

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

**EVALUATION CRITERIA
FOR**

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

EC 006-2010

1.0 INTRODUCTION

- 1.1 Purpose:** This criteria establishes the requirements for recognition by IAPMO Evaluation Service (IAPMO-ES) of headed and mechanically anchored deformed reinforcement bars in tension (Manufactured Product) under the 2006 *International Building Code*® (IBC), the 2006 *International Residential Building Code*® (IRC), and *American Concrete Institute*® ACI 318-08. Bases of recognition are section 104.11 of the 2006 *International Building Code*®, section R104.11 of the 2006 *International Residential Code*®, and section 12.6 of the American Concrete Institute ACI 318-08.

The development of this criterion is to provide a guideline for the evaluation of headed and mechanically anchored deformed reinforcing Bars in tension, since the IBC, IRC, and associated reference standards do not specify design guidelines for these products.

- 1.2 Scope:** This criteria provides a basis for the testing and evaluation as applicable to the design of 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 consistently with the specific code(s) complied.

2006 IBC	<i>International Building Code</i> ®
2006 IRC	<i>International Residential Code</i> ®
ANSI/AWS D1.4-98	Structural Welding Code-Reinforcing Steel
ANSI/AWS C6.1-89	Recommended Practices for Friction Welding
ACI 318-08	Building Code Requirements for Structural Concrete, American Concrete Institute.
ACI 318-05	Building Code Requirements for Structural Concrete, American Concrete Institute.
ASTM A 370-05	Standard Test Methods and Definitions for Mechanical Testing of Steel Products, ASTM International.

ASTM A 615-04b	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A 706-04b	Standard Specification for Low Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A 970-07	Standard Specification for Headed Steel Bars for Concrete Reinforcement.
ASTM A 970-06	Standard Specification for Headed Steel Bars for Concrete Reinforcement.
ASTM E 8-04	Standard Test Methods for Tension Testing of Metallic Materials, ASTM International.

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, or factory-threading, and used in the reinforcement of normal weight concrete.
- 3.2 A_b :** Nominal cross-sectional area of the bar.
- 3.3 Net Bearing Area of the Head:** The bearing area of the head A_{brg} , 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 ($4A_{br}$).
- 3.4 Development Length:** Length of embedded reinforcement required to develop the design strength of reinforcement at a critical section, reference ACI 318-08 Section 9.3.3.
- 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.

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 bars shall include product installation requirements and details regarding installation of the product.
- 4.1.3 Identification:** Headed bars shall be permanently identified with the manufactures mark or logo, shall include the unique heat code identification, and the letter T indicating that

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the welded, threaded, or forged headed bar was produced to an ASTM A 970 specification. Packaging labels for headed bars shall include the manufacturer or a registered trademark, model or name of the product, size, and applicable IAPMO-ES evaluation report number.

- 4.2 Testing Laboratories:** Testing laboratories shall comply with the requirements for compliance with the International Accreditation Service (IAS) ISO/IEC standard 17025 or accredited independent agency recognized by the International Laboratory Accreditation or ANSO. Testing at a non-accredited laboratory may be permitted by IAPMO-ES, provided the testing is conducted under the supervision of an accredited laboratory and the supervising laboratory issues the test report.
- 4.3 Test Reports:** Test reports, submitted for approval by IAPMO-ES, 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.
- 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 A 970-06. Alternately, tensile tests can be prepared in accordance with ASTM A 970-07, 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.
- 4.5** The head component in a welded headed bar shall conform to one of the following steel specifications: ASTM A 29, ASTM A 36, ASTM A 108, ASTM A 304, ASTM A 572, or ASTM A 706.
- 4.6** Welded headed bars shall be manufactured with Low-Alloy Steel bars conforming to ASTM A 706.
- 4.7** Deformed reinforcing bars with forged and threaded heads shall conform to ASTM A 615 or A 706.
- 4.8** Bars with heads attached 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 produced 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 2db 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 0.5db.

- 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 bar.
- 5.1.4 Tensile Tests:** Reports of tensile and cyclic testing shall be conducted in accordance with Section 6.1 of and shall be submitted for verification in compliance with the conditions cited in Section 6.1, 6.1.1, or 6.1.2.
- 5.1.5 Bend Tests:** Welded headed bars require bend testing. Reports of bend testing shall be conducted in accordance with Section 6.2 of this criterion and shall be submitted for verification in compliance with the conditions cited in Section 6.2.1.

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. The failure shall be defined as specified in the respective ASTM A 970 standard. The headed rebar connection shall sustain stages 1 through 3 of the specified loading program shown in Table 1, without failure. Bar sizes that exceed No. 11 or a bar designated yield strength that exceeds 60.000 shall be tested in accordance with section 6.1.2.

Table 1: Loading Protocol for Cyclic Tension Tests

Stage	1	2	3	4
Maximum Load	$0.95f_y$	$2\varepsilon_y$	$5\varepsilon_y$	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 headed deformed bars satisfying ACI 318-08 section 3.5.9: the tensile strength, yield strength, and elongation after cycling per the requirements of Table 1 shall meet or exceed the requirements presented in Table 1 of ASTM A 970-06.
- 6.1.2** Alternate Acceptance under ACI 318-08 section 12.6.4, ASTM A 970-07, 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 12.6.4 of ACI 318-08. Additionally, the tensile strength of the headed bar assembly must meet or exceed the minimum specified tensile strength of the reinforcing bar, as defined in ASTM A615 or ASTM A706. The anchorage shall be designed in accordance with ACI 318-05 appendix D or otherwise designed to the satisfaction of the licensed design professional and approved by the Building Official.

- 6.2 Bend Test:** At least three specimens shall be tested for each welded bar size and head type. The welded headed reinforcement shall be bent around a mandrel at least 90 degrees. 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 Fig. 2 of ASTM A 970-06. The minimum mandrel dimensions for the bend test are in accordance with table 3 of ASTM A970-06.
- 6.2.1 Failure:** No observed partial or total fracture of the head, the bar, or the head-to-bar connection.

7.0 Quality Control

- 7.1** IAPMO-ES approved inspections of the manufacturing facilities are required for this product.
- 7.2** Manufacturers' Quality Assurance System shall comply with the IAPMO-ES Minimum Requirements for Listee's Quality Assurance System (IAPMO ES-010).

8.0 EVALUATION REPORT RECOGNITION

- 8.1** Evaluation reports that comply with the above criteria shall include the manufacturer's name and products name of proprietary components and the description of the material specifications for all assembly components.
- 8.2** The evaluation report shall also include:
1. Any recommendations for special inspections to be consistent with the requirements of the model code (section 1704.4 and 1704.13 of the IBC) and as required by IAPMO-ES.
 2. Reference in ACI 318-08 Figure R3.5.9 for headed deformed reinforcing bar with obstructions, Figure R12.6 (a) and Figure R12.6 (b) for development of headed deformed bars.
 3. When utilizing the equation in Section 12.6.2 of ACI 318-08 to calculate development length, the license design professional shall verify that the proposed heads meet ASTM A970-06, the maximum compressive design strength of concrete used in the calculation is 6,000 psi, and that conditions a-f as stated in Section 12.6.1 of ACI 318-08 have been met. For reinforcement that does not meet these requirements, the anchorage shall be designed in accordance with ACI 318-05 appendix D or designed otherwise to the satisfaction of the licensed 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.

Adopted: April 2010