



**INTERNATIONAL ASSOCIATION OF PLUMBING
AND MECHANICAL OFFICIALS UNIFORM EVALUATION SERVICES**

**EVALUATION CRITERIA
FOR**

**HEADED AND MECHANICALLY ANCHORED
DEFORMED REINFORCEMENT BARS IN TENSION**

**EC 006-2018
(Adopted April 2014, Revised – June 2018)**

1.0 INTRODUCTION

- 1.1 Purpose:** The purpose of this evaluation criteria is to establish requirements for an evaluation report on headed and mechanically anchored deformed reinforcement bars in tension (Manufactured Product) under the 2018, 2015, and 2012 *International Building Code*® (IBC), the 2018, 2015 and 2012 *International Residential Building Code*® (IRC), and *American Concrete Institute*® ACI 318-14 and 318-11. Bases of recognition are IBC Section 104.11, IRC Section R104.11, and Sections 25.4.1.1, 25.4.4 and 25.4.5 of ACI 318-14 (Sections 12.1.1, 12.6 and 12.6.4 of ACI 318-11).

This Evaluation Criteria provides a guideline for the evaluation of headed and mechanically anchored deformed reinforcing bars in tension, to supplement requirements provided in the IBC, IRC, and associated reference standards for these products.

- 1.2 Scope:** This criteria provides a basis for the testing and evaluation as applicable to the design for Class HA headed and mechanically anchored deformed steel reinforcing bars that develop the specified yield and specified tensile strengths tested without concrete. The use of headed and mechanical anchored deformed reinforcement for lap splices are outside the scope of this criteria.

2.0 REFERENCE STANDARDS

- 2.1** Standards referenced in this criteria shall be applied consistent with the specific edition of the code(s) for which the Evaluation Report is prepared unless otherwise approved by UES.

American Concrete Institute

ACI 318-14	Building Code Requirements for Structural Concrete and Commentary (2018 and 2015 IBC and IRC)
ACI 318-11	Building Code Requirements for Structural Concrete and Commentary (2012 IBC and IRC)



American Welding Society

ANSI/AWS D1.4-11 Structural Welding Code-Reinforcing Steel
ANSI/AWS C6.1-89 Recommended Practices for Friction Welding

ASTM International

ASTM A29 Standard Specification for General Requirements for Steel Bars, Carbon and Alloy, Hot-Wrought
ASTM A36-12 Standard Specification for Carbon Structural Steel
ASTM A108 Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished
ASTM A304-11 Standard Specification for Carbon and Alloy Steel Bars Subject to End-Quench Hardenability Requirements
ASTM A572-15 Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
ASTM A370-14 Standard Test Methods and Definitions for Mechanical Testing of Steel Products
ASTM A615-14 Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A706-14 Standard Specification for Low Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A970-13a Standard Specification for Headed Steel Bars for Concrete Reinforcement
ASTM A944-10 Standard Test Method for Comparing Bond Strength of Steel Reinforcing Bars to Concrete Using Beam-End Specimens
ASTM E8-04 Standard Test Methods for Tension Testing of Metallic Materials
ASTM E2935 Standard Practice for Conducting Equivalence Testing in Laboratory Applications

International Code Council

2018, 2015 and 2012 *International Building Code®*, IBC
2018, 2015 and 2012 *International Residential Code®*, IRC

International Organization for Standardization

ISO 15698-1:2012 Steel for the Reinforcement of Concrete – Headed Bars – Part 1: Requirements
ISO 15698-2:2012 Steel for the Reinforcement of Concrete – Headed Bars – Part 2: Test Methods
ISO/IEC 17011 Conformity Assessment – General Requirements for Accreditation Bodies Accrediting Conformity Assessment Bodies
ISO/IEC 17020 Conformity Assessment – Requirements for the Operation of Various Types of Bodies Performing Inspection
ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories
ISO/IEC 17065 Conformity Assessment – Requirements for Bodies Certifying Products, Processes and Services

3.0 DEFINITIONS

- 3.1 Headed Deformed Reinforcement:** Deformed reinforcing bars with heads attached at one or both ends. Heads are attached to the bar end by means of factory-welding, factory-forging, factory-threading; and cold-swaged, cold-extruded, or ferrous metal-filled sleeve that are mechanically attached to one or both ends in the field without factory preparation of the reinforcing bars and used in the reinforcement of normal weight concrete. The headed reinforcing bar shall be identified in accordance with Section 14 and Annex A1 of ASTM A970.
- 3.2 A_b :** Nominal cross-sectional area of the deformed reinforcing bar, square inches (mm^2).
- 3.3 A_{brg} , Net Bearing Area of the Head:** The net bearing area of the head A_{brg} , square inches (mm^2) for deformed rebar is measured perpendicular to the axis of the bar. The net bearing area of headed deformed bar equals the gross area of the head minus the larger of the area of the bar and the area of any obstruction. The minimum net bearing area of the head of a headed deformed bar shall not be less than four times the area of the bar ($4A_b$).
- 3.4 Development Length:** Length of embedded reinforcement required to develop the design strength of reinforcement at a critical section, in accordance with Section 25.4.4.2 of ACI 318-14 (Section 12.6 of ACI 318-11).
- 3.5 Welding:** Factory-welding of heads to the reinforcing steel shall be performed by a procedure conforming to ANSI/AWS D1.4 except for friction welding that conforms to ANSI/AWS C6.1.
- 3.6 Forging:** Integrally factory-forged headed bars where the heads are produced by deforming the bar end(s) in a hot forging process.
- 3.7 Threading:** attachment of the head(s) to the reinforcing bar using straight or tapered internal threads within the head mating to factory-threaded bar ends or by securing the head to the factory-threaded bar end with a separate internally threaded nut.
- 3.8 Cold-Extruded:** attachment of head(s) to the reinforcing bar by coupling sleeve that is axially cold-extruded to the bar end(s).
- 3.9 Cold-Swaging:** attachment of head(s) to the reinforcing bar using threaded, sleeved or headed coupling that is cold-swaged to the bar end(s).
- 3.10 Ferrous-Filled Sleeve:** attachment of head(s) to the reinforcing bar by coupling sleeve using an interlock of ferrous-filler material.
- 3.11 Certification Body:** Conformity assessment agency operating certification schemes. Such agencies shall be accredited as complying with ISO/IEC 17065 by a recognized accreditation body conforming to ISO/IEC 17011 or other nationally recognized certification program, which is accepted by the evaluation service agency.
- 3.12 d_b :** Nominal diameter of the deformed reinforcing bar, inches (mm).
- 3.13** [For ACI 318-14] ϵ_y : specified yield strain in the extreme layer of longitudinal tension reinforcement used to define a compression-controlled section
- 3.14** [For ACI 318-11] ϵ_{ya} : actual yield strain in the extreme layer of longitudinal tension reinforcement used to define a compression-controlled section
- 3.15 E_s :** modulus of elasticity of reinforcement and structural steel, excluding prestressing reinforcement, psi

- 3.16 f_{ya} : actual yield strength for nonprestressed reinforcement, psi.
- 3.17 **Statistically Equivalent:** Two groups of test results shall be considered statistically equivalent if there are no significant differences between the means of the two groups. Statistical equivalence shall be demonstrated using a two one-sided (TOST) procedure in accordance with ASTM E2935 at a significance $\alpha = 0.10$ for an assumed symmetrical equivalence limit $E = 15\%$. For this purpose, the equivalence or nonequivalence of variances shall be established with the F-test or with Levene's test with $\alpha = 0.10$.

4.0 BASIC INFORMATION

- 4.1 **General:** Each submittal shall include the following information for an evaluation report:
- 4.1.1 **Product Description:** Description of headed bar products shall include dimensions, designations, and material specifications.
- 4.1.2 **Installation Instructions:** Installation instructions for the headed deformed bars shall include product installation requirements and details regarding installation of the product.
- 4.1.3 **Identification:** Headed deformed bars shall be permanently identified with the manufacturers mark or logo, shall include the unique heat code identification, and the letter H indicating conformance to Annex A1 of ASTM A970 when specified. Packaging labels for headed deformed bars shall include the manufacturer or a registered trademark, model or name of the product, size, and applicable certification body logo and evaluation report number.
- 4.2 **Testing Laboratories:** Testing laboratories shall be accredited for the applicable testing procedures in accordance with ISO/IEC 17025 by a recognized accreditation body conforming to ISO/IEC 17011. Testing at a non-accredited laboratory may be permitted by the certification body, provided the testing is conducted under the supervision of an accredited laboratory and the supervising laboratory issues the test report.
- 4.3 **Test Reports:** Test reports, submitted for approval by the certification body, shall consist of:
1. A description of the test procedures, test results, observations, tested assemblies, load measurements, and photographs of specimens and typical failures.
 2. A description of the test specimens.
 3. Information as set forth in the referenced test standard.
- 4.4 **Product Sampling and Preparation of Test:** The testing laboratory shall verify random sampling of the components, provided by the manufacturer that represents the production components. Tensile and bend test shall be prepared in accordance with ASTM A970. Alternately, tensile tests can be prepared in accordance with ASTM A970, when Section 6.1.2 of this criteria is used. Tests shall be performed on test specimens at a temperature not less than 16°C (61°F).
- 4.5 The head component in a welded headed bar shall conform to one of the following steel specifications: ASTM A29, ASTM A36, ASTM A108, ASTM A304, ASTM A572, or ASTM A706.
- 4.6 Welded headed deformed bars shall be manufactured with Low-Alloy Steel bars conforming to ASTM A706.
- 4.7 Deformed reinforcing bars with forged, threaded, cold-swaged, cold-extruded, and ferrous-filled sleeved heads shall conform to ASTM A615 or A706.

- 4.8** Bars attached to heads using tapered or straight threads shall have threads placed either internally in the head to mate with external threads on the bar surface or using a separate accompanying internally threaded nut to secure the head to the threaded bar end.

5.0 TESTING AND PERFORMANCE REQUIREMENTS

5.1 Head Dimensions:

- 5.1.1 General:** The heads shall be manufactured in such a manner that they are sufficiently rigid to produce uniform bearing without deformation up to the specified yield strength of the reinforcing bar.
- 5.1.2 Obstructions to the Head Bearing Area:** Obstructions or interruptions shall not extend more than two times the nominal bar diameters from the orthogonal bearing face of the head along the longitudinal axis of the reinforcing bar. The obstructions perpendicular to the axis of the bar shall not extend radially from the perimeter of the reinforcement more than 1.5 times nominal bar diameter as per Section A1.1.1.5 of Annex A1 of ASTM A970.
- 5.1.3 Bar Deformations:** Bar deformations shall not be interrupted from the orthogonal bearing surface of the head for more than a distance of $2d_b$ along the longitudinal axis of the reinforcing bar.
- 5.1.4 Tensile Tests:** Reports of tensile and cyclic testing shall be conducted in accordance with Section 6.1 of this criteria and shall be submitted for verification in compliance with the conditions cited in Sections 6.1, 6.1.1, or 6.1.2 of this criteria.
- 5.1.5 Bend Tests:** Welded headed deformed bars require bend testing. Reports of bend testing shall be conducted in accordance with Section 6.2 of this criteria and shall be submitted for verification in compliance with the conditions cited in Section 6.2.1 of this criteria.
- 5.1.6** Class HA headed deformed bars not conforming to the requirements of Section 20.2.1.6 of ACI 318-14 (Section 3.5.9 of ACI 318-11) and not anchored in accordance with Section 25.4.4 of ACI 318-14 (Sections 12.6.1 and 12.6.2 of ACI 318-11) may be used if test data conforms to Section 25.4.5 of ACI 318-14 (Section 12.6.4 of ACI 318-11). Tests in concrete shall include confined or unconfined beam end tests in accordance with ASTM A944. A qualification plan using provisions for testing headed steel bars in concrete shall comply with Sections 5.0 and 7.0 of ISO 15698 – Part 2 and ISO 15698-Part 1, respectively, and shall be submitted to the certification body for approval before commencing the tests.
- 5.1.7 Reinforcing Bar Deformations for Headed Bars:** If recognition is sought for multiple reinforcing bar deformation patterns for headed bars, a comparison of at least three unique deformation patterns for each bar size and head type shall be performed in accordance with Section 6.1 of this criteria on five specimens made using each bar pattern. Where recognition is sought for multiple sizes of headed deformed bars, with similar configurations, the largest and smallest sizes of reinforcing bar and head type shall be tested. Where a statistically equivalent analysis shows that there is a significant difference in tensile capacity of the headed bar based on the reinforcing bar deformation pattern, all testing according to Section 6.1 of this criteria shall be performed with the reinforcing bar pattern that yielded the lowest tensile capacity in this comparison. Optionally, only the reinforcing bar deformation patterns included in the comparison testing will be recognized in the evaluation report.

- 5.1.8 Separate Head and Bar:** For heads that fit onto deformed bar ends, only the bar deformation patterns tested in accordance with Sections 6.1 and 6.2 of this criteria shall be permitted in the evaluation report. As an option, additional testing may be conducted on at three diameters using the alternative deformation pattern(s) in accordance with Section 6.1 and 6.2 of this criteria. The minimum, maximum, and at least one intermediate diameter shall be tested. The results shall be proven as statistically equivalent to the results of tests on the fully tested deformation pattern (all diameters).

6.0 TEST METHODS

- 6.1 Tensile Test: Anchorage Capacity Under Cyclic Elastic-Plastic Loading Followed by Monotonic Tension.** At least five specimens shall be tested for each bar size, grade, and head type for which recognition is sought. Samples shall be tested in accordance with ASTM A370. For each steel reinforcing bar, ϵ_{ya} , shall be calculated as $\epsilon_{ya} = f_{ya} / E_s$, where and $E_s = 29,000$ ksi. The calculated value for ϵ_{ya} for used for controlling cyclic tension and compression tests preset forth in Table 1 of this criteria. The failure shall be defined as specified in Section 6.2.1 of ASTM A970. The headed deformed bar connection shall sustain stages 1 through 3 of the specified loading program shown in Table 1 of this criteria, without failure. As an alternative, bar sizes that exceed No. 11 or a bar designated yield strength that exceeds 60,000 psi shall be permitted to be tested in accordance with Section 6.1.2 of this criteria.

Table 1: Loading Protocol for Cyclic Tension Tests

Stage	1	2	3	4
Maximum Load	$0.95f_y$	$2\epsilon_{ya}$	$5\epsilon_{ya}$	Load in Tension to Failure
Minimum Load	$0.05f_y$	$0.05f_y$	$0.05f_y$	
Number of Cycles	20	4	4	

- 6.1.1** Acceptance for Class HA headed deformed bars shall satisfy ACI 318-14 Section 20.2.1.6 (ACI 318-11 Section 3.5.9): the tensile strength, yield strength, and elongation after cycling per the requirements of Table 1 of this criteria shall meet or exceed the requirements presented in Annex A1 of ASTM A970.
- 6.1.2** Alternate Acceptance under ACI 318-14 Section 25.4.5.1 (ACI 318-11 Section 12.6.4), ASTM A970, Class A: Tensile strength after cycling per the requirements of Table 1 shall meet or exceed the minimum specified yield strength of the reinforcing bar per Section 25.4.5.1 of ACI 318-14 (Section 12.6.4 of ACI 318-11). Additionally, the tensile strength of the headed bar assembly shall meet or exceed the minimum specified tensile strength of the reinforcing bar, as defined in Annex A1 of ASTM A970. The anchorage shall be designed in accordance with ACI 318-14 Chapter 17 (ACI 318-11 Appendix D) or otherwise designed to the satisfaction of the registered design professional and approved by the building official.
- 6.2 Bend Test:** At least two specimens shall be tested for each welded headed bar and head type in sizes No.4 through 10 as specified in Sections 6.4 and 7.1.1 of ASTM A970. The welded headed reinforcement shall be bent around a mandrel at least 90 degrees as specified in Section 6.4 of ASTM A970. The mandrel is to be placed to directly bend the welded region with the centerline of the bend test mandrel placed at the intersection of the reinforcing bar and the weld region, as shown in Figure 2 of ASTM A970. The minimum mandrel dimensions for the bend test shall be in accordance with Table 1 of ASTM A970.

- 6.2.1 Failure:** No observed partial or total fracture of the head, the bar, or the head-to-bar connection; no slip between the head-to-bar connection.

7.0 QUALITY CONTROL

- 7.1** IAPMO-UES approved inspections of manufacturing facilities are required for this product by the evaluation service agency or an accredited inspection agency. Inspections by inspection agencies accredited for metal products in accordance with ISO/IEC 17020 by an accreditation body recognized as conforming to ISO/IEC 17011 are permitted.
- 7.2** Quality documentation complying with IAPMO-UES Minimum Requirements for Listee's Quality Assurance System (IAPMO ES-010) or equivalent shall be submitted.

8.0 EVALUATION REPORT RECOGNITION

- 8.1** Evaluation reports shall include the manufacturer's name, product name of proprietary components, and the basic information set forth in Section 4.1 of this criteria for all assembly components.
- 8.2** The evaluation report shall also include the following or equivalent statements:
1. Procedures for special inspections complying with the requirements of the model code Sections 1704.4 and 1705.3 of the 2018, 2015 and 2012 IBC and as required by the certification body.
 2. Reference in ASTM A970 Figure A1.1 for headed deformed reinforcing bar with obstructions, ACI 318-14 Figure R25.4.4.2a (ACI 318-11 Figure R12.6 (a)), and ACI 318 -14 Figure R25.4.4.2b (ACI 318-11 Figure R12.6 (b)) for development of headed deformed bars.
 3. Statements indicating that when utilizing the equation in Section 25.4.4.2 of ACI 318-14 (Section 12.6.2 of ACI 318-11) to calculate development length, the registered design professional shall verify that the proposed heads meet ASTM A970, the maximum compressive design strength of concrete used in the calculation is 6,000 psi (41.4 MPa), and those conditions referenced in Section 25.4.1.1 of ACI 318-14 (Section 12.6.1 of ACI 318-11) have been met. For reinforcement that does not meet these requirements, the anchorage shall be designed in accordance with ACI 318-14 Chapter 17 (ACI 318-11 Appendix D) or designed otherwise to the satisfaction of the registered design professional and approved by the building official.
 4. Information specified in Sections 4.1, 4.1.1, 4.1.2, and 4.1.3 of this criteria.
 5. Permitted deformation patterns based on Section 5.1.7 or 5.1.8 of this criteria.