensating devices are required where continuous tie-down assemblies exceed two stories in height.

The Commins proposal requests that threaded rod couplers be allowed to comply with IFI-128, 1986 edition as an alternative to testing as currently required in Section 4.5 of AC391. This proposal is unclear on the couplers' structural performance relative to the connected threaded rod: Should proof tests in a manner similar to nuts

be used or should calculations based on the couplers' net area and steel tensile or yield strength be permitted?

You are cordially invited to submit written comments, within 30 days of the date of this letter. Please use the comment form on the web site attaching any letters to the form. An explanation of the alternate criteria process can be found on our web site at http://www.icc-es.org/Criteria_Development/alternative_criteria_process.shtml.

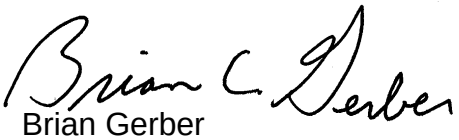
All comments received in the 30-day comment period will be considered in preparing revisions to the criteria that may be considered at a future Evaluation Committee meeting. Comments received will be posted on the web site shortly after the close of the comment period.

Your cooperation is requested in forwarding to the Los Angeles business/regional office all material directed to the Evaluation Committee. Parties interested in the deliberations of the committee should refrain from communicating, whether in writing or verbally, with committee members. The committee reserves the right to refuse communications that do not comply with this request.

Newly approved acceptance criteria may involve test methods or test protocols that are not currently included in the scope of testing services offered by accredited testing laboratories. As noted in the ICC-ES Rules of Procedure for Evaluation Reports, the scope of the laboratory's accreditation must include the type of testing that is to be reported to ICC-ES. We encourage accredited laboratories to expand their scopes of accreditation to include testing under newly approved acceptance criteria. Please note that testing laboratories must be accredited by the International Accreditation Service (IAS) or by another accreditation body that is a signatory to the International Laboratory Accreditation Cooperation Mutual Recognition Arrangement. For further information, please contact IAS at (562) 699-0541, extension 3309, or send an e-mail to pmccullen@iasonline.org.

Please submit all comments using the form on the web site. Attach any letters to the comment form. If you have any questions (not comments), please contact the undersigned at (800) 423-6587, extension 3260, or Woods McRoy, Senior Staff Engineer at 5686. You may also reach us by e-mail at es@icc-es.org.

Yours very truly,



Brian Gerber
Principal Structural Engineer

BG/raf

Enclosure

cc: Evaluation Committee

June 22, 2009

Brian Gerber, S.E.
Principal Structural Engineer
ICC Evaluation Service, Inc.
Los Angeles Business/Regional Office
5360 Workman Mill Road
Whittier, CA 90601

Subject: ICC-ES AC391 Acceptance Criteria for Continuous Rod Tie-down Assemblies

Dear Mr. Gerber,

Attached please find our revision recommendations for ICC-ES AC391 entitled "Acceptance Criteria for Continuous Rod Tie-down Assemblies." We respectfully request that this Acceptance Criteria be placed on the next ICC-ES Committee agenda (October 2009) in order to review and approve the recommended revisions.

Please email me at jellis@strongtie.com or call me at 714-738-2029 with any questions or comments you may have.

Sincerely,
Simpson Strong-Tie Co., Inc.

Jeff Ellis, P.E., S.E.
Code Report & Branch Engineering Manager

dw/LM,BW

Attachment: AC391 Revision Recommendations

Copies: Kurt Stochlia, ICC-ES
Ricardo Arevalo, Simpson Strong-Tie
Lisa McGurty, Simpson Strong-Tie

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ICC-ES AC391 Revision Recommendations:

ACCEPTANCE CRITERIA FOR CONTINUOUS ROD TIE-DOWN ASSEMBLIES RESISTING WIND UPLIFT FORCES

1.0 INTRODUCTION

1.1 Purpose: The purpose of this acceptance criteria is to establish requirements for continuous rod tie-down assemblies attached to wood structural members used to resist wind uplift loading to be recognized in an ICC Evaluation Service, Inc. (ICC-ES), evaluation report under the 2006 and 2009 *International Building Code*® (IBC) and the 2006 and 2009 *International Residential Code*® (IRC). Bases of recognition are IBC Section 104.11 and IRC Section R104.11. The reason for the development of this criteria is to establish guidelines for the evaluation of continuous rod tie-down assemblies, since the IBC, IRC, and associated referenced standards do not specify qualification, installation, design, and quality requirements for such systems.

1.2 Scope:

1.2.1 This criteria provides methods to establish the Allowable Stress Design (ASD) loads for continuous rod tie-down assemblies, based on tests ~~or~~ and calculations. The evaluation report applicant has the option of deriving tie-down system or component capacities by ~~either~~ test-based methodology ~~or~~, however, system or component capacities cannot exceed loads derived through calculation-based methodology in accordance with the code. This acceptance criteria is limited to determining the continuous rod tie-down assemblies' capacity to resist tension loads caused by wind uplift restraint ~~or wind or seismic shear wall overturning forces~~ in light-framed~~,~~ ~~cold-formed steel or~~ wood structures. ~~Continuous rod tie down assemblies shall be considered to be independent from the rest of the lateral load- resisting system (e.g., shear wall).~~ Lateral ~~or uplift~~ load–resisting system considerations, including shear wall geometry, shear resisting element size, shear resisting element material, fastening, and compression framing, shall be considered and designed separately and are outside the scope of this criteria. Uplift resisting system considerations, including top plate design (bending capacity, deflection limitations, and rotation control), wood shrinkage, bearing plate capacities, rod strength capacities, and rod elongation shall be considered within this criteria. Installations are limited to dry, interior locations protected from exposure to weather, except as permitted by Section 3.5 of this criteria.

Reason: *Capacities determined from testing the continuous rod system or its components are not permitted to exceed code determined capacities. Continuous rod tie-down systems to resist overturning forces are completely different from continuous rod tie-down systems for wind uplift and should not be included in the same Acceptance Criteria.*

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Cold-formed steel should not be in the same Acceptance Criteria as wood framing. Cold-formed steel track typically used for top plates has negligible bending capacity, hence why joists/trusses must align over studs or a wood member added to the top track.

1.2.1.1 ASD ~~allowable~~ loads and load-deflection characteristics for continuous rod tie-down assemblies attached to structural members shall be based on measured (tested) ~~or~~ and calculated strength characteristics, and measured (tested) ~~or~~ and calculated displacement characteristics.

1.2.1.2 ASD ~~allowable~~ loads and load-deflection characteristics for continuous rod tie-down assembly components shall be based on measured (tested) strength ~~or~~ and calculated strength of the components.

1.2.2 This criteria is applicable to continuous rod tie-down components and assemblies as defined in Sections 1.4.1 and 1.4.2, respectively~~, of this criteria~~.

1.2.3 The following components or anchorage devices are outside the scope of this criteria:

1.2.3.1 Devices that are connected to wood members and installed partially embedded into concrete or masonry construction, such as metal straps, die-stamped sill plate connectors, or similar cold-formed or structural steel devices.

1.2.3.2 Straight flat metal straps installed to collect and transfer tension forces from their point of origin to load-resisting elements.

1.2.3.3 Anchorage to concrete or masonry.

~~**1.2.3.4** Assemblies using wire rope or cable as the tension component.~~

1.3 Codes and Referenced Standards:

1.3.1 2006 and 2009 *International Building Code*® (IBC), International Code Council.

1.3.2 2006 and 2009 *International Residential Code*® (IRC), International Code Council.

1.3.3 ANSI/AF&PA NDS-2005, National Design Specification for Wood Construction (NDS), American Forest & Paper Association.

1.3.4 ASTM A 36–05, Standard Specification for Carbon Structural Steel, ASTM International.

1.3.5 ASTM A 193-04a, Standard Specification for Alloy-Steel Nuts, ASTM International.

1.3.6 ASTM A 307-04e01, Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength, ASTM International.

~~**1.3.7** ASTM A 325-04b, Standard Specification for Structural Bolts, Steel, Heat Treated,120/105 ksi Minimum Tensile Strength, ASTM International.~~

1.3.8 ASTM A 354-03a, Standard Specification for Quenched and Tempered Alloy Steel Bolts, Studs, and Other Externally Threaded Fasteners, ASTM International.

1.3.9 ASTM A 449-04, Standard Specification for Hex Cap Screws, Bolts and Studs, Steel, Heat Treated, 120/105/90 ksi Minimum Tensile Strength, General Use, ASTM International.

1.3.10 ASTM A 563-04, Standard Specification for Carbon and Alloy Steel Nuts, ASTM International.

1.3.11 ASTM A 370-09, Standard Test Methods and Definitions for Mechanical Testing of Steel Products, ASTM International.

1.3.12 ASTM E 4-07, Standard Practices for Force Verification of Testing Machines, ASTM International.

~~**1.3.13** ACI 318-08, Building Code Requirements for Structural Concrete and Commentary, American Concrete Institute.~~

~~**1.3.14** ACI 530-08, Building Code Requirements for Masonry Structures and Specifications for Masonry Structures, American Concrete Institute.~~

~~**1.3.15** ANSI/AISI S100-2007, North American Specification for the Design of **Cold-Formed Steel** Structural Members, American Iron and Steel Institute.~~

1.3.~~9~~ 13 ASTM A 434-06, Standard Specification for Steel Bars, Alloy, Hot-Wrought or Cold-Finished, Quenched and Tempered, ASTM International.

1.4 Definitions:

1.4.1 Continuous Rod Tie-down Assembly: A continuous rod tie-down assembly is installed in ~~cold-formed steel or~~ wood light-framed walls and is used to resist tension loads caused by vertical wind (uplift) <u>force</u> ~~restraint or seismic or wind shear wall overturning forces~~. Continuous rod tie-down assemblies shall include all components defined in Section 1.4.2 that are needed to transfer tension loads from the point of origin in a structure into a supporting element such as a foundation.

Reason: *Cold-formed steel should not be in the same Acceptance Criteria as wood framing. See reasoning for this under Section 1.2.1.*

1.4.2 Continuous Rod Tie-down Assembly Components: A continuous rod tie-down assembly consists of the following components: (1) steel rods <u>with a length greater than ½ the story height</u>;

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(2) ~~metal intermediate connectors or~~ coupling devices used to attach the continuous rod tie-down components, ~~such as hold-downs complying with AC155 or shrinkage compensating devices complying with AC316, if applicable; and~~ (3) steel bearing plates or hold-downs complying with AC155 ~~or washers used to enhance the performance of the assembly.~~; and (4) shrinkage compensating devices complying with AC316 when determined necessary by the Designer or when the structure is greater than two stories in height. System anchorage to supporting element (i.e. foundation) is outside the scope of this criteria, but must follow applicable code and standards.

Reason: *Grouping of components does not make sense: hold-downs do not serve the same purpose as coupling devices, rather they serve the same purpose of bearing plates – transferring load from wood system to rod. If bearing plates are used rather than hold-downs, then bearing plates do not "enhance the performance of the assembly" – without bearing plates to transfer the load from the wood top plate to the rod, the system would not work. Shrinkage compensating devices are needed to ensure system is consistently engaged in multi-story structures.*

1.4.3 Threaded Steel Rod: Mild steel threaded rod shall comply with ASTM F1554 Grade A 36, ASTM A 36 or ASTM A 307. High-strength threaded steel rod shall comply with one of the following standards: ASTM A 193, A 325, A 354, A 434 or A 449. ~~Other specifications may be acceptable with prior concurrence of ICC-ES staff.~~

1.4.4 Nuts: Nuts used with threaded steel rod as defined in Section 1.4.3 shall satisfy the requirements cited in the rod specification. The strength of the nuts shall comply with the proof load requirements of ASTM A 563.

1.4.5 Couplers: The evaluation report applicant shall submit coupler dimensions and material specifications to justify the coupler capacity, including cross-sectional area and thread engagement lengths. Complying couplers shall be supplied by the evaluation report applicant and be included described in the quality documentation.

1.4.6 Manufacturer Exclusive or Tested Items: An exclusive or tested item submitted for testing is any item that has a characteristic or property that does not comply with the code-referenced standards. These characteristics or properties may include, but are not limited to, articles items such as ultimate tensile strength or a mechanical configuration.

2.0 BASIC INFORMATION

2.1 General: The following information shall be submitted:

2.1.1 Product Description: Complete information pertaining to the continuous rod tie-down components, including material specifications, scaled production drawings showing all dimensions and tolerances, and information on protective coatings and the manufacturing process (including welds, if applicable). Material specifications shall comply with applicable referenced standards noted in Section 1.3 of this criteria. If the steel material used in the

calculation method has higher strengths than the minimum specified in the referenced standards, verification of the higher strength material certifications, shall be required in the quality control documentation shall be required in accordance with Section 5.3.1.

2.1.2 Installation Instructions: Installation details and drawings, noting installation requirements and/or limitations.

2.1.3 Packaging and Identification: Descriptions are required of field identification methods for the continuous rod tie-down components are required. For components that comply with the standards referenced in Section 1.3 of this criteria, identification provisions shall comply with the stated requirements. For manufacturer exclusive or tested items, components shall be clearly identified as to the manufacturer (such as a registered trademark), the model number, the ICC-ES evaluation report number (ICC-ES ESR-XXXX), and, as applicable, the inspection agency.

2.2 Testing Laboratories: Testing laboratories shall comply with Section 2.0 of the ICC-ES Acceptance Criteria for Test Reports (AC85) and Section 4.2 of the ICC-ES Rules of Procedure for Evaluation Reports.

2.3 Test Reports: Test reports shall comply with AC85 and include the following information:

2.3.1 A description of the tested continuous rod tie-down assembly and its components, or individually tested components, including drawings detailing all pertinent dimensions of the assembly and/or components. The description shall also include information concerning each component of the tested continuous rod tie-down assemblies described in Section 1.4.2 of this criteria.

2.3.2 Actual dimensions, species, specific gravity, and moisture content for each wood specimen.

2.3.3 A description of any modifications to wood members used in assembly testing.

2.3.2~~2~~4 The measured steel physical properties of the continuous rod tie-down components, including yield strength, tensile strength, elongation, and base-metal thickness.

2.3.3~~3~~5 A description of the components, including the information required in Section 3.2 of this criteria.

2.3.4~~4~~6 Detailed drawings of the test setup, depicting rod attached to steel bearing plate (or hold-down), rod location and spacing, wood top plate splice location and detailing, location and direction of load application, load applicator (hurricane tie simulator) including fastener description, location of displacement instrumentation and points of reference, and details of any deviations from the test requirements as outlined in Section 4.0 of this criteria. Additionally, photographs shall supplement the detailed drawings confirming the test setup, and the failure modes during and at the conclusion of the test shall be noted.

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2.3.5~~7~~ Individual and average maximum test load values observed. There shall be a description of the nature, type and location of failure exhibited by each continuous rod tie down assembly or component tested, and a description of the general behavior of the test assembly or components during load application.

2.3.6~~8~~ A description of the test method and loading procedure used; rate of loading; and time to failure or maximum load in accordance with Section 4.4.2 of this criteria.

2.3.9 The test sample size shall be in compliance with Section 4.2 of this criteria.

2.4 Product Sampling: Sampling shall comply with Section 3.1 of AC85 for welded continuous rod tie-down components. Sampling shall comply with either Section 3.1 or Section 3.2 of AC85 and Section 3.2.2 of this criteria, for continuous rod tie-down components fabricated without welds. The testing laboratory shall check and report on the characteristics of the specimens for to confirm compliance with the drawings and specifications referenced in Section 2.1.1 of this criteria.

3.0 TEST AND PERFORMANCE REQUIREMENTS

3.1 General: Allowable loads shall be determined ~~by testing in accordance with Sections 3.1 through 3.3 of this criteria of this criteria or~~ by calculations in accordance with Section 3.4 of this criteria, but may be determined by testing in accordance with Sections 3.1 through 3.3 of this criteria provided tested values do not exceed calculated values. Testing may be utilized where the assembly contains a component that does not comply with a referenced standard or acceptance criteria; or where the system assemblage performance cannot be readily confirmed by calculation~~; or when testing proves consistent performance exceeding calculated predictions and components is produced under a continuous quality control program where characteristics are correlated with test specimens~~. ~~Testing, when used,~~ Calculations shall consider ~~tests of~~ various lengths of assemblies to confirm length effects on deflection. When allowable loads are determined by testing, testing shall be in accordance with Sections 3.1 through 3.3 of this criteria.

Reason: *Without testing of the system, calculations could only support a single wood top plate being relied on in bending to transfer loads to rods. Testing of top plate splice connections could allow the use of two top plates in bending – increasing capacity, but ultimately limited by the calculated capacity of a wood double top plate.*
Reason: *Rod strength, wood bending capacity, and wood deflection capacity can be calculated – to be consistent with existing Acceptance Criteria (i.e. AC13).*
Reason: *Rod elongation can be calculated using the standard PL/AE code equation.*

3.1.1 Tension Load Testing: Continuous rod tie-down components shall be tested such that a tension load is applied in reference to the intended application of the components when attached to a test apparatus as described in Sections 4.1 through 4.3 of this criteria . The ASD ~~allowable~~ steel tension load capacity shall be calculated from tested maximum load in accordance with AISC 360 as well as limited by AC155 for systems with hold-down devices or AC316 for

systems with shrinkage take-up devices, as applicable. In addition, load deflection characteristics shall be reported.

3.2 Test Materials:

3.2.1 Steel: The steel properties of the tested continuous rod tie-down components, including yield point, tensile strength, elongation, and uncoated base-metal steel thickness, shall be determined by testing in accordance with the corresponding referenced standard. As an alternative, mill certificates shall be provided for the specific heat or lot of material subjected to the load tests described in this acceptance criteria.

3.2.1.1 Standard Steel Components Used in Typical Assemblies: If tested yield and tensile strengths or dimensions of the steel components exceed minimum specified values as established in accordance with Section 2.1 of this criteria, the allowable loads determined in accordance with Section 3.3 of this criteria shall be proportionally reduced. If the product under consideration uses materials with yield and tensile strengths always greater than the minimum specified by the referenced standard, and these higher strengths are confirmed by the quality documentation, then the reductions based on the minimum strength specified in the standard are not necessary. However, steel strength reductions shall be based on the manufacturers minimum specification, which shall be listed in the quality documentation and the evaluation report. The reduction shall be calculated as follows:

$$R_s = \frac{F_{u(spec)}}{F_{u(test)}} \leq 1.0$$

where:

R_S = Steel strength reduction factor.

$F_{u(spec)}$ = Tensile strength of the steel bolt from the manufacturer's specifications in the approved quality documentation, psi (Pa).

$F_{u(test)}$ = Measured tensile strength of the steel bolt used in the test specimens, psi (Pa). The measured steel tensile strength value shall not exceed the specified value by more than 20 percent.

The high strength, non-standard products shall be identified with etching and be color coded for clear identification. In addition, periodic special inspection is required to ensure proper installation. Verification of the higher strength material certifications in the quality control documentation by an accredited inspection agency shall be required in the quality control documentation as applicable.

Reason: *This allowance will create field inspection issues where installation inspection is not required, therefore, additional periodic inspection is required. Steel strength reduction factor as noted in other AC's such as AC398.*

3.2.2 Components: All components that are used in continuous rod tie-down assembly testing shall be sampled from the same manufacturer's lot in accordance with Section 2.4 of this criteria.

3.2.2.1 Anchor bolts and threaded rods shall comply with a standard referenced in Section 1.3 of this criteria .

3.3 Factor of safety: Factor of safety for determination of ASD allowable loads from test results:

3.3.1 ~~Continuous Threaded~~ Rod ~~Tie-down Assemblies and Components~~: Except as set forth in Section 3~~.3.3~~.4, the tested allowable load for rods shall be determined as follows:

Reason: *There is no Section 3.3.3. Should it say Section 3.3.2?*
Reason: *This test is only for rod capacity, not system capacity*

3.3.1.1 Where the test sample size is three to five, the allowable load is the lowest peak value from a single specimen divided by a factor of safety of ~~3~~2.

3.3.1.2 Where the test sample size is six or more, the allowable load is the mean peak value from all specimens divided by a factor of safety of ~~3~~2.

Reason: *Per AISC, the omega factor (in order to calculate ASD loads) for the tensile strength of a threaded rod is 2.0.*

3.3.1.3 The allowable loads derived in accordance with Section 3.3.1.1 or 3.3.1.2 of this criteria shall be adjusted in accordance with Section 3.2.1.1 of this criteria, as applicable.

3.3.2 Threaded Rod Couplers: ~~For~~ Threaded rod coupling components used to extend the continuity of the ~~anchors~~ threaded rod shall meet the minimum requirements in Section 4.5. ~~the minimum ASD load shall be no greater than the strength of the connected threaded rod. Couplers shall be tested in accordance with Section 4.5.~~ The report applicant shall submit minimum coupler dimensions and material specifications to justify the coupling cross-sectional area and thread engagement lengths that satisfy this requirement. These couplers shall be procured by the report applicant and documented in the quality control manual. ~~Manufacturer exclusive coupling devices that conform to AC316 shall also be subject to this criteria.~~

Reason: *The requirements in section 4.5 match the rebar coupler specification in ACI and in the IBC. Calculating ASD capacities is not required. In addition, shrinkage compensating take-up coupling devices already have an acceptance criteria to conform to: AC316, and should not be required to conform to this AC as well. Documenting compliance with AC316 should be sufficient.*

3.4 Continuous Rod Tie-down Design Load Calculations: ~~In lieu of testing described in Sections 3.1 through 3.3 of this critieria, calculations~~ Calculations determining the ASD ~~allowable~~ load for ~~certain~~ the system components, system connections, and members to which the system is attached shall be submitted in accordance with the following requirements:

Reason: *Code calculations should be required and testing can be performed in addition to the calculations.*

3.4.1 Threaded Rod Capacities: The ASD steel ~~and Load Resistance and Factor Design (LRFD)~~ tension load capacity and elongation shall be calculated in accordance with AISC 360.

Reason: *This document needs to be edited throughout for LRFD, because it is not mentioned continuously throughout. We recommend either removing it completely, or editing the document to represent LRFD.*

3.4.2 Steel Bearing Plate Capabilities: For steel plate materials, ASD ~~and LRFD~~ structural capacities shall be calculated in accordance with AISC 360. For plate bearing against wood, ASD structural capacities shall be calculated in accordance with Section 3.4.5 of this criteria.

3.4.3 Nuts and Couplers: Nuts and thread engagement length of couplers shall comply with ASTM A 563. High-strength-grade nuts and couplers shall be used with corresponding high-strength-grade threaded rod.

3.4.4 ASD Allowable Load and Deflection: The ASD allowable loads for continuous rod tie-down assemblies shall equal the lowest determined allowable load of any component or connection of components comprising the intended assembly. The cumulative deflections corresponding to the ASD load ~~and the LRFD load~~ shall be established, along with variations due to length of the assembly.

3.4.5 Steel-to-Wood Bearing Calculations: ASD wood bearing load and steel bending capacity ~~deformation~~ values for steel-to-wood bearing connections shall be calculated in accordance with the ANSI/AF&PA NDS and shall consider the following: (1) contact area of the steel bearing plate supported by a wood member attached to the threaded rod by a continuous rod tie down component; ~~and~~ (2) applicable adjustment factors specified in the ANSI/AF&PA NDS~~.~~; and (3) the steel bearing capacity derived from the cantilever bending action of the plate to ensure the proper plate thickness. ~~In addition, for LRFD, the deformation at 1.4 times the ASD load shall be reported.~~

~~**3.4.6 Wood-to-wood Compression Calculations:** ASD load and deformation values for wood-to-wood connections in compression shall be calculated in accordance with the ANSI/AF&PA NDS. In addition, for LRFD, the deformation at 1.4 times the ASD load shall be reported.~~

Reason: *In a wind uplift restraint rod system there is no wood to wood compression.*

~~**3.4.7 Steel-to-Steel Compression Calculations:** ASD load and deformation values for steel to **cold-formed steel** shall be determined in accordance with AISC 360 for steel bearing plates. The plates shall be designed to span across **cold-formed steel** support members. The **cold-formed steel** support members shall be designed in accordance with ANSI/AISI S100.~~

Reason: *See reasons described under Section 1.2.1 for removing cold-formed steel from this Acceptance Criteria*

3.4.6 Top Plate Calculations: For wind uplift resistance, ASD load values based on the wood top plate resisting bending between the tension rods shall be determined in accordance with the ANSI/AF&PA NDS considering only a single member of the wood top plate, unless it can be shown by testing that double top plates are sufficiently fastened together at wood plate splices to provide increased bending capacity. Top plate splice details shall be provided in the code report. The maximum calculated deflection of the single wood top plate shall be limited to L/180, where L = top plate span equal to the distance between rod restraints.
System capacity shall be limited to the lesser of:

- Calculated or tested uplift load at deflection limit
- Tested ultimate load divided by a factor of safety = 2.0 (see Section 4.3.2.2)
- Calculated or tested rod tension capacity (but limited to calculation)

3.4.6 Top Plate Details: For wind uplift resistance, top plate rotation shall be accounted for with top plate to stud ties installed on the same side as the connectors attaching the roof framing to the top plate.

Reason: *The wood top plate design and detailing is critical to the proper performance of rod systems used to resist wind uplift forces. Wood top plate splices negate the use of both top plates to be used to resist the uplift forces between the tension rods unless testing to substantiate additional capacity. Furthermore, significant rotation due to eccentricity compromises the performance of these systems. Additionally, a deflection limit based on span between the rods should be required for serviceability requirements. The span divided by 180 matches the average code deflection limitations on wood studs bending out of plane for wind load (averaging requirements for brittle finish and flexible finish on walls in IBC Table 1604.3).*

3.5 Exterior Exposure or Damp Environments: Where the continuous rod tie-down assembly is intended for exterior exposure or damp environments, evidence of durability shall be submitted. The steel components shall be produced from corrosion-resistant stainless or zinc-coated steel. Evidence of compliance based on the requirements in the applicable code or referenced standard shall be submitted.

4.0 TEST METHODS

4.1 Apparatus:

4.1.1 Rod Tension Testing Machine: A testing machine that is capable of operation at a constant rate of motion of the movable crosshead or a constant rate of loading, and a force measuring device that is calibrated in accordance with ASTM E 4, shall be used. A typical steel jig apparatus is illustrated in Figure 1 for optional tension rod capacity testing. A testing machine that is capable of attaching to a wood wall assembly at 16"to 24"o.c. with independent uplift load actuators capable of operation at a constant rate of motion of the movable crosshead or a constant rate of loading, and force measuring devices that are calibrated in accordance with ASTM E 4, shall be used. A typical set up for testing the continuous rod tie-down system on a wood wall assembly is shown in Figure 2.

4.1.2 Displacement Measurements: All displacements during tests shall be measured by dial gages or linear variable displacement transformers (LVDTs) having a least reading increment of 0.001 inch (0.025 mm) or less.

4.1.2.1 When ~~testing~~ continuous rod tie-down components are tested, the displacement measurement device shall measure the relative movement between the component-to-component assembly or between the component and the test apparatus. Placement of the dial gages or LVDTs shall ensure accurate measurement of the relative movement.

4.2 Test Specimen Quantity:

4.2.1 Continuous Rod Tie-down Component Testing:

4.2.1.1 A minimum of three continuous rod tie-down components for each type of component (size, configuration, and material specifications) shall be tested on a steel jig test apparatus for the optional tension rod strength testing.

4.2.1.2 If the maximum test load for an individual tested component varies by more than 15 percent from the average result, testing shall be conducted on three or more additional (six or more, total) continuous rod tie-down components.

4.2.2 Continuous Rod Tie-down Assembly Testing on a Wood Wall Assembly:

4.2.2.1 Differences in assembly configuration and component specifications, as indicated in Section 1.4.2 of this criterion, as well as any modifications in wood size, species, or grade, shall be the basis for establishing the test specimen quantity.

4.2.2.2 A minimum of ~~three~~ two continuous rod tie-down assemblies shall be tested for their intended usage and for each selected combination of variables affecting the continuous rod tie-down assembly performance.

4.2.2.3 If the maximum test load for an individual tested assembly varies by more than 15 percent from the average result, ~~testing shall be conducted on three or more (six or more, total)~~ an additional continuous rod tie-down ~~assemblies~~ assembly test must be completed.

Reason: *Each wood wall test assembly as shown in Figure 2 allows for four rod tie-down assemblies (and three spans between), therefore each test is providing multiple data points for system capacity, and thus less tests are required. This is similar to ASTM E 564 shear wall assembly requirements.*

4.3 Test Setup:

4.3.1 General:

4.3.1.1 Continuous rod tie-down components and assemblies ~~shall~~ may be tested individually and independently in such a manner as to simulate the essential function of the continuous rod tie-down component or assembly. Test loads shall be applied with reference to the intended end-use application of the continuous rod tie-down component or assembly, but individual component testing as described in section 4.2.1 cannot supersede the load determined by the system test described in Section 4.2.2, nor can it surpass code calculated values.

4.3.1.2 The anchor bolt or rod shall be fastened to the test apparatus in such a manner that the connection to the test bed does not affect the test results. Additionally, the anchor bolt or rod shall be attached to the test apparatus with a nut and washer in accordance with the end-use application as set forth in the manufacturer's installation instructions.

4.3.2 Continuous Rod Tie-down Assembly Testing:

4.3.2.1 Continuous rod tie-down assembly testing shall only require the application of load up to the peak load or capacity of the critical component.

4.3.2.2 Wood jig (assembly) test: The continuous rod tie-down assembly shall be tested in a wood framed uplift system setup such as that shown in Figure 2.

4.3.2.3 Steel jig (device) test: The continuous rod tie-down assembly may be tested in a steel jig such as that shown in Figure 1 in order to test tension rod capacity.

4.4 Test Procedure

4.4.1 Preloading: Where pretensioning of the threaded rod occurs during installation, an initial load, or preload, shall be applied for tension (uplift) load testing of continuous rod tie-down components or assemblies, as follows: (1) The nut securing the bearing plate shall be tightened as defined in the manufacturer's installation instructions and this is not to exceed a ½ turn of the nut. (2) The testing machine load shall be recorded at this point (identified as preload). (3) Displacement measuring devices shall then be zeroed.

4.4.2 Test Load Application and Recording: The test load shall be applied at a

uniform crosshead rate between 0.03 and 0.20 inch (0.8 to 5.1 mm) per minute until failure or maximum load. Loads shall be recorded to a precision of 1 percent during application of test loads.

4.4.3 Displacement Recording: The displacements shall be recorded to the nearest 0.001 inch (0.025 mm), and a sufficient number of readings shall be taken until failure or maximum load is achieved.

4.5 Static Tension Test of Rod Couplers: Couplers shall be tested in all threaded rod sizes for which recognition is sought. For each threaded rod diameter and grade, a minimum of five couplers shall be tested in accordance with ASTM A 370. Each connection, in tension, shall develop 100 percent of the specified tensile strength, fu times the net area of the threaded rod, and 125 percent of the specified yield strength, fy, times the net area of the threaded rod.

Reason: *Multiply the fy and fu times the net area of the threaded rod to calculate the actual yield and tensile point of the rod.*

5.0 QUALITY CONTROL

5.1 Quality Documentation: Quality documentation complying with the ICC-ES Acceptance Criteria for Quality Documentation (AC10) shall be submitted.

5.2 Structural Welding: If the assembly or components incorporate structural welds, inspections by an inspection agency accredited by the International Accreditation Service, or otherwise acceptable to ICC-ES, shall be provided.

5.3 Material Traceability: The evaluation report holder shall demonstrate within the quality documentation continuous material traceability of all continuous rod tie-down components within the quality documentation. This requirement includes documenting the batch or heat lot number on high-strength or heat-treated threaded rods and high-strength couplers.

5.3.1 Mechanical Properties Testing Requirements: If components of the tested assemblies consist of either high-strength threaded rods defined in Section 5.3.2 of this criteria or items with properties exceeding values specified in the referenced standards, the report holder shall provide in the quality documentation for mill certificates and mechanical property test reports in the quality documentation for each batch or heat lot procured. Verification shall comply with either Section 5.3.1.1 or Section 5.3.1.2.

5.3.1.1 The report holder shall obtain continual mechanical property test reports from the manufacturer for the high-strength threaded rods or other components, in lieu of independent testing by an accredited test facility.

5.3.1.2 The report holder shall obtain reports of continual independent testing from an accredited testing laboratory for each batch or heat lot procured.

5.3.2 High-strength threaded rod shall comply with requirements described in Section 1.4.3.

5.3.3 Couplers and nuts used with high-strength threaded rod shall comply with Sections 1.4.5 ~~1.4.4 and 1.4.5.7~~ of this criteria.

Reason: *Section References do not make sense: 1.4.4 is for nuts and 1.4.5.7 does not exist*

6.0 EVALUATION REPORT RECOGNITION

6.1 General: The evaluation report shall include the basic information in accordance with Section 2.1 of this criteria.

6.2 Engineered Applications of Continuous Rod Tie-down Components and Assemblies: The evaluation report shall provide include a table specifying the following information:

6.2.1 Continuous rod tie-down component dimensions as set forth in Section 2.1.1 of this criteria.

6.2.2 ASD ~~and LRFD (1.4 times the ASD load~~) load and load-deflection characteristics of the continuous rod tie-down assembly as determined in accordance with Section 3.3 or Section 3.4 of this criteria, with the following footnoted information:

6.2.2.1 A statement indicating that when specified by the registered design professional, or when required by the code official, hold-downs complying with AC155, or wood shrinkage compensating devices complying with AC316, evaluated in an ICC-ES evaluation report may be installed with consideration of corresponding allowable values.

6.2.2.2 A statement indicating that the contribution of anchor bolt or rod elongation, wood shrinkage, wood deformation under load, and fastener or component slip, to the overall deflection of the continuous rod tie-down assembly, shall be analyzed by the registered design professional. Shrinkage compensating devices meeting AC316 criteria may be required by the registered design professional at their discretion, but are required on structures greater than two stories in height.

6.2.3 The ~~lowest~~ average of the tested ASD allowable loads or~~, at the option of the evaluationreport applicant,~~ the calculated ASD allowable loads for each component of the continuous rod tie down assembly, determined in accordance with Section 3.3 or Section 3.4 of this criteria, with the following footnoted information

6.2.3.1 A statement indicating that the assembly shall have an ASD allowable strength equal to or exceeding the required strength of the assembly determined in accordance with the ASD (Allowable Stress Design) load combinations referenced in the applicable code.

6.2.3.2 A statement indicating which adjustment factors taken from the ANSI/AF&PA NDS are included in the derivation of the tabulated allowable loads for wood compression members and steel-to-wood connections.

6.2.3.3 The following statement: "When using the basic load combinations in accordance with IBC Section 1605.3.1, the tabulated allowable loads for the continuous rod tie-down assembly shall not be increased for wind or earthquake loading. When using the alternate basic load combinations in IBC Section 1605.3.2 that include wind or earthquake loads, the tabulated allowable loads for the continuous rod tie-down assembly shall not be increased by 331/3 percent, nor shall the alternative basic load combinations be reduced by a factor of 0.75."

6.2.3.4 The following statement: "The components described in this report have been evaluated with respect to their performance characteristics and their performance characteristics with relation to other components described in this report and the identified structural members. Uses of any components other than those specifically identified within this report are outside the scope of this report."

6.2.3.5 High-strength Threaded Rod: A statement that the report holder shall have available, upon request of by the code official, current mill certificates and mechanical property test reports to demonstrate compliance with the appropriate specification of for each batch or heat lot to be used in the field. Identification of the high strength material must be provided on each rod for verification in the field.

~~**6.2.3.6** A statement indicating that capacities for the continuous rod tie-down assemblies are not intended to represent the capacity of framing systems connected to the assemblies. Design of the framing systems shall be the responsibility of the design professional and shall be performed in accordance with the applicable code. The framing design shall also consider the ability of framing elements to span between continuous rod tie-down assemblies used as wind uplift restraints, if applicable.~~

Reason: *Not required if full scale testing of rod tie-down assemblies on wood walls assemblies is added to the AC391 as suggested*

6.3 Continuous Rod Tie-down Assembly Diagrams: The evaluation report shall include sample multistory diagrams that clearly illustrate the complete continuous tie-down assembly used in wind ~~or overturning seismic~~ uplift applications. Diagrams of typical system assemblies shall be submitted for intended multistory wood ~~and cold-formed steel~~ frame construction applications, and show building tie-off points, and clearly depict intended load path to supporting foundation or anchorage point ~~via the wood or cold-formed steel compression members~~. Special anchorage conditions, such as a steel beam or wood beam connection, may optionally be included.

6.4 Conditions of Use: The evaluation report shall include the following Conditions of Use:

6.4.1 Chemically Treated Preservative- or Fire-treated Wood: The use of continuous rod tie-down assemblies in contact with chemically treated wood is subject to the approval of the code official, since the effects of corrosion of metal in contact with chemically treated wood, on the structural performance of the components, are outside the scope of this report.

6.4.2 Exterior or Damp Environment Exposed Conditions Exposure: If the final Installation of the tie-down assemblies has them exposed to exterior or damp environments, the evaluation report shall state whether such exposure is permitted based on information described in Section 2.1.1. shall be limited to dry interior locations; as an option, installations may be allowed in exterior exposures or damp environments, when evidence of compliance with Section 3.5 of this criteria is provided

6.4.3 Duration of Load Increase: No further increase in duration of load for wind ~~or earthquake~~ loading shall be allowed for the tie-down assemblies.

6.4.4 Drawings and Design Details: Drawings and design details verifying compliance with this report shall be submitted to the code official for approval. Drawings and calculations shall be prepared by a registered design professional when required by the statutes of the jurisdiction in which the project is to be constructed.

Simpson Strong-Tie Co., Inc. 5956 W. Las Positas Boulevard, Pleasanton, CA 94588 Phone: 925.560.9000 Fax: 925.847.1605 www.strongtie.com

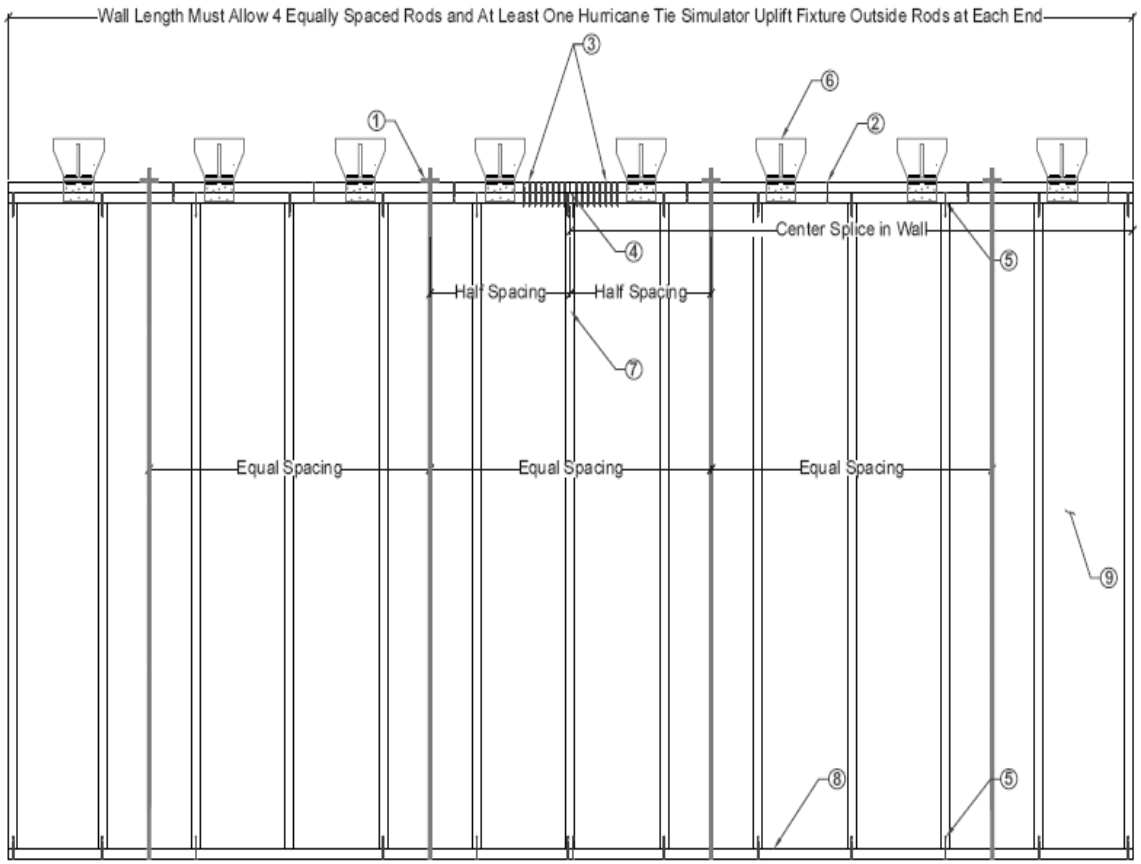


Figure 2: Wood Jig Test Set-up

① Steel Rod w/ Steel Bearing PlateCapable of Developing Rod Tension Capacity, Typ.

② System Mfr. shall specify fastener size and spacing used to along double top plates

③ Fasten double top plates togther at splice per IBC 2308.9.2.1 min. System Mfr. to specify splice connection used in testing

④ Splice in Top-Most Top-Plate.

⑤ (2) 16d end nails plate to stud, Typ. At top plate only System Mfr. may add top plate to stud connectors. System mfr. shall specify what type of connector is used and spacing of connectors.

⑥ Attach Roof Framing Hurricane Tie Simulator to Top-Plate at 24"o.c. max. Hurricane Tie Simulator shall be atttached to top plate with (9)-10d common nails (0.148" dia. x 3"). Simulators shall be independant of each other

⑦ 2x Studs at 16" o.c. (studs shall be Stud Grade of top plate wood species used)

⑧ 2x Sill Plate attached to test bed with ½" dia. A.B. w/ 2"x2"x3/16" min. plate washers at 32"oc max (No A.B. required where rods exist)

⑨ If System Mfr. installs structural sheathing on wall, Mfr. shall provide sheathing and fastening schedule

NOTE: Framing Shall be 8' Nominal Plate Height, Locate Splice in Center of Upper Top-Plate and Base Spacing of Rods from Center of Wall.

Rosalind Fazel

From: Al Commins [al@comminsmfg.com]
Sent: Monday, June 08, 2009 5:25 PM
To: Brian Gerber
Cc: Kurt Stochlia; John Nosse
Subject: AC 391 Couplers
Attachments: Al Commins.vcf; IFI 128 1986 HEX COUPLER NUTS.pdf

Brian

Attached please find a copy of the IFI 128 standard.

This standard covers Hex coupler nuts.

Note #7 allows the addition of a sight hole.
Note #8, material and mechanical properties of steel nuts, defaults to ASTM A563, Grade A, page B-108.
ASTM A563, provides a proof test if required. (Note a, table 3)

The IFI Standard provides everything required for the specifying of Couplers with two exceptions. Two sight holes and reducing couplers.

Our non-reducing couplers use two sight holes and a center stop. The stop aids installation and prevents over insertion, while the holes show minimum engagement.
Adding the stop and two sight holes should be handled with a calculation and appropriate drawings.

Reducing couplers are limited by the larger of the two ends. A calculated capacity of both ends based on ASTM A563 should suffice for proper specification.

Specifying couplers based on the IFI standard and ASTM A563 would provide the best control we could expect, better than a separate test program.

I suggest that an Editorial Change that allows either: the IFI 128 Standard- ASTM A563 or the testing proposed at the meeting.

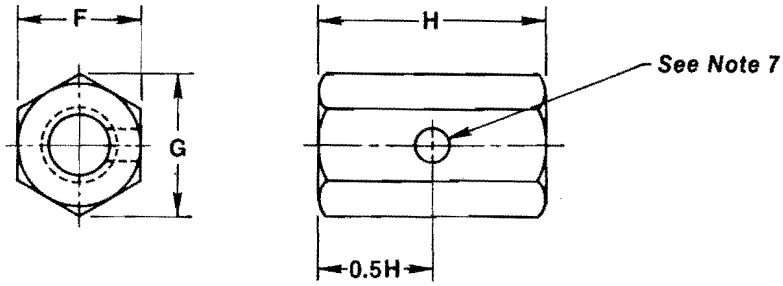
Al Commins

360 378-9484

HEX COUPLING NUTS

IFI Note:

1. IFI-128 is a standard developed through the procedures of Industrial Fasteners Institute. IFI-128 was first published in 1978 and reaffirmed, without technical change, in 1986.



Dimensions of Hex Coupling Nuts

Nom Size or Basic Major Dia of Thread		F			G		H		
		Width Across Flats			Width Across Corners		Thickness		
		Basic	Max	Min	Max	Min	Basic	Max	Min
1/4	0.2500	3/8	0.375	0.365	0.433	0.416	3/4	0.76	0.74
5/16	0.3125	1/2	0.500	0.489	0.577	0.557	15/16	0.95	0.93
3/8	0.3750	9/16	0.562	0.551	0.650	0.628	1-1/8	1.13	1.11
7/16	0.4375	11/16	0.688	0.675	0.794	0.769	1-5/16	1.32	1.30
1/2	0.5000	3/4	0.750	0.736	0.866	0.839	1-1/2	1.51	1.49
9/16	0.5625	7/8	0.875	0.861	1.010	0.981	1-11/16	1.70	1.67
5/8	0.6250	15/16	0.938	0.922	1.083	1.051	1-7/8	1.89	1.86
3/4	0.7500	1-1/8	1.125	1.088	1.299	1.240	2-1/4	2.27	2.22
7/8	0.8750	1-5/16	1.312	1.269	1.516	1.447	2-5/8	2.65	2.60
1	1.0000	1-1/2	1.500	1.450	1.732	1.653	3	3.03	2.97
1-1/8	1.1250	1-11/16	1.688	1.631	1.949	1.859	3-3/8	3.40	3.34
1-1/4	1.2500	1-7/8	1.875	1.812	2.165	2.066	3-3/4	3.78	3.71
1-3/8	1.3750	2-1/16	2.062	1.994	2.382	2.273	4-1/8	4.16	4.09
1-1/2	1.5000	2-1/4	2.250	2.175	2.598	2.480	4-1/2	4.54	4.46
1-5/8	1.6250	2-9/16	2.562	2.481	2.959	2.828	4-7/8	4.91	4.83
1-3/4	1.7500	2-3/4	2.750	2.662	3.175	3.035	5-1/4	5.29	5.21
1-7/8	1.8750	2-15/16	2.938	2.844	3.392	3.242	5-5/8	5.67	5.58
2	2.0000	3-1/8	3.125	3.025	3.608	3.448	6	6.04	5.95
2-1/4	2.2500	3-1/2	3.500	3.388	4.041	3.862	6-3/4	6.80	6.70
2-1/2	2.5000	3-7/8	3.875	3.750	4.474	4.275	7-1/2	7.55	7.44
2-3/4	2.7500	4-1/4	4.250	4.112	4.907	4.688	8-1/4	8.31	8.19
3	3.0000	4-5/8	4.625	4.475	5.340	5.101	9	9.06	8.94
3-1/4	3.2500	5	5.000	4.838	5.773	5.515	9-3/4	9.81	9.68
3-1/2	3.5000	5-3/8	5.375	5.200	6.206	5.928	10-1/2	10.57	10.43
3 3/4	3.7500	5-3/4	5.750	5.562	6.639	6.340	11-1/4	11.32	11.17
4	4.0000	6-1/8	6.125	5.925	7.072	6.754	12	12.08	11.92
4-1/4	4.2500	6-1/2	6.500	6.288	7.506	7.168	12-3/4	12.83	12.67
4-1/2	4.5000	6-7/8	6.875	6.650	7.939	7.581	13-1/2	13.58	13.42
4-3/4	4.7500	7-1/4	7.250	7.012	8.372	7.994	14-1/4	14.34	14.16
5	5.0000	7-5/8	7.625	7.375	8.805	8.408	15	15.09	14.91
5-1/4	5.2500	8	8.000	7.738	9.238	8.821	15-3/4	15.85	15.65
5-1/2	5.5000	8-3/8	8.375	8.100	9.671	9.234	16-1/2	16.60	16.40
5-3/4	5.7500	8-3/4	8.750	8.462	10.104	9.647	17-1/4	17.35	17.15
6	6.0000	9-1/8	9.125	8.825	10.537	10.060	18	18.11	17.89
See Note					3				

HEX COUPLING NUTS

NOTES:

1. All dimensions are in inches.

2. Top Surfaces of Nuts. Nuts shall be double chamfered. The diameter of chamfer circle shall be equal to the maximum width across flats within a tolerance of minus 15 percent.

The length of chamfer at hex corners shall be from 5 to 15 percent of the basic thread diameter. The surface of chamfer may be slightly convex or rounded.

3. Corner Fill. A rounding or lack of fill at junction of hex corners with chamfer shall be permissible provided the width across corners is within specified limits at and beyond a distance equal to 17.5 percent of the basic thread diameter from the chamfered faces.

4. Concentricity of Tapped Hole. Axis of tapped hole shall be concentric with axis of nut body within a tolerance equal to 3 percent (6 percent FIM) of the maximum width across flats.

5. Countersink. Tapped hole may be countersunk on both faces.

6. Threads. Threads shall be Unified coarse or 8 thread series (UNC or 8 UN series), Class 2B, in accordance with ANSI/ASME B1.1, page A-26.

7. In some applications it may be desirable to assure that the threaded parts joined by a coupling nut are each engaged to approximately one-half nut thickness. As a visual inspection aid, a hole drilled through one side of the nut is recommended. The hole should be located at mid nut thickness, and have a diameter of 0.2 to 0.4 times nominal nut size for sizes 2½ in. and smaller, and 1 in., for sizes 2¾ in. and larger. Nuts shall be furnished without a hole, unless specially ordered by the purchaser.

8. Material. Unless otherwise specified, chemical and mechanical properties of steel nuts shall conform with ASTM A563, Grade A, page B-108. Other materials shall be as agreed upon by manufacturer and purchaser.

9. For wrench openings, refer to Appendix III, ANSI/ASME B18.2.2, page D-20.