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To: ICC-ES Evaluation Committee

From: Manuel Chan, S.E. and Vincent Chui, S.E., ICC-ES Staff

Date: October 2, 2020

Subject: Proposed Revisions to Acceptance Criteria for Mechanical Splice Systems for Steel Reinforcing Bars, Subject AC133-1020-R1 (MC/VC)

MEMO

Proposed Revisions to the Acceptance Criteria for Mechanical Splice Systems for Steel Reinforcing Bars, Subject AC133-1020-R1, were posted on the ICC-ES website with our staff letter dated August 18, 2020. In response to our August 18, 2020 posting of the subject criteria, we received the following public comments:

1) An email from Conrad Paulson, P.E. S.E., Principal, Wiss, Janney, Elstner (WJE) Associates, Inc.
2) A letter from Tim Cartwright, Barsplice Products.
3) A letter from Robbie Hall, Headed Reinforcement Corporation (HRC).
4) A letter from Mostafa Tazarv, Ph.D., P.E..
5) A letter from Robert C. Stewart, nVent.

Staff reviewed the public comments outlined above and proposes a revised version of acceptance criteria AC133 using ~~double strikeout~~/bold underlining to denote the revisions based on the public comments, which is enclosed with this memo.

Comments received are outlined below and are addressed accordingly:

A. Editorial revisions from public comments:

1) Added “and Preload slack are” and deleted “is” in Section 3.2.3.
2) Corrected reference Section 3.25 to 3.2.5.
3) Corrected reference under Section 3.2.5a to refer to Section 4.4.3.
4) Added the statement “ASTM A706 as modified by” in Section 3.3.2.
5) Added the statement “Reinforcement used with all Type 2HS splice test specimens shall conform to the requirements of Section 3.3.2” in Section 4.4.
6) Added the statement “The Type 2HS splice shall additionally develop strain in tension in the reinforcing bar as specified in Table 7” in subsections 6.7.c(ii), 6.8.b(ii), 6.9.b(ii), and 6.10.d.
7) Removed the statement “using the same grout” and replaced it with “from each batch (bag) of grout”, and removed the statement “24 hours of the structural tests” and replaced it with “the permissible tolerance on test age as specified in ASTM C109” in Annex A, Section A3.2.2.
8) Corrected word “Applied” with “Apply” in Annex B, item C

B. Technical revisions based on public comments received:

1) Revised Section 4.2.3. Staff is in agreement with the comment from Barsplice related to the Type 1 splice residual slip requirements and removed the condition of acceptance related to it.

2) Revised Section 4.4.2. Staff is in agreement with the comment from nVent related to the Type 2HS splice Monotonic Compression Tests requirements to consider 125 percent of the specified yield strength, *fy*, which need not exceed 100 percent of the specified tensile strength, *fu*, of the reinforcing bar under Section 4.4.2.

3) Revised Annex B, item a. Staff is in agreement with the comment from nVent related to the test setup for the Type 2HS splice to allow for reduced gage lengths to prevent buckling.

C. Other public comments are summarized below with ICC-ES Staff responses:

- Justification for including a slip criteria for mechanical splice systems.
  ICC-ES response: Currently**,** mechanical splice systems under AC133 do not need to satisfy any residual slip requirement to be categorized as a Type 2 splice. Type 2 splices are typically used in reinforced concrete structures subjected to reversed cyclic loading during earthquake events. It is prudent to include a residual slip criteria limit, since a Type 2 splice may exhibit excessive slip under reversed cyclic loading. The proposed residual slip criteria limit is based on the building seismic provisions of the Japanese standard (JCI-C10E) upon which AC133 was developed.

- Available data and procedures to determine residual slip of mechanical splice systems.
  ICC-ES response: Currently, all mechanical splice systems are required to report elongation measurements, so the test data and procedures to determine the residual slip are available from the current AC133 report holders. The original term for “Elongation” in AC133 has been replaced with “Residual Slip” as part of the proposed revisions. For all mechanical splice systems addressed in the proposed revisions for AC133, the method for determining “residual slip” has not changed.

- Justification for including a Type 2HS (high strain) splice prior to adoption in ACI 318.
  ICC-ES response: A significant precedent exists for ICC-ES to develop acceptance criteria for product evaluations to a code or standard that has not yet been adopted. The ICC-ES acceptance criteria development process allows for such early implementation of the latest tech requirements. The proposed Type 2HS splice is optional and based on ACI 318-19 reinforcement requirements for ASTM A706 grades higher than 60 ksi. ICC-ES Staff is aware of code officials in jurisdictions seeking information on high strain mechanical splice systems for rebar of Grade 80 ksi and 100 ksi used to resist flexural forces, axial forces, shear forces, confinement and temperature and shrinkage reinforcement in special seismic systems. The proposed AC133 revisions for an optional Type 2HS splice will provide sufficient information in the evaluation reports for the code officials in jurisdictions requesting this information.

- Requirements for Type 2HS splice and applicable steel reinforcing bars.
  ICC-ES response: ACI 318-19 allows for the use of rebar of Grade 80 ksi or 100 ksi used to resist flexural forces, axial forces, shear forces, confinement and temperature and shrinkage reinforcement in special seismic systems. The intent of the Type 2HS splice is to meet or exceed the performance requirements in accordance with ACI 318-19 Section 20.2.1.3(b), of deformed bar ASTM A706 requirements for Grade 80 ksi or 100 ksi.

- CALTRANS requirements.
  ICC-ES response: The proposed residual slip and optional Type 2HS splice in AC133 are slightly more conservative than the requirements under CALTRANS, and are intended for use in reinforced concrete building structures, rather than transportation structures.

- Requirements for compression and cyclic load testing.
  ICC-ES response: Compression and cyclic load testing are not new requirements in AC133, They have been part of the original AC133 which was based upon the Japanese standard (JCI-C10E) and nothing has changed in this regard.

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PROPOSED REVISIONS TO ACCEPTANCE CRITERIA FOR MECHANICAL SPLICE SYSTEMS FOR STEEL REINFORCING BARS

AC133

Proposed August 2020 (Revised October 2, 2020)

Previously approved August 2019, October 2015, May 2014, December 2012, January 2010, May 2008, June 2007, October 2004, April 2002, January 2001, January 1998

(Previously editorially revised February 2018, August 2013)

PREFACE

Evaluation reports issued by ICC Evaluation Service, LLC (ICC-ES), are based upon performance features of the International family Evaluation reports issued by ICC Evaluation Service, LLC (ICC-ES), are based upon performance features of the International family of codes. (Some reports may also reference older code families such as the BOCA National Codes, the Standard Codes, and the Uniform Codes.) Section 104.11 of the *International Building Code*® reads as follows:

> **The provisions of this code are not intended to prevent the installation of any materials or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been approved. An alternative material, design or method of construction shall be approved where the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability and safety.**

ICC-ES may consider alternate criteria for report approval, provided the report applicant submits data demonstrating that the alternate criteria are at least equivalent to the criteria set forth in this document, and otherwise demonstrate compliance with the performance features of the codes. ICC-ES retains the right to refuse to issue or renew any evaluation report, if the applicable product, material, or method of construction is such that either unusual care with its installation or use must be exercised for satisfactory performance, or if malfunctioning is apt to cause injury or unreasonable damage.

Acceptance criteria are developed for use solely by ICC-ES for purposes of issuing ICC-ES evaluation reports

PROPOSED REVISIONS TO ACCEPTANCE CRITERIA FOR MECHANICAL SPLICE SYSTEMS FOR STEEL REINFORCING BARS (AC133)

1.0 INTRODUCTION

1.1 Purpose: The purpose of this acceptance criteria is to establish requirements for ~~mechanical splice systems for steel reinforcing bars to be recognized in an~~ issuance of ICC Evaluation Service, LLC (ICC-ES), evaluation reports on mechanical splice systems for steel reinforcing bars, under the 2021, 2018, 2015, 2012 and 2009 *International Building Code*® (IBC) and the 2021, 2018, 2015, 2012 and 2009 *International Residential Code*® (IRC). The bases of ~~recognition~~ this acceptance criteria and resulting evaluation reports are IBC Section 104.11 and IRC Section R104.11.

The reason for development of this criteria is to establish guidelines for the evaluation of mechanical splice systems for steel reinforcing bars and to provide additional information to clarify the requirements of the IBC, and IRC, and documents referenced by those codes.

1.2 Scope: The scope of this criteria is mechanical splice systems used to connect uncoated, deformed steel reinforcing bars installed in concrete as addressed in the sections of ACI 318 noted in Table 2 and in the IRC sections noted in Table 3, or installed in fully-grouted, reinforced concrete masonry, as addressed in the sections of TMS402/602 noted in Table 5 and Section R301.1.3 of the 2021, 2018, 2015, 2012 and 2009 IRC. Mechanical splice systems for partially-grouted concrete masonry are outside of the scope of this criteria. The criteria is applicable to reinforcing bar splices that are field-assembled onto the ends of reinforcing bars that have been prepared at a factory or the jobsite. The criteria is also applicable to reinforcing bar splices that include components that are factory-attached to the reinforcing bars, for final assembly of the connection at the jobsite. Additional requirements for cementitious grouted sleeve steel reinforcing bar splices, are described in Annex A.

1.3 Referenced Standards: Where standards are referenced in this criteria, these standards must be applied consistently with the code upon which compliance is based. See Table 4.

1.3.1 2021, 2018, 2015, 2012, and 2009 *International Building Code*® (IBC), International Code Council.

1.3.2 2021, 2018, 2015, 2012, and 2009 *International Residential Code*® (IRC), International Code Council

~~1.3.1~~1.3.3 ASTM A370, Test Methods and Definitions for Mechanical Testing of Steel Products, ASTM International.

~~1.3.2~~1.3.4 ACI 318, Building Code Requirements for Structural Concrete, American Concrete Institute.

~~1.3.3~~1.3.5 ACI 439.3R-07, Types of Mechanical Splices for Reinforcing Bars, American Concrete Institute.

~~1.3.4~~1.3.6 JCI-CIOE, Volume 2, October 27-31, 1986, Standard for Performance Evaluation of Rebar Joints, Seminar on Precast Concrete Construction in Seismic Zones, Japan Concrete Institute.

~~1.3.5~~1.3.7 TMS 402/602, Building Code Requirements and Specification for Masonry Structures, The Masonry Society.

1.4 Definitions:

1.4.1 Splice Systems: Splice systems consist of all components utilized to facilitate mechanical connection or mechanical splice of steel reinforcing bars. For example, for splice systems where a splice/coupler is solely swaged onto the bars, the splice system component is the splice/coupler. For sleeve-type systems installed with grout, the splice system typically is the steel sleeve and grout. For systems utilizing a coupler installed onto reinforcing bars that have specially prepared ends, such as bars with threaded ends, the splice system components are the coupler and the reinforcing bars.

1.4.2 Jobsite: The construction site where the structure is being constructed.

1.4.3 Test Specimen: Unless noted otherwise, each mechanical splice test specimen is an assembly of the completed splice, or completed splice system, connecting two sections of steel reinforcing bars.

1.4.4 Affected Zone of Reinforcing Bar: The affected zone is defined as that portion of the reinforcing bar where any property of the bar, including physical, metallurgical or material characteristics, has been altered by manufacture, fabrication and/or installation of the splice. Examples include, but are not limited to, heat affected zones, bar upset zones, sections of the bar affected by threading or other machining, and significant sharp marks or notches left in the bar by gripping during manufacture, fabrication or installation of the mechanical splice.

1.4.5 Preload Slack: Preload slack is referred to any movements of the reinforcing bars within the mechanical splice prior to the application of loads.

2.0 BASIC INFORMATION

2.1 General: The following information regarding the steel reinforcing bar splice system shall be submitted:

2.1.1 Product Description: Description of each component of the system shall include dimensions, designations and material specifications.

2.1.2 Packaging and Identification: The method of packaging and field identification of each component of the system shall be described. Product identification shall be in accordance with the product identification provisions of the ICC-ES Rules of Procedure for Evaluation Reports and shall also include~~The packaging information of each component of the system supplied by the evaluation report holder shall include~~ the name and address of the evaluation report holder~~, product model (style) and size and the applicable ICC-ES evaluation report number~~.

Each splice and splice system component supplied by the evaluation report holder shall also be identified by the manufacturer's mark or logo, and indicate whether the splice is intended for a Type 1, Type 2 and/or Type 2HS splice connection. The Type 1, Type 2 and/or Type 2HS identification shall be spelled out or indicated by a symbol to be identified in the evaluation report.

2.1.3 Installation Instructions: Instructions shall include requirements and limitations regarding installation of the product and description of the methods of field preparation and assembly.

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 describe the process used to assemble and prepare the test specimens.

2.4 Product Sampling: For the tests specified in this criteria, systems with components that are factory-attached to reinforcing bar ends by mechanical or welding processes shall be sampled in accordance with Section 3.1 of AC85. Reinforcing bars that are factory-prepared to receive field-installed couplers shall also be sampled in accordance with Section 3.1 of AC85. All other products subjected to tests required by this criteria are permitted to be sampled in accordance with Section 3.2 of AC85. The testing laboratory shall witness the portion of the preparation and assembly of the test specimens that reflects the field preparation and assembly procedures.

2.5 Qualification Test Plan: A qualification test plan shall be submitted to and approved by ICC-ES staff prior to any testing being conducted.

3.0 TEST PERFORMANCE AND PRODUCT REQUIREMENTS

3.1 General: Reports of tests specified by Sections 3.2 and 4.0 and any applicable annex to this criteria shall be submitted.

3.2 Structural Performance:

3.2.1 Types of Splices: The manufacturer has the option of qualifying the splice systems for use in either Type 1 or Type 2 mechanical splices. For installation into concrete, Sections 18.2.7.2, 18.9.2.1(c), 18.12.7.4 of ACI 318-19 under the 2021 IBC, ~~or~~ 318-14 under the 2018 and 2015 IBC, or ~~(~~Sections 21.1.6.2, 21.8.2(b) and 21.11.7.4 of ACI 318-11 or -08 under the 2012 or 2009 IBC, respectively~~)~~, as applicable, describe permitted uses for each type of splice under the IBC and IRC. For installation into fully-grouted concrete masonry, Section 2108.3 of the 2021, 2018, 2015, 2012 and 2009 IBC describes permitted uses for each type of splice.

a) Type 2HS Splice (Optional): The manufacturer may seek additional evaluation of the splice system as a Type 2HS mechanical splice ("HS" denotes "High Strain"). The Type 2HS splice is a mechanical splice with a minimum tensile strength and tensile strain capacity intended for use in seismic applications with reinforcing bar conforming to ACI 318-19 Section 20.2.1.3(b). The conditions of acceptance in Section 4.4 for the Type 2HS splice includes strain-based performance requirements that are in addition to the stress-based performance requirements of the Type 2 splice in Section 4.3. A splice evaluated as a Type 2HS splice by testing under Section 4.4 may also be described as a Type 2 splice under Section 4.3 without further testing.

3.2.2 Control Bars: For all mechanical splice testing performed in accordance with Section 4.0~~1~~ of this criteria, an unspliced control reinforcing bar of each bar size, type and grade to be ~~recognized~~ evaluated is to be tested in tension in accordance with ASTM A370 to establish the actual yield and actual ultimate stress of the reinforcing bars. The actual yield stress from each control bar tension test shall be determined in accordance with ACI 318-19 under the 2021 IBC, ACI 318-14 under the 2018 and 2015 IBC, (ACI 318-11 or -08 under the 2012 or 2009 IBC, respectively), as applicable.

For each unspliced control reinforcing bar, the strain at actual yield stress, ε_{ya}, shall be calculated as $\varepsilon_{ya} = f_{ya}/E_s$, where f_{ya} is the actual yield strength of the unspliced control bar in ksi, determined in accordance with this section, and $E_s = 29000$ ksi. The resulting value for ε_{ya} is used for controlling cyclic tension and compression tests per Table 1 of this criteria, as described in Section 3.2.4.

For any bar size group, the control bars and the bars that are part of the mechanical splice test specimen assemblies being tested shall be from the same heat.

3.2.3 ~~Elongation~~ Residual Slip and Preload Slack Measurement: For all mechanical splice testing conducted in accordance with Section 4.~~1~~0 of this criteria, ~~elongation~~ preload slack as defined in Section 1.4.5 shall be measured and reported, residual slip across the connection shall be recorded and load-elongation plots shall be provided in the test report. ~~Elongation~~ Residual Slip and Preload Slack are ~~is~~ to be measured between two gage points located on the reinforcing bars, one gage point beyond either end of the mechanical splice. A gage point shall not be located on the connection itself, nor within the affected zone (see Section 1.4.4) of the reinforcing bar. Each gage point shall be located not more than one bar diameter away from an end of the mechanical splice or end of the affected zone. Alternatively, for specimens tested in monotonic compression, the specimens can be gripped at the gage point with the test machine crosshead or piston movement monitored as the elongation measurement.

3.2.4 Reference Strain: For all tension and cyclic testing conducted in accordance with Section 4.0~~1~~ of this criteria, reference strain shall be continuously recorded, and load-strain plots shall be provided for each spliced bar test specimen. The reference strain is to be measured and monitored at a location on the reinforcing bar, remote from the splice and outside of the affected zone.

The strain at actual yield stress, ε_{ya}, as determined from the control bar tests described in Section 3.2.2, shall be used to establish the numerical values of reference strains $2\varepsilon_{ya}$ and $5\varepsilon_{ya}$ (See Table 1). The tensile loads in Stages 2 and 3 of the cyclic testing shall be based on the first cycle of tensile load that results in a reference strain of, respectively, $2\varepsilon_{ya}$ and $5\varepsilon_{ya}$ in the bar of the spliced bar test specimen.

The zero or baseline strain reading shall be taken at zero applied load prior to the start of the load test on a specimen and shall not be re-zeroed during the test. The reference strain shall be recorded throughout Stages 1, 2 and 3, and as far into Stage 4 as practicable.

3.2.5 Strain Developed During Stage 4 for Type 2HS Splice: For Type 2HS splices, the strain developed during Stage 4 of testing (see Section 4.4.3) is permitted to be determined by either of the following methods:

a) The reference strain of Section 3.2.4 shall be recorded to at least the minimum tensile strain specified in the conditions of acceptance of Section 4.4.3~~.1~~, and the maximum value of the recorded data is reported as the strain developed during Stage 4.

b) The manual method using punch or scribe marks as described in Annex B.

3.3 Steel Reinforcing Bars:

3.3.1 Requirements for ~~High~~ Seismic Resistance ~~Applications~~Elements: Under the 2021, 2018 and 2015 IBC, for use as longitudinal reinforcement resisting earthquake-induced moment, axial force, or both, in special moment frames, special structural walls, and all components of special structural walls including coupling beams and wall piers, the deformed reinforcing bars of the mechanical splice systems shall comply with ACI 318-19 and ACI 318-14 ~~–~~Sections 20.2.2.5 and 26.13.2.3 for concrete installation, as applicable, or TMS 402 (-16, -13) Section 9.1.9.3 and TMS 602 (-16, -13) Article 2.4A for concrete masonry installation, as applicable. Under the 2012 IBC, for use as reinforcement resisting earthquake-induced flexure, axial force, or both, in special moment frames, special structural walls, and all components of special structural walls including coupling beams and wall piers, the deformed reinforcing bars of the mechanical splice systems shall comply with ACI 318-11 Section 21.1.5.2 for concrete installation or TMS 402-11 Sections 3.1.8.3 and 8.1.8.6 and TMS 602-11 Article 2.4A for concrete masonry installation, as applicable. Under the 2009 IBC, for use as reinforcement resisting earthquake-induced flexural and axial forces in frame members, structural walls, and coupling beams, the deformed reinforcing bars of the mechanical splice systems shall comply with ACI 318-08 Section 21.1.5.2 for concrete installation or TMS 402-08 Sections 3.1.8.3 and 8.1.8.6 and TMS 602-08 Article 2.4A for concrete masonry installation, as applicable.

3.3.2 Reinforcement for use with Type 2HS Splices: In addition to the other applicable requirements for reinforcing bars specified in this acceptance criteria, the reinforcement used with a splice system that is recognized as a Type 2HS mechanical splice shall also conform to the requirements of ASTM A706 as modified by ~~of~~ ACI 318-19 Section 20.2.1.3(b) for the grade of reinforcement for inclusion in the evaluation report.

~~3.3.2~~3.3.3 Specified Tensile Strength of Spliced Bars: For the purpose of evaluating data for conformance with AC133 and for satisfying Section 18.2.7.1(b) of ACI 318-19 and 318-14 (Section 21.1.6.1(b) of ACI 318-11 and 318-08) for concrete and concrete masonry, the specified tensile strength of the bars shall be the minimum specified tensile strength prescribed in the corresponding ASTM standard for the grade of steel reinforcement.

4.0 STRUCTURAL PERFORMANCE TESTS ~~METHODS~~

4.1 ~~Structural Performance Tests~~General: Mechanical splice systems shall be tested in all reinforcing bar sizes, types, and grades for inclusion in the evaluation report. Transition mechanical splice systems shall be tested in all combinations of bar size, type, and grade transitions for inclusion in the evaluation report. Testing shall be in accordance with ASTM A370. Conditions of acceptance are outlined in Sections 4.2 through 4.4 for each splice type and test loading condition.

~~4.1.1~~4.2 Type 1 Splice: For each bar size and each transition combination, a minimum of three replicate mechanical splice test specimens shall be tested for each of the following loading conditions:

~~4.1.1.1~~4.2.1 ~~Static~~ Monotonic Tension ~~and Compression~~ Tests: Each test specimen shall be tested in monotonic tension to failure. Each test specimen shall develop in tension with at least 125 percent of the specified yield strength, f_y, of the reinforcing bar. See conditions of acceptance under Section 4.2.3 for the condition that permits omission of monotonic tension testing prescribed in this section. ~~Mechanical splice systems shall be tested in all reinforcing bar sizes for which recognition is sought. All reinforcing bar transition splices shall be tested. For each size, a minimum of three replicate test specimens in each load direction shall be tested in accordance with ASTM A370. Each connection shall develop, in tension and compression, at least 125 percent of the specified yield strength of the reinforcing bar. See Section 4.1.1.3 for the condition that permits omission of static tension testing prescribed in Section 4.1.1.1.~~

~~4.1.1.2~~4.2.2 ~~Cyclic Tension and~~ Monotonic Compression Tests: Each test specimen shall be tested in monotonic compression. Each test specimen shall develop in compression with at least 125 percent of the specified yield strength, f_y, of the reinforcing bar. ~~Mechanical splice systems shall be tested in all reinforcing bar sizes for which recognition is sought. All reinforcing bar transition splices shall be tested. For each reinforcing bar size, a minimum of three replicate test specimens shall be tested. The cyclic testing procedure is as noted in Table 1. See Section 4.1.1.3 for the conditions of acceptance on cyclic tension and compression tests.~~

4.2.3 Cyclic Tension and Compression Tests: Each test specimen shall be tested according to Stage 1 followed immediately by Stage 4 of the cyclic testing procedure noted in Table 1; Stages 2 and 3 need not be applied. Residual slip shall be determined at the end of Stage 1, according to the method illustrated in Figure 1. See conditions of acceptance under this section on cyclic tension and compression tests.

~~4.1.1.3~~Conditions of Acceptance: For cyclic tension and compression tests, each test specimen shall sustain Stage~~s~~ 1 ~~through 3~~ without failure. ~~Each test specimen shall satisfy the residual slip requirement specified in Table 6.~~ If the load at failure of each test specimen under Stage 4 testing complies with the conditions of acceptance of Section 4.~~1.1.1~~2.1, the ~~static~~ monotonic tension testing of Section 4.~~1.1.1~~2.1 may be omitted.

~~4.1.2~~4.3 Type 2 Splice: For each bar size and each transition combination splice, a minimum of five replicate mechanical splice test specimens shall be tested for each of the following loading conditions:

~~4.1.2.1Static Tension and Compression Tests:~~

~~4.1.2.1.1~~4.3.1 ~~Static~~Monotonic Tension Test~~s~~: ~~Mechanical splice systems shall be tested in all reinforcing bar sizes for which recognition is sought. All reinforcing bar transition splices shall be tested. For each reinforcing bar size, a minimum of five replicate test specimens shall be tested in accordance with ASTM A370~~Each test specimen shall be tested in monotonic tension to failure. For use under the IBC and IRC, each test specimen ~~connection,~~shall develop in tension~~,~~ with ~~shall develop~~ 100

percent of the specified tensile strength, f_u, of the reinforcing bar, and 125 percent of the specified yield strength, f_y, of the reinforcing bar. See conditions of acceptance under Section 4.3.3.1~~1.2.3~~ for the condition that permits omission of ~~static~~ monotonic tension testing prescribed in this s~~S~~ection ~~4.1.2.1.1~~.

~~4.1.2.1.2~~4.3.2 ~~Static~~ Monotonic Compression Test~~s~~: Each test specimen shall be tested in monotonic compression. Each test specimen shall develop in compression with~~All requirements noted in Section 4.1.2.1.1 of this criteria apply to compression tests, except that each splice in compression need only develop~~ at least 125 percent of the specified yield strength, f_y, of the reinforcing bar.

~~4.1.2.2~~4.3.3 Cyclic Tension and Compression Tests: ~~Mechanical splice systems shall be tested in all reinforcing bar sizes for which recognition is sought. All reinforcing bar transition splices shall be tested. For each reinforcing bar size, a minimum of five replicate test specimens shall be tested. The~~Each test specimen shall be tested according to the cyclic testing procedure ~~is as~~ noted in Table 1. Residual slip shall be determined at the end of each of Stage 1, Stage 2 and Stage 3 of cyclic loading according to the method illustrated in Figure 1. See conditions of acceptance under this S~~s~~ection ~~4.1.2.3~~3.3.1 ~~for the conditions of acceptance~~ on cyclic tension and compression tests.

> **~~4.1.2.3~~Conditions of Acceptance:** For cyclic tension and compression tests, each test specimen shall sustain Stages 1 through 3 without failure. Each test specimen shall satisfy the residual slip requirements specified in Table 6. If the load at failure of each test specimen under Stage 4 testing complies with the conditions of acceptance of Section 4.~~1.2.1.1~~3.1, the ~~static~~ monotonic tension tests of Section 4.~~1.2.1.1~~3.1 may be omitted.

4.4 Type 2HS Splice: Reinforcement used with all Type 2HS splice test specimens shall conform to the requirements of Section 3.3.2. For each bar size and each transition combination, a minimum of five replicate mechanical splice test specimens shall be tested for each of the following loading conditions:

4.4.1 Monotonic Tension Tests: Monotonic tension tests are not required. The Stage 4 tensile strength that is developed after application of Stages 1, 2, and 3 of cyclic loading in accordance with Section 4.4.3 shall be used to assess the tensile strength of Type 2HS mechanical splices in accordance with conditions of acceptance under Section 4.4.3.

4.4.2 Monotonic Compression Tests: Each test specimen shall be tested in monotonic compression. Each test specimen shall develop in compression ~~at least~~ 125 percent of the specified yield strength, f_y, which need not exceed 100 percent of the specified tensile strength, f_u, of the reinforcing bar.

4.4.3 Cyclic Tension and Compression Tests: Each test specimen shall be tested according to the cyclic testing procedure noted in Table 1. Residual slip shall be determined at the end of each of Stage 1, Stage 2 and Stage 3 according to the method illustrated in Figure 1. The maximum strain in tension developed in the reinforcing bar during Stage 4 shall be determined as specified in Section 3.2.5. See conditions of acceptance under this section on cyclic tension and compression tests.

> **Conditions of Acceptance**: For cyclic tension and compression tests, each test specimen shall sustain Stages 1 through 3 of loading without failure. Each test specimen shall satisfy the residual slip requirements specified in Table 6. Under Stage 4 of the test, each test specimen shall develop in tension all of the following: 100 percent of the specified tensile strength, f_u, of the reinforcing bar; 125 percent of the specified yield strength, f_y, of the reinforcing bar; and strain in tension in the reinforcing bar as specified in Table 7.

5.0 QUALITY CONTROL

5.1 Each component of the splice system supplied by the evaluation report holder shall be manufactured under an approved quality control program with quality documentation, complying with the ICC-ES Acceptance Criteria for Quality Documentation (AC10), submitted for each manufacturing facility.

The quality documentation, as it relates to manufacturing of steel components of the splice system, shall include the tolerance for physical and chemical properties, acceptance test standards, fabrication geometric tolerance and other aspects of the controls on the production.

5.2 The quality control program shall include inspections by ICC-ES or by a properly accredited inspection agency that has a contractual relationship with ICC-ES, for splice systems that include components of the splice system that are factory-attached to reinforcing bars.

5.3 For splice systems that do not include components of the splice system that are factory-attached to reinforcing bars, an annual inspection shall be conducted at each manufacturing facility in accordance with the requirements of the ICC-ES Acceptance Criteria for Inspections and Inspection Agencies (AC304).

5.4 A qualifying inspection shall be conducted at each manufacturing facility in accordance with the requirements of AC304.

6.0 EVALUATION REPORT ~~RECOGNITION~~

6.1 The evaluation report shall indicate whether the mechanical splice system is classified as a Type 1 or Type 2 or Type 2HS splice of reinforcing bars, and whether it is used in reinforced concrete, fully-grouted concrete masonry, or both, and describe the labeling of each component of the splice system that identifies whether the splice system is for Type 1, Type 2 or Type 2HS splices. (See Section 2.1.2.)

6.2 The evaluation report shall indicate that special inspection shall be provided at the jobsite as required by Section 1705 of the 2021, 2018, 2015 and 2012 IBC (Section 1704 for the 2009 IBC). The evaluation report shall include statements that in addition to verifying placement of reinforcing bar mechanical splices, the special inspector shall verify field preparation of components (including field preparation of reinforcing bar ends, if applicable) and assembly of the components resulting in spliced reinforcing

bars. See Annex A of this criteria for additional requirements, if any.

6.3 The evaluation report shall include product description, installation instructions, and packaging and labeling information based on requirements in Section 2.1 of this criteria.

6.4 When installed in concrete, the evaluation report shall include a condition of use that the minimum concrete cover shall be in accordance with the applicable code and shall be measured from the outer surface of the connecting device.

6.5 When installed in fully-grouted concrete masonry, the evaluation report shall include a condition of use that the minimum grout space requirements shall be in accordance with the applicable code and shall be measured from the outer surface of the connecting device.

6.6 Where freeze-thaw tests in accordance with Section A4.1 are not submitted, the evaluation report shall include the condition of use that grouted sleeve reinforcing bar splices are limited to areas where the average rainfall does not exceed 20 inches (508 mm) annually and the average daily low temperature exceeds 30°F (-1.1°C).

6.7 For splice systems consisting of steel reinforcing bars with specially prepared ends supplied by fabricators' facilities not identified in the evaluation report, the evaluation report shall include statements that address the following items:

a. The fabricator must be a fabricator approved by the code official in accordance with Section 1704.2.7.1 of the 2021 IBC, Section 1704.2.5.1 of the 2018 and 2015 IBC (Section 1704.2.5.2 of the 2012 IBC or Section 1704.2.2 of the 2009 IBC, as applicable).

b. The fabricator must be approved by the evaluation report holder.

c. The fabricator must demonstrate the following items to the satisfaction of the code official for each splice system model type and steel reinforcing bar size:

(i) The fabricator prepares the ends of the steel reinforcing bar as required by the evaluation report holder in a manner consistent with the qualifying test specimens. The evaluation report will need to include a sufficiently detailed description of the method of preparing the reinforcing bars and specifications, or refer to specific documents that contain this information.

(ii) For Type 2 or 2HS splices, splices of each steel reinforcing bar using the fabricator-prepared steel reinforcing bars, tested in ~~static~~monotonic tension, develop 100 percent of the specified tensile strength of the steel reinforcing bar and 125 percent of the specified yield strength of the reinforcing bar for use under the IBC and IRC. The Type 2HS splice shall additionally develop strain in tension in the reinforcing bar as specified in Table 7. This may be demonstrated in test report(s) submitted to the code official.

(iii) For Type 1 splices, splices of each steel reinforcing bar using fabricator-prepared steel reinforcing bars, tested in ~~static~~monotonic tension, develop at least 125 percent of the specified yield strength of the steel reinforcing bars. This may be demonstrated in test report(s) submitted to the code official.

6.8 For splice systems consisting of steel reinforcing bars with specially prepared ends, where the steel reinforcing bars are prepared at the jobsite, the evaluation report shall include statements that address the following items:

a. The jobsite fabricator must be approved by the evaluation report holder.

b. The jobsite fabricator must demonstrate the following items to the satisfaction of the special inspector for each splice system model type and steel reinforcing bar size:

(i) The fabricator prepares the ends of the steel reinforcing bar as required by the evaluation report holder in a manner consistent with the qualifying test specimens. The evaluation report will need to include a sufficiently detailed description of the method of preparing the reinforcing bars and specifications, or refer to specific documents that contain this information.

(ii) For Type 2 or 2HS splices, splices of each steel reinforcing bar using the fabricator-prepared steel reinforcing bars, tested in ~~static~~monotonic tension, develop 100 percent of the specified tensile strength of the steel reinforcing bar and 125 percent of the specified yield strength of the reinforcing bar for use under the IBC or IRC. The Type 2HS splice shall additionally develop strain in tension in the reinforcing bar as specified in Table 7. This may be demonstrated in test report(s) submitted to the code official. These tests should be conducted prior to commencement, and periodically throughout the duration, of the jobsite preparation of the ends of the steel reinforcing bars. The frequency of the tensile tests shall be acceptable to the registered design professional for the building project, and to the applicable code official.

(iii) For Type 1 splices, splices of each steel reinforcing bar using the fabricator-prepared steel reinforcing bars, tested in ~~static~~monotonic tension, develop 125 percent of the specified yield strength of the steel reinforcing bar. This may be demonstrated in test report(s) submitted to the code official. These tests shall be conducted prior to commencement, and periodically throughout the duration, of the jobsite preparation of the ends of the steel reinforcing bars. The frequency of the tensile tests shall be acceptable to the registered design professional for the building project, and to the applicable code official.

6.9 For splice systems consisting of couplers that are swaged or otherwise pressed onto the steel reinforcing bars by fabricators at the jobsite, the evaluation report shall include statements that address the following items:

a. The jobsite fabricator must be approved by the evaluation report holder.

b. The jobsite fabricator must demonstrate the following items to the satisfaction of the special inspector for each splice system model type and steel reinforcing bar size:

(i) The fabricator assembles the splice system onto the ends of the steel reinforcing bar as required by the evaluation report holder in a manner consistent with the qualifying test specimens. The evaluation report will need to include a sufficiently detailed description of the method of installing the splice system onto the reinforcing bars and

specifications, or refer to specific documents that contain this information.

(ii) For Type 2 or 2HS splices, splices using the fabricator-prepared assemblies of couplers and steel reinforcing bars, tested in ~~static~~monotonic tension, develop 100 percent of the specified tensile strength of the steel reinforcing bar and 125 percent of the specified yield strength of the reinforcing bar for use under the IBC or IRC. The Type 2HS splice shall additionally develop strain in tension in the reinforcing bar as specified in Table 7.This may be demonstrated in test report(s) submitted to the code official. These tests should be conducted prior to commencement, and periodically throughout the duration, of the jobsite assembly of the splice system onto the ends of the steel reinforcing bars. The frequency of the tensile tests shall be acceptable to the registered design professional for the building project, and to the applicable code official.

(iii) For Type 1 splices, splice using the fabricator-prepared couplers and steel reinforcing bars, tested in ~~static~~monotonic tension, develop 125 percent of the specified yield strength of the steel reinforcing bar. This may be demonstrated in test report(s) submitted to the code official. These tests shall be conducted prior to commencement, and periodically throughout the duration, of the jobsite assembly of the splice system on the ends of the steel reinforcing bars. The frequency of the tensile tests shall be acceptable to the registered design professional for the building project, and to the applicable code official.

6.10 For splice systems consisting of couplers that are swaged or otherwise pressed onto the steel reinforcing bars at facilities of fabricators not identified in the evaluation report, the evaluation report shall include statements that address the following items:

a. The fabricator must be approved by the code official in accordance with Section 1704.2.7.1 of the 2021 IBC, Section 1704.2.5.1 of the 2018 and 2015 IBC (Section 1704.2.5.2 of the 2012 IBC or Section 1704.2.2 of the 2009 IBC, as applicable).

b. The fabricator must be approved by the evaluation report holder.

c. The fabricator must assemble the couplers onto the ends of the steel reinforcing bar as required by the evaluation report holder in a manner consistent with the qualifying test specimens. The evaluation report must include a sufficiently detailed description of the method of installing the couplers onto the reinforcing bars and specifications, or refer to specific documents that contain this information.

d. For Type 2 or 2HS splices, splices using the fabricator-prepared assemblies of couplers and steel reinforcing bars, tested in ~~static~~monotonic tension, must develop 100 percent of the specified tensile strength of the steel reinforcing bar and 125 percent of the specified yield strength of the reinforcing bar for use under the IBC or IRC. The Type 2HS splice shall additionally develop strain in tension in the reinforcing bar as specified in Table 7. This may be demonstrated in test report(s) submitted to the code official.

e. For Type 1 splices, splices using the fabricator-prepared assemblies of couplers and steel reinforcing bars, tested in ~~static~~monotonic tension, must develop 125 percent of the specified yield strength of the steel reinforcing bar. This may be demonstrated in test report(s) submitted to the code official.

6.11 For ~~recognition~~evaluation under the 20211~~8~~ IBC, the evaluation report shall include a paragraph similar to the following: "Under the 20211~~8~~ IBC, for structures regulated by Chapter 18 of ACI 318-19~~4~~ (as required by 20211~~8~~ IBC Section 1905.1), to splice deformed longitudinal reinforcing bars resisting earthquake-induced moment, axial force, or both, in special moment frames, special structural walls, and all components of special structural walls including coupling beams and wall piers, with the mechanical splice systems, mill certificates of reinforcing bars must be submitted to the code official as evidence that the steel reinforcing bars comply with ACI 318-19~~4~~ Section 20.2.2.5."

6.12 For evaluation under the 2018 IBC, the evaluation report shall include a paragraph similar to the following: "Under the 2018 IBC, for structures regulated by Chapter 18 of ACI 318-14 (as required by 2018 IBC Section 1905.1), to splice deformed longitudinal reinforcing bars resisting earthquake-induced moment, axial force, or both, in special moment frames, special structural walls, and all components of special structural walls including coupling beams and wall piers, with the mechanical splice systems, mill certificates of reinforcing bars must be submitted to the code official as evidence that the steel reinforcing bars comply with ACI 318-14 Section 20.2.2.5."

~~6.12~~6.13 For ~~recognition~~evaluation under the 2015 IBC, the evaluation report shall include a paragraph similar to the following: "Under the 2015 IBC, for structures regulated by Chapter 18 of ACI 318-14 (as required by 2015 IBC Section 1905.1), to splice deformed longitudinal reinforcing bars resisting earthquake-induced moment, axial force, or both, in special moment frames, special structural walls, and all components of special structural walls including coupling beams and wall piers, with the mechanical splice systems, mill certificates of reinforcing bars must be submitted to the code official as evidence that the steel reinforcing bars comply with ACI 318-14 Section 20.2.2.5."

~~6.13~~6.14 For ~~recognition~~evaluation under the 2012 IBC, the evaluation report shall include a paragraph similar to the following: "Under the 2012 IBC, for structures regulated by Chapter 21 of ACI 318-11 (as required by 2012 IBC Section 1905.1), to splice deformed reinforcing bars resisting earthquake-induced flexure, axial force, or both, in special moment frames, special structural walls, and all components of special structural walls including coupling beams and wall piers, with the mechanical splice systems, mill certificates of reinforcing bars must be submitted to the code official as evidence that the steel reinforcing bars comply with ACI 318-11 Section 21.1.5.2."

~~6.14~~6.15 For ~~recognition~~evaluation under the 2009 IBC, the evaluation report shall include a paragraph similar to the following: "Under the 2009 IBC, for structures regulated by Chapter 21 of ACI 318-08 (as required by 2009 IBC Section 1908.1), to splice deformed reinforcing bars resisting earthquake-induced flexural and axial forces in frame members, structural walls and coupling beams, with the mechanical splice systems, mill certificates of reinforcing bars must be submitted to the code official as

evidence that the steel reinforcing bars comply with ACI 318-08 Section 21.1.5.2."

~~6.15~~6.16 For ~~recognition~~evaluation under the 2018, 2015, 2012 and 2009 IBC, the evaluation report shall include a paragraph similar to the following: "For splice systems installed in fully-grouted concrete masonry, mill certificates of reinforcing bars must be submitted to the code official as evidence that the steel reinforcing bars comply with TMS 602 (-16, -13, -11, and -08) Article 2.4, as required by Section 2103.4 of the 2018 and 2015 IBC (Section 2103.14 of the 2012 IBC and 2013.13 of the 2009 IBC). In addition, the specified yield strength of reinforcement shall not exceed 60,000 psi (413.7 MPa) in accordance with Section 9.1.9.3 of TMS 402-16 and -13 (Section 3.1.8.3 of TMS 402-11 and -08)".

~~6.16~~6.17 The evaluation report shall include a sentence similar to the following for installation in concrete and for installation in fully-grouted concrete masonry, where applicable: "Splice locations must comply with applicable IBC requirements and be noted on plans approved by the code official."

6.18 The evaluation report shall include a sentence similar to the following to address corrosion resistance: "The evaluation of corrosion resistance of the mechanical splice is outside the scope of this evaluation and shall be considered by the registered design professional during the design".

6.19 For mechanical splice systems with reported preload slack in accordance with Section 3.2.3, the evaluation report shall include the following statement: "The mechanical splice system is not suitable for use with reverse loading and the designer shall consider preload slack in the design. The mechanical splice system shall be fully engaged with the reinforcing bar, removing preload slack during installation, prior to concrete or grout masonry pour." ■

TABLE 1—DESCRIPTION OF CYCLIC TENSION AND COMPRESSION TESTS

STAGE	TENSION	COMPRESSION	CYCLES
1	$0.95f_y$	$0.5f_y$	20
2	$2\varepsilon_{ya}$	$0.5f_y$	4
3	$5\varepsilon_{ya}$	$0.5f_y$	4
4	Load in tension to failure		

Note:
f_y is the specified yield strength of the steel reinforcing bar.
ε_{ya} is the strain of steel reinforcing bar at actual yield stress as determined in accordance with Section 3.2.2.

TABLE 2—CONCRETE APPLICABLE SECTIONS OF ACI 318 UNDER THE 2021 2018, 2015, 2012 AND 2009 IBC

ACI 318-19 (2021 IBC)	ACI 318-14 (2018 and 2015 IBC)	ACI 318-11 (2012 IBC)	ACI 318-08 (2009 IBC)
25.5.7	25.5.7	12.14.3	12.14.3
		12.15.4	12.15.4
		12.15.6	12.15.6
		12.16.3	12.16.3
20.2.2.4 for Applications In Special Seismic Systems	20.2.2.4 for Applications In Special Seismic Systems	21.1.5.1	21.1.5.1
20.2.2.5 and 26.13.2.3	20.2.2.5 and 26.13.2.3	21.1.5.2	21.1.5.2
18.2.7.1	18.2.7.1	21.1.6.1	21.1.6.1
18.2.7.2	18.2.7.2	21.1.6.2	21.1.6.2
18.6.3.4	18.6.3.4	21.5.2.4	21.5.2.4
18.7.4.4	18.7.4.3	21.6.3.3	21.6.3.2
18.9.2.1(c)	18.9.2.1(c)	21.8.2(b)	21.8.2(b)
18.10.2.3(d)	18.10.2.3(c)	21.9.2.3(d)	21.9.2.3(d)
18.12.7.4	18.12.7.4	21.11.7.4	21.11.7.4
18.14.3.3(a)	18.14.3.3(a)	21.13.4.1	21.13.4.1

TABLE 3—CONCRETE APPLICABLE SECTIONS OF THE 2021, 2018, 2015, 2012 AND 2009 IRC

2021 IRC	2018 IRC	2015 IRC	2012 AND 2009 IRC
R301.2.2.5	R301.2.2.5	R301.2.2.2.4	R301.2.2.2.4
R301.2.2.5	R301.2.2.5	R301.2.2.3.4	R301.2.2.3.4
R404.1.3	R404.1.3	R404.1.3	R404.1.2
R404.1.3.1	R404.1.3.1	R404.1.3.1	R404.1.2.1
R404.1.3.3	R404.1.3.3	R404.1.3.3	R404.1.2.3
R404.1.3.4	R404.1.3.4	R404.1.3.4	R404.1.2.4
R404.1.4.2	R404.1.4.2	R404.1.4.2	R404.1.4.2
R404.5.1	R404.5.1	R404.5.1	R404.5.1
R608.1	R608.1	R608.1	R611.1
R608.1.1	R608.1.1	R608.1.1	R611.1.1
R608.1.2	R608.1.2	R608.1.2	R611.1.2
R608.2	R608.2	R608.2	R611.2
R608.6.1	R608.6.1	R608.6.1	R611.6.1
R608.8.2	R608.8.2	R608.8.2	R611.8.2
R608.9.2, Item 5	R608.9.2, Item 5	R608.9.2, Item 5	R611.9.2, Item 5
R608.9.3, Item 5	R608.9.3, Item 5	R608.9.3, Item 5	R611.9.3, Item 5

TABLE 4—APPLICABLE EDITIONS OF CODES AND REFERENCED STANDARDS[1]

REFERENCED STANDARD	STANDARD EDITION				
	2021	2018 IBC	2015 IBC	2012 IBC	2009 IBC
ACI 318	-19	-14		-11	-08
TMS 402/602	-16	-16	-13	-11	-08
ASTM A370	-18	-14		-97	-97

[1]When different editions of an ASTM standard are listed above, the different editions are deemed to be technically equivalent for the purpose of this criteria. New report applicants are expected to use the edition referenced for the corresponding IBC edition. Current report holders, whose evaluation reports are based on data complying with one of the earlier editions of the standard, will not need to submit new data to demonstrate compliance with the latest edition of the referenced standard.

TABLE 5— CONCRETE MASONRY APPLICABLE SECTIONS OF TMS 402/602 UNDER THE 2021, 2018, 2015, 2012 AND 2009 IBC

TMS 402/602-16 (2021/2018 IBC)	TMS 402-13/ACI 530-13/ ASCE 5-13 (2015 IBC)	TMS 402-11/ACI 530-11/ ASCE 5-11 (2012 IBC)	TMS 402-08/ACI 530-08/ ASCE 5-08 (2009 IBC)
3.2.1	3.2.1	1.20.1	1.19.1
6.1.6.1	8.1.6.7	2.1.7.7	2.1.9.7
6.1.6.1.3	8.1.6.7.3, 9.3.3.4 (d)	2.1.7.7.3, 3.3.3.4 (d)	2.1.9.7.3, 3.3.3.4 (c)
7.3.2.6 (e)	7.3.2.6 (e)	NA	NA

TABLE 6—MAXIMUM RESIDUAL SLIP PERMITTED UNDER CYCLIC TENSION AND COMPRESSION TESTS

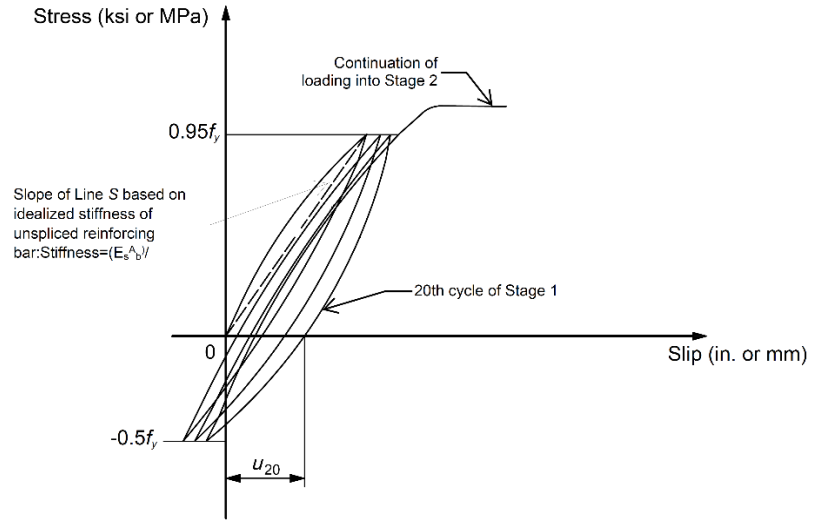
LAST CYCLE OF STAGE	SLIP MEASUREMENT	TYPE 1 SPLICE	TYPE 2 SPLICE	TYPE 2HS SPLICE
1	δ_{20}	No requirement	0.3 mm (0.012 in.)	0.3 mm (0.012 in.)
2	δ_{24}	No requirement	0.3 mm (0.012 in.)	0.3 mm (0.012 in.)
3	δ_{28}	No requirement	0.6 mm (0.024 in.)	0.6 mm (0.024 in.)

Note: Residual slip is measured in accordance with methods defined in Figure 1.

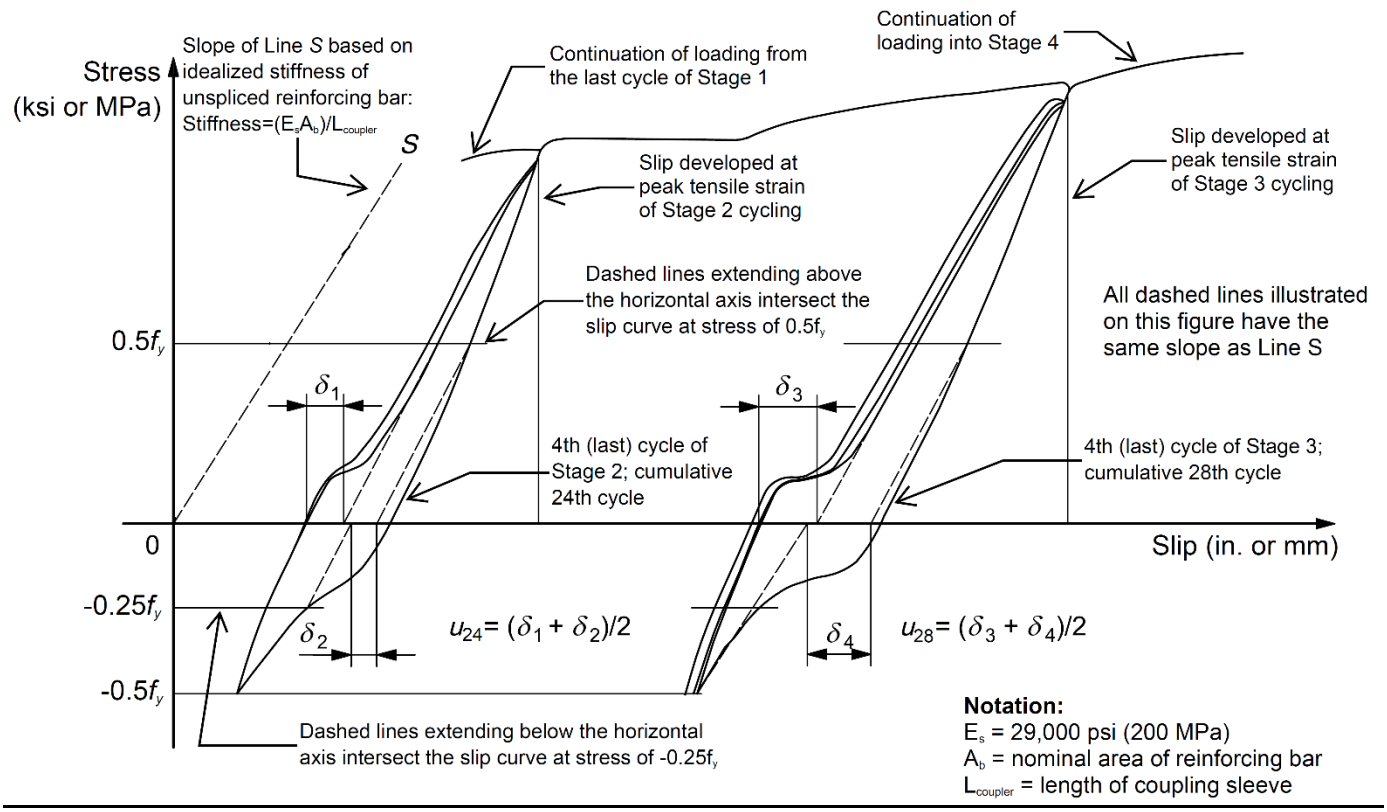
TABLE 7— MINIMUM STRAIN DEVELOPED DURING STAGE 4 OF CYCLIC TENSION AND COMPRESSION TESTS FOR TYPE 2HS SPLICE

	Reinforcing Bar Grade		
	Grade 60	Grade 80	Grade 100
	Strain Developed during Stage 4, minimum, percent		
Bar designation No.			
3, 4, 5, 6, 7, 8, 9, 10	9	7	6
11, 14, 18	6	6	6

Note: Strain requirements listed in this table are based on the requirements for uniform elongation of deformed bar reinforcement as specified in ACI 318-19 Table 20.2.1.3(c).



A) MEASUREMENT OF RESIDUAL SLIP DURING LAST CYCLE OF STAGE 1



B) MEASUREMENT OF RESIDUAL SLIP DURING LAST CYCLES OF STAGES 2 AND 3

FIGURE 1 - MEASUREMENT OF RESIDUAL SLIP DURING LAST CYCLES OF STAGES 1, 2 AND 3 OF CYCLIC TENSION AND COMPRESSION LOADING (© ISO. THIS MATERIAL IS ADAPTED FROM ISO 15835-2:2009, WITH PERMISSION OF THE AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI) ON BEHALF OF THE INTERNATIONAL ORGANIZATION FOR STANDARDIZATION. ALL RIGHTS RESERVED)

ANNEX A
CEMENTITIOUS GROUTED SLEEVE REINFORCING BAR SPLICE SYSTEMS

A1.0 INTRODUCTION

A1.1 Purpose: The purpose of this annex to the Acceptance Criteria for Mechanical Splice Systems for Steel Reinforcing Bars is to establish additional requirements for grouted sleeve reinforcing bar splices due to the unique aspects of this type of splice.

A1.2 Scope: The scope of this annex is reinforcing bar splices that consist of a sleeve and a cementitious grout, where the reinforcing bars are inserted into the core of the sleeve prior to installation of the grout into the core of the sleeve. This annex is applicable to grouted sleeve reinforcing bar splices that are field-installed or installed at a fabricator of concrete building components. This annex does not address the use of grouted sleeve reinforcing bar splices in fire-resistance-rated construction.

A1.3 Reference Standards:

A1.3.1 ASTM C109-16, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50 mm] Cube Specimens), ASTM International.

A1.3.2 ASTM C666-97, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing, ASTM International.

A1.4 Definitions

A1.4.1 Angular Misalignment. Angular misalignment is the misalignment of the longitudinal axis of the reinforcing bar inserted into the sleeve with respect to the longitudinal axis of the sleeve, such that the two axes are not parallel.

A2.0 BASIC INFORMATION

A2.1 General: In addition to the information required under Section 2.1 of this criteria, the following information concerning the grouted sleeve reinforcing bar splices shall also be submitted:

A2.1.1 Description: Both the sleeves and the grout material shall be described.

A2.1.2 Packaging and Identification: The method of packaging and identification of both the sleeves and the grout shall be described. If the grout is a proprietary material supplied under the evaluation report holder's name, the packaging of the grout shall include the company name of the evaluation report holder, product name, and the evaluation report number. If the grout is a proprietary material supplied by a company other than the evaluation report holder's company, the evaluation report holder shall describe the product labeling.

A2.1.3 Installation Instructions: Installation, mixing, and curing instructions for the grout shall be submitted. The instructions need to include methods of verifying the compressive strength of the mixed and cured grout.

A2.2 Test Reports: Test reports shall comply with Section 2.3 of this criteria and describe the preparation of grout, grouting operation and curing of the test specimens.

A2.3 Product Sampling: The sleeves used in the tests shall be sampled in accordance with Section 2.4 of this criteria. The grout shall be sampled in accordance with Section 3.2 of AC85. The testing laboratory shall witness the preparation of the load test specimens, including mixing of the grout, embedment of reinforcing bar into the sleeve, the grouting of the sleeve and the curing of the test specimen assembly.

A3.0 TEST PERFORMANCE AND PRODUCT REQUIREMENTS

A3.1 General: Due to the unique aspects of grouted sleeve reinforcing bar splices, the additional tests specified in the following sections of this annex are required. Also, the structural performance tests under Section 3.2 of this criteria need to address the additional considerations described in the following sections of this annex.

A3.2 Structural Performance:

A3.2.1 General: The grouted sleeve reinforcing bar splice shall be classified as a Type 1 or Type 2 splice, with the structural performance demonstrated by tests in accordance with Section 3.2 of the criteria, modified in accordance with this section of this annex (Section A3.2).

A3.2.2 Grout: The grout placed into the sleeve of the reinforcing bar splice and reinforcing bar assemblies subjected to the structural performance tests shall be prepared in accordance with the installation instructions (see Section A2.1.3). The ratio of all ingredients shall be consistent in all test specimens.

The compressive strength of the grout of the structural performance test specimens shall be determined by preparing grout compression test specimens ~~using the same grout~~ from each batch (bag) of grout placed into the structural performance test specimens and conducting the tests in accordance with ASTM C109. The grout compressive strength test specimens shall be prepared in accordance with the published instructions, and stored and cured under the same conditions as the structural performance test specimens. Grout compression tests shall be conducted on a minimum of two compressive strength test specimens at both the beginning and ending of the structural performance tests. The beginning tests shall be concurrent with the initiation of the structural performance tests within the permissible tolerance on test age as specified in ASTM C109~~24 hours of the structural tests~~. To establish the grout strength of the structural performance tested assemblies, the results of the four

grout compressive strength tests shall be averaged. The established grout strength will be expressed in the evaluation report as the minimum grout strength.

A3.2.3 Reinforcing Bar Deformation Patterns: Reinforcing bars are available with numerous deformation patterns, such as spiral, diagonal, diamond or bamboo. As a result, unless the evaluation report limits the use of the grouted sleeve reinforcing bar splices to the specific deformation pattern of the reinforcing bars used in the structural performance tests, the effects of various reinforcing bar deformation patterns shall be addressed. Comparison tests, in the form of tension tests in accordance with Section 4.1.1.1 or Section 4.1.2.1.1, as applicable, shall be conducted on assemblies of reinforcing bars and reinforcing bar splice with at least three different patterns of reinforcing bar deformations. A minimum of five assemblies for each reinforcing bar deformation pattern with the same size reinforcing bar splice shall be tested. Where numerous sizes of reinforcing bar splices are to be recognized, all sizes of the reinforcing bar splices shall be tested, unless a T-test at 95 percent confidence is done with the smallest and largest sizes of the reference deformation pattern. Unless the results of the comparison tests indicate that the ultimate tension strength of the reinforcing bar splice is not affected by the type of reinforcing bar deformation pattern, all of the other structural performance tests required by Section A3.2.1 of this annex shall be conducted on assemblies with reinforcing bar having the deformation pattern with the lowest ultimate load tensile strength of the comparison tests.

A3.2.4 Angular Misalignment: Comparison tests, in the form of tension tests in accordance with Section 4.1.1.1 or Section 4.1.2.1.1, as applicable, shall be conducted on assemblies of reinforcing bars and reinforcing bar splice at the maximum angular displacement, and conducted also on assemblies with the longitudinal axis of the reinforcing bars and sleeve aligned and parallel. Where numerous sizes of reinforcing bar splices are to be recognized, unless all sizes are tested, the evaluation report holder shall provide an analysis of the reinforcing bar splices to establish which size, or sizes, of reinforcing bar connections shall be subjected to the angular misalignment tests.

The results of these comparison tension tests shall demonstrate that the ultimate tensile strength of the assembly is not reduced as a result of angular misalignment.

A3.3 Grout Durability: To address the durability of the grout, reports of freeze-thaw tests in compliance with Section A4.1 of this criteria shall be required.

A4.0 TEST METHODS

A4.1 Freezing and Thawing Tests: Freezing and thawing tests of the grout shall be conducted in accordance with ASTM C666, using Procedure A for a minimum of 300 cycles. The grout shall be prepared in accordance with Section A3.2.2 of this annex and as specified in ASTM C666. The specimens shall be cured as specified in ASTM C666 for 14 days prior to testing.

The conditions of acceptance are that the relative dynamic modulus of elasticity (RDME) of the specimens after 300 cycles of freezing and thawing exposure shall be a minimum of 90 percent.

EXCEPTION: Tests may be omitted if mechanical splices are restricted to areas where the average rainfall does not exceed 20 inches (508 mm) annually and the average daily low temperature exceeds 30°F (-1.1°C).

A5.0 QUALITY CONTROL

A5.1 Sleeve: The quality control requirements for the sleeve are as specified in Section 5.0 of the criteria.

A5.2 Grout:

A5.2.1 Quality documentation complying with the ICC-ES Acceptance Criteria for Quality Documentation (AC10) shall be submitted.

A5.2.2 An annual inspection shall be conducted at each manufacturing facility in accordance with the requirements of AC304.

A5.2.3 A qualifying inspection shall be conducted at each manufacturing facility in accordance with the requirements of AC304.

A6.0 EVALUATION REPORT ~~RECOGNITION~~

A6.1 Sections 6.1 through 6.6 and 6.11 through 6.15 are applicable to grouted sleeve reinforcing bar splices and shall be addressed in the evaluation report.

A6.2 The evaluation report shall specify the water-to-cementitious material ratio and minimum required compressive strength of the grout consistent with the test specimens.

A6.3 The evaluation report shall include a statement that the use of grouted sleeve reinforcing bar splices in fire-resistance-rated construction is outside the scope of the evaluation report.

ANNEX B
TYPE 2HS - MEASUREMENT OF STRAIN DEVELOPED DURING STAGE 4 OF CYCLIC LOADING BY USING MARKS

a) Before applying any load to the mechanical splice test assembly, place punch or scribe marks to create two 8-inch (200-mm) gage lengths, one gage length on each reinforcing bar on each side of the mechanical splice and outside of the splice affected zone. Gage lengths may be reduced to less than 8-inches, as required to prevent buckling, but shall not be reduced to less than 2 times the nominal bar diameter or 2 inches, whichever is greater. Leave a space of at least two bar diameters between any mark and an end of the mechanical splice or the face of a test machine grip.

b) Individually measure and record the actual initial gage length (L_o) for each of the two 8- inch (200-mm) gage lengths to the nearest 0.001 in. (0.00005 mm).

c) ~~Applied~~ Apply the required cyclic loading to the mechanical splice test assembly followed by the Stage 4 tensile test to failure of the mechanical splice test assembly.

d) After the Stage 4 test to failure, measure and record, to the nearest 0.001 in. (0.00005 mm), the final gage length (L_f) on the reinforcing bar that did not fracture. If neither reinforcing bar fractured, such as is the case for the pullout failure mode, among other possible failure modes that do not result in bar fracture, measure the final gage length (L_f) of the bar that did not pull out or otherwise separate from the mechanical splice.

e) Calculate the strain developed during Stage 4 as follows:

$$percent\ strain = \{[(L_f - L_o)/L_o] + f_{max}/E_s\} \times 100$$

where:

L_o = *Initial gage length*

L_f = *final gage length*

f_{max} = *maximum stress sustained by the test sample, based on nominal area of the reinforcing bar, ksi (MPa)*

E_s = *modulus of elasticity of the reinforcing bar, 29,000 ksi (200 MPa)*