

REFERENCE MANUAL

**Specifications for Masonry Structures
ACI 530.1-92/ASCE 6-92/TMS 602-92**

with ASTM references

SP-115(92)



REFERENCE MANUAL

Specifications for Masonry Structures ACI 530.1-92/ASCE 6-92/TMS 602-92

with ASTM references

A compilation of ACI 530.1-92/ASCE 6-92/TMS 602-92 and ASTM references listed in that specification and in "Building Code Requirements for Masonry Structures (ACI 530-92/ASCE 5-92/TMS 402-92)." The specifications and standards herein are authorized reprints of copyrighted material of the American Concrete Institute, The American Society of Civil Engineers, The Masonry Society, and the American Society for Testing and Materials.

SP-115(92)



American Concrete Institute, Detroit

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Specifications for Masonry Structures (ACI 530.1-92/ASCE 6-92/TMS 602-92)

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This standard covers minimum construction requirements for masonry structures. Included are requirements for materials; the placing, bonding and anchoring of masonry; the placement of grout and of reinforcement.

Keywords: bricks, clay bricks, concrete blocks; concrete brick; construction; construction materials; curing; grout; grouting; inspection; joints; masonry; materials handling; mortars (material); reinforcing steels; specifications; tests; tolerances.

FOREWORD

F1. This foreword is included for explanatory purposes only; it does not form a part of Standard Specifications ACI 530.1/ASCE 6/TMS 602.

F2. Standard Specifications ACI 530.1/ASCE 6/TMS 602 are a Reference Standard which the Architect/Engineer may cite in the Contract Documents for any project, together with supplementary requirements for the specific project.

F3. Standard Specifications ACI 530.1/ASCE 6/TMS 602 are written in the three-part section format of the Construction Specifications Institute, as adapted by ACI; the numbering system is modified by ACI requirements. The language is generally imperative and terse.

F4. A Specification Checklist is included as a preface to, but not forming a part of, Standard Specifications ACI 530.1/ASCE 6/TMS 602. The purpose of this Specification Checklist is to assist the Architect/Engineer in properly choosing and specifying the necessary mandatory and optional requirements for the Project Specifications.

PREFACE TO SPECIFICATIONS CHECKLIST

P1. Standard Specifications ACI 530.1/ASCE 6/TMS 602 are intended to be used in their entirety by reference in the Project Specifications. Individual sections, articles, or paragraphs should not be copied into the Project Specifications since taking them out of context may change their meaning.

P2. Building codes (of which this standard is a part by reference) set minimum requirements necessary to protect the public. Project specifications often stipulate requirements more restrictive than the minimum. Adjustments to the needs of a particular project are intended to be made by the Architect/Engineer by reviewing each of the items in the Specification Checklist and then including the Architect/Engineer's decision on each item as a mandatory requirement in the Project Specifications.

P3. These mandatory requirements should designate the specific qualities, procedures, materials, and perfor-

Adopted as a standard of the American Concrete Institute November 1988, in accordance with the Institute's standardization procedure. Revised by the Institute's Expedited Standardization Procedure effective July 1, 1992. Adopted as a standard of the American Society of Civil Engineers August 1989, in accordance with the Society's standardization procedure and revised by the Society's standardization procedure effective July 1, 1992. Adopted as a standard of The Masonry Society, July 1, 1992, in accordance with the Society's standardization procedure.

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mance criteria for which alternatives are permitted or for which provisions were not made in the Specifications. Exceptions to the Standard Specifications should be made in the Project Specifications, if required.

P4. A statement such as the following will serve to make Standard Specifications ACI 530.1/ASCE 6/TMS 602 an official part of the Project Specifications:

Masonry construction and materials shall conform to all requirements of "Specifications for Masonry Structures (ACI 530.1/ASCE 6/TMS 602)," published by the American Concrete Institute, Detroit, Michigan,

except as modified by the requirements of these Contract Documents.

P5. The Specifications Checklist which follows is addressed to each item of the Specifications where the Architect/Engineer must or may make a choice of alternatives; may add provisions if not indicated; or may take exceptions. The Specification Checklist consists of two columns; the first identifies the sections, parts, and articles of the Specifications, and the second column contains notes to the Architect/Engineer to indicate the type of action required by the Architect/Engineer.

MANDATORY SPECIFICATIONS CHECKLIST

Section/Part/Article	Notes to the Architect/Engineer
Section 1—General requirements	
1.1.2	Indicate the articles (parts and sections) of ACI 530.1/ASCE 6/TMS 602 excluded from the Project Specifications. List the articles of ACI 530.1/ASCE 6/TMS 602 at variance with the Project Specifications.
1.5.1 Inspection and testing	Designate the Owner's representatives for "Inspection and Testing."
1.5.2 Compressive strength requirements	Specify f'_m .
1.6.1 Determination of compressive strength	Specify method used to determine compressive strength.
1.6.2 Unit strength method	Specify when strength of grout is to be determined by test. [1.6.2.1(c)2 - 1.6.2.2(c)2].
Section 2—Masonry	
2.2.1 and 2.2.2 Masonry units and mortar	Specify the masonry units and mortar to be used for the various parts of the project and the type of mortar to be used with each type of masonry unit.
2.2.5 Prefabricated masonry	Specify prefabricated masonry and requirements in supplement of those of ASTM C 901.
2.2.8. Joint fillers	Specify size and shape of joint fillers.
2.3.1.1 Scope [(a) through (f)]	Specify testing and inspection requirements.
2.3.3.6(b) Pipes and conduit	Specify sleeve sizes and spacing.
2.3.3.6(f) Accessories	Specify accessories not indicated on the Project Drawings.
2.3.3.6(g) Movement joints	Indicate type and location of movement joints on the Project Drawings.
Section 3—Reinforcement and metal accessories	
3.2.1 Materials	Specify type and grade of reinforcement, connectors and accessories.
3.2.1.1.4 Wire fabric	Specify when wire fabric is to be smooth.



MASONRY STRUCTURES SPECIFICATIONS

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Section/Part/Article	Notes to the Architect/Engineer
Section 4—Grout	
4.2.1 Materials	Specify grout requirements at variance with ACI 530.1/ASCE 6/TMS 602. Specify admixtures.

OPTIONAL SPECIFICATIONS CHECKLIST

Section/Part/Article	Notes to the Architect/Engineer
Section 1—General requirements	
1.5.1.2 Inspection of foundations	Specify requirements of variance ACI 530.1/ASCE 6/TMS 602.
Section 2—Masonry	
2.1.2.1(a) through (h)	Specify when required.
2.1.2.2 Sample panels	Specify sample panels needed.
2.1.2.3 Sample panels	Specify whether sample panels shall not be part of finished construction.
2.1.3.3 Quality assurance prism test	See Article 1.6.1.
2.1.3.4 Quality assurance mortar test	Specify mortar tests.
2.1.3.5 Quality assurance grout test	Specify grout tests.
2.2.2.2 Pigments	Specify pigments.
2.2.6 Movement joint	Specify requirements at variance with ACI 530.1/ASCE 6/TMS 602.
2.2.7.2 Masonry cleaner	Specify where other than potable water, detergents, acid or caustic solutions are allowed and how to neutralize them.
2.3.2.4 Wetting masonry units	Specify when units are to be wetted.
2.3.2.5 Mortar	Specify if hand mixing is allowed and the method of measurement of material.
2.3.3.1 Bond pattern	Specify bond pattern other than running bond.
2.3.3.3(a) Joints	Specify thickness and tooling differing from ACI 530.1/ASCE 6/TMS 602.
2.3.3.3(b) Collar joints	Specify the filling of collar joints less than $\frac{3}{4}$ in. thick differing from ACI 530.1/ASCE 6/TMS 602.
2.3.3.3(d) Hollow units	Specify when cross webs are to be mortar bedded.
2.3.3.3(e) Solid units	Specify mortar bedding at variance with ACI 530.1/ASCE 6/TMS 602.
2.3.3.6(b) Embedded items	Specify locations where sleeves are required for pipes or conduits.
2.3.3.6(h) Insulation	Specify insulation.

Section/Part/Article	Notes to the Architect/Engineer
2.3.4.2 Clean	Specify requirements at variance with ACI 530.1/ASCE 6/TMS 602.
Section 3—Reinforcement and metal accessories	
3.2.1.4 Corrosion protection	Specify items not needing corrosion protection.
3.3.3.5(b), (c), and (d) Wall ties	Specify requirements at variance with ACI 530.1/ASCE 6/ TMS 602.
Section 4—Grout	
4.1.3 Quality assurance	Specify if testing of grout is required.
4.2.2 Grout proportioning and mixing	Specify requirements at variance with ACI 530.1/ASCE 6/ TMS 602.

SUBMITTALS

Section/Part/Article	Notes to the Architect/Engineer
Section 2—Masonry	
2.1.2 Submittals	Specify submittals required under Article 2.1.2.1. (See also Part 1.4 and Articles 3.1.2 and 4.1.2.)

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- 1.7—Acceptance

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- 3.1—General
- 3.2—Products
- 3.3—Execution

Section 4—Grout, p. S-13

- 4.1—General
- 4.2—Products
- 4.3—Execution

SECTION 1—GENERAL REQUIREMENTS

1.1—Scope

- 1.1.1 These Specifications cover requirements for ma-

terials and construction of masonry structures.

1.1.2 The provisions of these Specifications govern except where different provisions are specified.

1.2—Definitions

Acceptable, accepted—Acceptable to or accepted by the Architect/Engineer.

Architect/Engineer—The architect, engineer, architectural firm, engineering firm, or architectural and engineering firm, issuing Project Drawings and Specifications, or administering the Work under Contract Specifications and Drawings, or both.

Area, gross cross-sectional—The areas delineated by the out-to-out dimensions of masonry in the plane under consideration.

Area, net cross-sectional—The area of masonry units, grout and mortar, crossed by the plane under consideration based on out-to-out dimensions.

Collar joint—Vertical, longitudinal joint between wythes of masonry or between masonry and back up construction which is permitted to be filled with mortar or grout.

Compressive strength of masonry—Maximum compressive force resisted per unit of net cross-sectional area of masonry, determined by the testing of masonry prisms; or a function of individual masonry units, mortar and grout in accordance with the provisions of these specifications.

Contract Documents—Documents establishing the required Work, and including in particular the Project Drawings and Project Specifications.

Contractor—The person, firm, or corporation with whom the Owner enters into an agreement for construction of the Work.

Minimum/maximum (not less than ... not more than)—Minimum or maximum values given in this specification are absolute. Do not construe that tolerances allow lowering a minimum or increasing a maximum.

Otherwise required—Specified differently in requirements supplemental to the Standard Specification.

Owner—The public body or authority, corporation, association, partnership, or individual for whom the Work is provided.

Partition wall—An interior wall without structural function.

Project Drawings—The Drawings which, along with the Project Specifications, complete the descriptive information for constructing the Work required or referred to in the Contract Documents.

Project Specifications—The written documents which specify requirements for a project in accordance with the service parameters and other specific criteria established by the Owner or his agent.

Running bond—The placement of masonry units such that head joints in successive courses are horizontally offset at least one-quarter the unit length.

Specified compressive strength of masonry, f'_m —Minimum compressive strength, expressed as force per unit of net cross-sectional area, required of the masonry used in construction by the project documents and upon which the project design is based. Whenever the quantity f'_m is under the radical sign, the square root of the numerical value only is intended, and the result has units of pounds per square inch (psi).

Stack bond—For the purpose of this specification, stack bond is other than running bond. Usually the placement of masonry units is such that head joints in successive courses are vertically aligned.

Stone masonry—Masonry composed of field, quarried, or cast stone units bonded by mortar.

(a) **Stone masonry, ashlar**—Stone masonry composed of rectangular units having sawed, dressed, or squared bed surfaces and bonded by mortar.

(b) **Stone masonry, rubble**—Stone masonry composed of irregular shaped units bonded by mortar.

Submit, submitted—Submit, submitted to the Architect/Engineer for review.

Wall—A vertical element with a horizontal length to thickness ratio greater than 3, used to enclose space.

Wall, load-bearing—A wall carrying vertical loads greater than 200 lb/ft in addition to its own weight.

When required—Specified in requirements supplemental to ACI 530.1/ASCE 6/TMS 602.

Work—The furnishing and performance of all equipment, services, labor, and materials required by the contract documents for the construction of masonry for the project or part of project under consideration.

Wythe—Each continuous vertical section of a wall, one masonry unit in thickness.

1.3—Specified references

Standards of the American Concrete Institute, the American Society for Testing and Materials, and the American Welding Society referred to in these Specifications are listed below with their serial designations, including year of adoption or revision, and are declared to be part of the Specifications as if fully set forth in this document except as modified herein.

ACI 117-90	Standard Specifications for Tolerances for Concrete Construction and Materials
ACI SP66-88	Details and Detailing of Concrete Reinforcement
ASTM A 36-90	Specification for Structural Steel
ASTM A 82-90a	Specification for Steel Wire, Plain, for Concrete Reinforcement
ASTM A 123-89a	Specifications for Zinc (Hot Dipped-Galvanized) Coatings on Iron and Steel Products
ASTM A 153-82 (1987)	Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 167-90	Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A 185-90a	Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
ASTM A 307-88a	Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
ASTM A 366-85	Specification for Steel, Carbon, Cold-Rolled Sheet, Commercial Quality
ASTM A 496-90a	Specification for Steel Wire, Deformed, for Concrete Reinforcement
ASTM A 497-90a	Specification for Welded Deformed Steel Wire Fabric for Concrete Reinforcement
ASTM A 525-90	Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
ASTM A 615-90	Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM A 616-90	Specification for Rail-Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A 617-90	Specification for Axle-Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A 641-89	Specification for Zinc-Coated (Galvanized) Carbon Steel Wire
ASTM A 706-90	Specification for Low-Alloy Steel Deformed Bars for Concrete Reinforcement
ASTM C 34-84	Specification for Structural Clay Load-Bearing Wall Tile

ASTM C 55-85	Specification for Concrete Building Brick	ASTM C 901-85 (1990)	sonry Specification for Prefabricated Masonry Panels
ASTM C 56-71 (1986)	Specification for Structural Clay Non-Load-Bearing Tile	ASTM C 920-87	Specification for Elastomeric Joint Sealants
ASTM C 62-89a	Specification for Building Brick (Solid Masonry Units Made from Clay or Shale)	ASTM C 1019-89a	Method of Sampling and Testing Grout
ASTM C 67-90a	Method of Sampling and Testing Brick and Structural Clay Tile	ASTM D 994-71 (1982)	Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type)
ASTM C 73-85 (1989)	Specification for Calcium Silicate Face Brick (Sand-Lime Brick)	ASTM D 1056-85	Specification for Flexible Cellular Materials—Sponge or Expanded Rubber
ASTM C 90-90	Specification for Hollow Load-Bearing Concrete Masonry Units	ASTM D 2000-86	Classification System for Rubber Products in Automotive Applications
ASTM C 97-90	Test Methods for Absorption and Bulk Specific Gravity of Natural Building Stone	ASTM D 2287-81 (1988)	Specification for Nonrigid Vinyl Chloride Polymer and Copolymer Molding and Extrusion Compounds
ASTM C 99-87	Test Method for Modulus of Rupture of Natural Building Stone	ASTM E 447-84	Test Methods for Compressive Strength of Masonry Prisms
ASTM C 120-90	Method for Flexure Testing of Slate (Modulus of Rupture, Modulus of Elasticity)	AWS D1.4-79	Structural Welding Code—Reinforcing Steel
ASTM C 121-90	Test Method for Water Absorption of Slate		
ASTM C 126-86	Specification for Ceramic Glazed Structural Clay Facing Tile, Facing Brick, and Solid Masonry Units	1.4—Submittals	
ASTM C 129-85 (1990)	Specification for Non-Load Bearing Concrete Masonry Units	1.4.1	Submit the material samples, placement drawings, and documentation as required by these Specifications.
ASTM C 140-90	Method of Sampling and Testing Concrete Masonry Units	1.4.2	Obtain written acceptance of submittals prior to the use of the materials or methods requiring acceptance.
ASTM C 170-90	Test Method for Compressive Strength of Natural Building Stone	1.5—Quality assurance	
ASTM C 212-60 (1986)	Specification for Structural Clay Facing Tile	1.5.1 Inspection and testing	
ASTM C 216-90a	Specification for Facing Brick (Solid Masonry Units Made from Clay or Shale)	1.5.1.1	Tests required to document submittals, certify product compliance with these Specifications prior to use in construction, establish mix designs, provide acceptability of changes requested by the Contractor, or appeal rejection of material found defective by Owner's test, shall be performed by accepted laboratories under Contractor's responsibility. Cost of these services shall be paid by the Contractor.
ASTM C 270-89	Specification for Mortar for Unit Masonry	1.5.1.2	When required, the Owner will employ a qualified professional engineer or surveyor to survey foundations, and report any deviation from the tolerances specified in Article 2.3.2.1 to the Architect/Engineer, prior to the start of masonry.
ASTM C 476-83	Specification for Grout for Masonry	1.5.1.3	The Work in progress will be inspected and materials, equipment, and procedures will be evaluated for quality and acceptability by representatives of the Owner, designated in the Contract Documents. Cost for these services will be paid by the Owner.
ASTM C 503-89	Specification for Marble Dimension Stone (Exterior)	1.5.1.4	Permit and facilitate access of the Owner's representatives to the construction sites and the performance of all activities for quality assurance by these representatives, including inspection and testing required in these Specifications.
ASTM C 568-89	Specification for Limestone Dimension Stone	1.5.1.5	Failure to detect any defective work or material does not in any way prevent later rejection when a defect is discovered and it does not obligate the Archi-
ASTM C 615-85	Specification for Granite Building Stone		
ASTM C 616-89	Specification for Quartz-Based Dimension Stone		
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ASTM C 780-91	Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Ma-		

tect/Engineer for final acceptance.

1.5.2 Compressive strength requirements—Compressive strength of masonry in each masonry wythe and grouted collar joint shall equal or exceed the applicable f'_m .

1.6—Compressive strength determination

1.6.1 Alternatives for determination of compressive strength—Determine the compressive strength for each wythe by the unit strength method of Article 1.6.2 subject to the limitations stated therein, or by the prism test method of Article 1.6.3.

1.6.2 Unit strength method

1.6.2.1 Clay masonry—Determine the compressive strength of masonry meeting the requirements of Articles 1.6.2.1(a), (b), and (c) from the values given in Table 1.6.2.1 based on the strength of the units and the type of mortar specified.

Table 1.6.2.1—Compressive strength of masonry based on the compressive strength of the clay masonry units and type of mortar used in construction

Net area compressive strength of clay masonry units, psi		Net area compressive strength of masonry, psi
Type M or S mortar	Type N mortar	
2400	3000	1000
4400	5500	1500
6400	8000	2000
8400	10500	2500
10400	13000	3000
12400	—	3500
14400	—	4000

(a) Units conform to ASTM C 216, ASTM C 62, or ASTM C 652 and are sampled and tested in accordance with ASTM C 67.

(b) Thickness of bed joints does not exceed $\frac{3}{8}$ in.

(c) For grouted masonry, the grout meets one of the following requirements:

1. Grout conforms to ASTM C 476.
2. Grout compressive strength equals f'_m but compressive strength is not less than 2000 psi. Determine compressive strength of grout in accordance with ASTM C 1019.

1.6.2.2 Concrete masonry—Determine the compressive strength of masonry meeting the requirements of Articles 1.6.2.2(a), 1.6.2.1 (b), and 1.6.2.1 (c), from the values given in Table 1.6.2.2 based on the strength of the unit and type of mortar specified.

(a) Units conform to ASTM C 90, or ASTM C 55 and are sampled and tested in accordance with ASTM C 140.

Table 1.6.2.2—Compressive strength of masonry based on the compressive strength of concrete masonry units and type of mortar used in construction

Net area compressive strength of concrete masonry units, psi		Net area compressive strength of masonry, psi*
Type M or S mortar	Type N mortar	
1250	1300	1000
1900	2150	1500
2800	3050	2000
3750	4050	2500
4800	5250	3000

* For units of less than 4 in. height, 85 percent of the values listed.

1.6.3 Prism test method

1.6.3.1 Determine the compressive strength of masonry by the prism test method for the following conditions:

(a) When required.

(b) When masonry does not meet the requirements of Article 1.6.2 for application of the unit strength method.

1.6.3.2 A prism test consists of testing three prisms in accordance with ASTM E 447 Method B modified as follows:

- a) Construct prisms in stack bond, one unit long and thick with a full mortar bed.
- b) Construct clay masonry prisms with height to thickness ratios in the range from 2.0 to 5.0
- c) Construct concrete masonry prisms with height to thickness ratios in the range from 1.33 to 5.0.
- d) Provide a minimum of one joint in hollow unit masonry prisms.

1.6.3.3

(a) The compressive strength of masonry is the average strength of three prisms, but not more than the strength of the masonry units used in prism construction.

(b) For clay masonry, multiply the compressive strength of masonry, determined in Article 1.6.3.3(a), by the height to thickness correction factor indicated in Table 1.6.3.3(b).

Table 1.6.3.3(b)—Correction factors for clay masonry strength

Prism height to thickness ratio	2.0	2.5	3.0	3.5	4.0	4.5	5.0
Correction factor	0.82	0.85	0.88	0.91	0.94	0.97	1.0

(c) For concrete masonry, multiply the compressive strength of masonry, determined in Article 1.6.3.3(a), by the height to thickness correction factor

indicated in Table 1.6.3.3(c).

Table 1.6.3.3(c)—Correction factors for concrete masonry prism strength

Prism height to thickness ratio	1.33	2.0	3.0	4.0	5.0
Correction factor	0.75	1.00	1.07	1.15	1.22

1.7—Acceptance

1.7.1 Masonry complying with Contract Documents as determined by tests and procedures will be accepted.

SECTION 2—MASONRY

2.1—General

2.1.1 *Description*—Furnish and construct masonry in accordance with the requirements of the Contract Documents. This section covers the furnishing and construction of masonry including the following:

2.1.1.1 Furnishing and placing masonry units, grout, mortar, masonry lintels, sills, copings, through-wall flashing, and connectors.

2.1.1.2 Designing, furnishing, erecting and maintaining of bracing, forming, scaffolding, rigging, and shoring.

2.1.1.3 Furnishing and installing other equipment for constructing masonry.

2.1.1.4 Cleaning masonry and removing surplus material and waste.

2.1.1.5 Installing lintels, nailing blocks, inserts, window and door frames, connectors, and construction items to be built into the masonry, and building in vent pipes, conduits and other items furnished and located by other trades.

2.1.2 Submittals

2.1.2.1 When required, submit the following in accordance with the provisions of Part 1.4:

(a) Specimens of the masonry units which will be used in project construction, showing range of colors, textures, finishes and dimensions, as well as specimens of colored mortar.

(b) Results of mortar tests performed in accordance with the property specification requirements of ASTM C 270.

(c) Cold weather construction procedures for meeting the requirements of the Project Specifications.

(d) Hot weather construction procedures for meeting the requirements of the Project Specifications.

(e) Manufacturer's literature.

(f) Shop drawings showing:

- details of steel reinforcement
- lintels and door frames
- shelf angles and lintels

(g) One sample, at least 6 in. long, of each type of non-masonry joint material specified.

(h) Results of tests of masonry units and materials attesting compliance with the specified requirements.

2.1.2.2 When required, construct sample panels of masonry walls using materials and procedures conforming to the Project Specifications.

(a) The minimum sample panel size is 4 ft. square.

(b) The acceptable standard for the Work is established by the accepted panel.

2.1.2.3 Unless otherwise required, construct sample panels separate from the Work, and retain sample panels at the job site until all Work has been accepted.

2.1.3 Quality assurance

2.1.3.1 Comply with the quality assurance requirements of Parts 1.5 and 1.6, and Article 2.1.3.

2.1.3.2 Test masonry units in accordance with the following standards:

(a) Concrete masonry ASTM C 140

(b) Clay masonry ASTM C 67

(c) Stone masonry

Structural granite ASTM C 97

Building sandstone ASTM C 120

Structural slate ASTM C 99

Marble building stone

(exterior) ASTM C 170

Limestone building stone ASTM C 121

2.1.3.3 When the testing of prisms is required (Article 1.6.3), perform one test prior to construction and perform at least one test during construction for each 5,000 ft² of wall area or portion thereof.

2.1.3.4 When required, test mortar in accordance with the property specifications of ASTM C 270 or evaluate in accordance with ASTM C 780.

2.1.3.5 When required, test grout in accordance with the requirements of Section 4.

2.1.4 Product delivery, storage and handling

2.1.4.1 Do not use damaged masonry units, damaged components of structure, and damaged packaged material.

2.1.4.2 Protect moisture controlled, concrete masonry units and cementitious materials from precipitation or ground water.

2.1.4.3 Do not use masonry materials that are contaminated.

2.1.4.4 Store different aggregates separately.

2.2—Products

2.2.1 Masonry units

2.2.1.1 Provide concrete masonry units that conform to ASTM C 55, C 73, C 90, C 129 or C 744 as specified.

2.2.1.2 Provide clay or shale masonry units that conform to ASTM C 34, C 56, C 62, C 126, C 212, C 216 or C 652, as specified.

2.2.1.3 Provide stone masonry units that conform to ASTM C 503, C 568, C 615, C 616 or C 629, as specified.

2.2.2 Mortar

2.2.2.1 Provide mortar of the type and color specified that conforms to ASTM C 270.

2.2.2.2 When required, use mineral oxide or carbon black job site pigments. Limit the maximum percentage by weight of cement as follows:

- (a) Pigmented portland cement-lime mortar
 - 1. Mineral oxide pigment . . . 10 percent
 - 2. Carbon black pigment 2 percent
- (b) Pigmented masonry cement mortar
 - 1. Mineral oxide pigment 5 percent
 - 2. Carbon black pigment 1 percent

2.2.2.3 Do not use admixtures that contain chlorides in mortar or grout.

2.2.3 Grout

2.2.3.1 Use grout material that conforms to the requirements of Section 4.

2.2.4 Metal reinforcement and accessories

2.2.4.1 Use metal reinforcement and accessories that conform to the requirements of Section 3.

2.2.5 Prefabricated masonry

2.2.5.1 Unless otherwise required, provide prefabricated masonry that conforms to the provisions of ASTM C 901 and the Contract Documents.

2.2.5.2 When used, provide prefabricated masonry that conforms to the details shown on the Project Drawings and the requirements in the Contract Documents.

2.2.5.3 Unless otherwise required, provide prefabricated masonry lintels that have an appearance similar to the masonry units used in the wall surrounding each lintel.

2.2.5.4 Mark prefabricated masonry for proper location and orientation.

2.2.6 Movement joints

2.2.6.1 Unless otherwise required, provide contraction joint material that conforms to one of the following standards:

- (a) ASTM D 2000, M2AA-805 Rubber shear keys with a minimum durometer hardness of 80.
- (b) ASTM D 2287, Type PVC 654-4 PVC shear keys with a minimum durometer hardness of 85.
- (c) ASTM C 920

2.2.6.2 Unless otherwise required, provide expansion joint material that conforms to one of the following standards:

- (a) ASTM D 994
- (b) ASTM D 1056, Class 2A1
- (c) ASTM C 920

2.2.7 Masonry cleaner

2.2.7.1 Use potable water and detergents to clean masonry unless otherwise acceptable.

2.2.7.2 Unless otherwise required, do not use acid or caustic solutions.

2.2.8 Joint fillers—Use the size and shape of joint fillers specified.

2.3—Execution**2.3.1 Inspection and testing**

2.3.1.1 Scope—Inspection shall conform to the requirements of Parts 1.5, 1.6 and the following:

The testing agency designated by the Owner per Article 1.5.1.1 shall:

(a) Review and when required, test the Contractor's proposed materials for conformance to the Contract Documents.

(b) Review and when required, test the Contractor's proposed mix design of mortar and grout for conformance to the Contract Documents.

(c) When required, secure production samples of materials at plants or stock piles and test for conformance to the Contract Documents.

(d) When required, conduct strength tests of masonry units, prisms, and materials for conformance to the Contract Documents.

(e) When required, review the manufacturers' report for cement, reinforcing steel, wall ties and anchors, and/or conduct laboratory tests of the materials as received for conformance with the Contract Documents.

(f) When required, perform other testing or inspection services.

2.3.1.2 Duties and authorities of testing agency designated by the owner

(a) Representatives of the agency shall inspect, sample, and test the material and shall inspect the construction of masonry in accordance with the Contract Documents. When there is reason to believe that any material furnished or work performed by the Contractor fails to fulfill the requirements of the Contract Documents, report such deficiency to the Architect/Engineer and to the Contractor.

(b) The agency shall report all test and inspection results to the Architect/Engineer and Contractor immediately after they are performed. Include in test reports a summary of conditions under which test specimens were stored prior to testing and state what portion of the construction is represented by each test.

(c) The testing agency and its representatives are neither authorized to revoke, alter, relax, enlarge, or release any requirement of the Contract Documents, nor authorized to approve or accept, reject or disapprove, any portion of the work.

2.3.1.3 Responsibilities and duties of contractor

(a) The use of testing services does not relieve the Contractor of the responsibility to furnish materials and construction in full compliance with the Contract Documents.

(b) Include in the submittals the results of all testing performed to qualify the materials and to establish mix designs.

(c) To facilitate testing and inspection, comply with the following:

1. Furnish any necessary labor to assist the designated testing agency in obtaining and handling samples at the project or other sources of material.

2. Advise the designated testing agency suf-

ficiently in advance of operations to allow for completion of quality tests and for the assignment of personnel.

3. Provide and maintain for the sole use of the testing agency adequate facilities for safe storage and proper curing of test specimens on the project site in accordance with the Contract Documents.

2.3.2 Preparation

2.3.2.1 Foundations

2.3.2.1.1 Prior to the start of masonry construction, the contractor shall verify:

(a) That foundations are constructed with tolerances conforming to the requirements of ACI 117.

(b) That reinforcing dowels are positioned in accordance with the Project Drawings.

(c) If conditions (a) and (b) are not met, notify the Architect/Engineer.

2.3.2.1.2 Prior to placing masonry, remove laitance, loose aggregate, and anything else that would prevent mortar from bonding to the foundation.

2.3.2.2 Cold weather construction—Implement the requirements of Article 2.1.2.1 (c) when any of the following conditions exist:

(a) The ambient temperature falls below 40 F,

(b) The temperature of masonry units is below 40 F. In addition:

1. Do not lay masonry units having a temperature below 20 F. Remove visible ice on masonry units before the unit is laid in the masonry.

2. Heat mortar sand or mixing water to produce mortar temperatures between 40 F and 120 F at the time of mixing. Maintain mortar above freezing until used in masonry.

3. When ambient temperature is between 25 F and 20 F use heat sources on both sides of the masonry under construction and install wind breaks when wind velocity is in excess of 15 mph.

4. When ambient temperature is below 20 F, provide an enclosure for the masonry under construction and use heat sources to maintain temperatures above 32 F within the enclosure.

5. When mean daily temperature is between 40 F and 32 F, protect completed masonry from rain or snow by covering with a weather resistive membrane for 24 hr after construction.

6. When mean daily temperature is between 32 F and 25 F, completely cover completed masonry with a weather resistive membrane for 24 hr after construction.

7. When mean daily temperature is between 25 F and 20 F, completely cover completed masonry with insulating blankets or equal protection for 24 hr after construction.

8. When mean daily temperature is below 20 F, maintain masonry temperature above 32 F for 24 hr after construction by enclosure with supplementary heat, by electric heating blankets, by infrared heat lamps or by other acceptable methods.

2.3.2.3 Hot weather construction—Implement the

requirements of Article 2.1.2.1 (d) when the ambient air temperature exceeds the following:

(a) 100 F, or

(b) 90 F with a wind velocity greater than 8 mph

In addition, do not spread mortar beds more than 4 ft ahead of masonry. Set masonry units within one minute of spreading mortar.

2.3.2.4 Wetting masonry units

(a) Concrete masonry—Unless otherwise required, do not wet concrete masonry units before laying.

(b) Clay or shale masonry—Wet clay or shale masonry units having initial absorption rates in excess of one gram per minute, per in.², when measured in accordance with ASTM C 67, so the initial rate of absorption will not exceed one gram per minute, per in.² when the units are used. Lay wetted units when surface dry.

2.3.2.5 Mortar—Mix all cementitious materials and aggregates between 3 and 5 min in a mechanical batch mixer with a sufficient amount of water to produce a workable consistency. Unless acceptable, do not hand mix mortar. Maintain workability of mortar by remixing or retempering. Discard all mortar which has begun to stiffen or is not used within 2½ hours after initial mixing.

2.3.3 Erection

2.3.3.1 Bond pattern—Unless otherwise required, construct masonry in running bond pattern.

2.3.3.2 Tolerances—Erect masonry within the following tolerances from the specified dimensions:

(a) Dimension of elements

1. In cross section or elevation -¼ in., +½ in.
2. Mortar joint thickness
 - bed ±¼ in.
 - head -¼ in., +¾ in.
 - collar -¼ in., +¾ in.
3. Grout space or cavity width -¼ in., +¾ in.

(b) Elements

1. Variation from level:
 - bed joints ±¼ in. in 10 ft
 - ±½ in. maximum
 - top surface of bearing walls ±¼ in. in 10 ft
 - ±½ in. maximum
2. Variation from plumb ±¼ in. in 10 ft
 - ±¾ in. in 20 ft
 - ±½ in. maximum
3. True to a line ±¼ in. in 10 ft
 - ±¾ in. in 20 ft
 - ±½ in. maximum
4. Alignment of columns and walls (bottom versus top) ±½ in. for bearing walls
 - ±¾ in. for nonbearing walls

(c) Location of elements

1. Indicated in plan ±½ in. in 20 ft
 - ±¼ in. maximum
2. Indicated in

elevation $\pm \frac{1}{4}$ in. in story height
 $\pm \frac{3}{4}$ in. maximum

- (d) In placing of reinforcement. See Article 3.3.3.2
- (e) If the above conditions cannot be met due to previous construction, notify the Architect/Engineer.

2.3.3.3 Placing mortar and units

(a) *Bed and head joints*—Unless otherwise required or indicated on the Project Drawings, construct $\frac{3}{8}$ in. thick bed and head joints except at foundation. Construct bed joint of the starting course of foundation with a thickness not less than $\frac{1}{4}$ in. and not more than $\frac{3}{4}$ in. Construct joints that also conform to the following:

1. Fill line pin holes in exposed and below grade masonry with mortar.
2. Unless otherwise required, tool joints with a round jointer when the mortar is thumbprint hard.
3. Remove masonry protrusions extending $\frac{1}{2}$ in. or more into cells or cavities to be grouted.

(b) *Collar joints*—Unless otherwise required or indicated on the Project Drawings, solidly fill collar joints less than $\frac{3}{4}$ in. wide with mortar as the job progresses.

(c) The placement requirements of this section and of Section 4 apply to masonry to be grouted.

(d) *Hollow units*—Place hollow units so:

1. Face shells of bed joints are fully mortared.
2. Webs are fully mortared in all courses of piers, columns, and pilasters, in the starting course on foundations, where adjacent cells or cavities are to be grouted, and when otherwise required.
3. Head joints are mortared, a minimum distance from each face equal to the face shell thickness of the unit.
4. Vertical cells to be grouted are aligned and unobstructed openings for grout are provided in accordance with the Project Drawings.

(e) *Solid units*—Unless otherwise required, solidly fill bed and head joints with mortar and:

1. Do not fill head joints by slushing with mortar.
2. Construct head joints by shoving mortar tight against the adjoining unit.
3. Do not deeply furrow bed joints.

(f) *All units*

1. Place clean units while the mortar is soft and plastic. Remove and relay in fresh mortar any unit disturbed to the extent that initial bond is broken after initial positioning.
2. Cut exposed edges or faces of masonry units smooth or position such that all exposed faces or edges are unaltered manu-

factured surfaces.

2.3.3.4 Prefabricated concrete and masonry items—Erect prefabricated concrete and masonry items in accordance with the requirements indicated on the Project Drawings.

2.3.3.5 Wall ties—Fabricate and place ties and other reinforcement accessories in conformance with the provisions of Section 3.

2.3.3.6 Embedded items and accessories—Install imbedded items and accessories where shown in the Project Drawings and in accordance with the Contract Documents.

(a) Construct chases as masonry units are laid.

(b) When required, place pipes and conduits passing horizontally through masonry beams or masonry walls in steel sleeves or cored holes.

(c) Install pipes and conduits passing horizontally through nonbearing masonry partitions.

(d) Place pipes and conduits passing horizontally through piers, pilasters, or columns.

(e) Place horizontal pipes and conduits in and parallel to plane of walls.

(f) Install and secure connectors, flashing, weep holes, weep vents, nailing blocks, and other accessories.

(g) Install movement joints.

(h) When required, install insulation.

2.3.3.7 Reinforcement—Place reinforcement in accordance with Section 3.

2.3.3.8 Grout—Place grout in accordance with Section 4.

2.3.3.9 Bracing of masonry—Design, provide, and install bracing that will assure stability of masonry during construction.

2.3.3.10 Construction loads—Do not apply construction loads that exceed the safe superimposed load carrying capacity of the masonry and shores, if used.

2.3.3.11 Masonry protection—Cover top of unfinished masonry work to protect it from the weather.

2.3.4 Cleaning

2.3.4.1 Clean exposed masonry surfaces of all stains, efflorescence, mortar or grout droppings, and debris.

2.3.4.2 Unless otherwise required or accepted, clean masonry with cleaners meeting the requirements of Article 2.2.7.1.

SECTION 3—REINFORCEMENT AND METAL ACCESSORIES

3.1—General

3.1.1 Description—This section covers the requirements for furnishing and placing reinforcement, anchors, ties, and metal accessories.

3.1.2 Submittals

3.1.2.1 Submit the following in accordance with the requirements of Part 1.4:

- (a) Placing drawings, showing all fabrication

dimensions and locations for placing of the reinforcing steel and accessories.

(b) Certification of compliance for each type and size of reinforcement to be used in construction, demonstrating compliance with this specification.

(c) Certification of compliance for each type and size of anchors, ties, and metal accessories, demonstrating compliance with this specification and when required, samples of these items.

3.1.3 *Delivery, storage, and handling*

3.1.3.1 Protect reinforcement, ties, and metal accessories from permanent distortions and store them off the ground.

3.2—Products

3.2.1 *Materials*

3.2.1.1 *Reinforcing steel*—Provide reinforcement of the grade specified and that conforms to Articles 3.2.1.1.1, 3.2.1.1.2, 3.2.1.1.3, and 3.2.1.1.4 of these Specifications:

3.2.1.1.1 *Deformed reinforcing bars*—Provide deformed reinforcing bars that conform to one of the following as specified:

- (a) ASTM A 615
- (b) ASTM A 616, including Supplement 1
- (c) ASTM A 617
- (d) ASTM A 706

3.2.1.1.2 *Joint reinforcement*—Provide, except as required by Section 3.2.1.3, joint reinforcement manufactured with wire conforming to ASTM A 82 and with deformed longitudinal wires. One set of deformations shall occur around the perimeter of the wire at a maximum spacing of 0.7 times the diameter of the wire but these shall not be less than eight sets per inch of length. The overall length of each deformation within the set shall be such that the sum of gaps between the ends of the deformations shall not exceed 25 percent of the perimeter of the wire. The height or depth of the deformations shall be 0.012 in. for wire size W2.8 or larger, 0.011 in. for wire size W2.1, and 0.009 in. for wire size W1.7. Cross wires are permitted to be plain.

3.2.1.1.3 *Deformed reinforcing wire*—Provide deformed reinforcing wire that conforms to ASTM A 496.

3.2.1.1.4 *Wire fabric*—Provide wire fabric that conforms to one of the following specifications:

- a) Smooth ASTM A 185
- b) Deformed ASTM A 497

3.2.1.2 *Anchors, ties and accessories*—Provide anchors, ties, and accessories that conform to the following specifications, except as required by Article 3.2.1.3:

- (a) Plate and bent bar anchors ASTM A 36
- (b) Sheet metal anchors and ties ASTM A 366
- (c) Wire mesh ties ASTM A 185
- (d) Wire ties and anchors ASTM A 82
- (e) Anchor bolts 2ASTM A 307, Grade A

3.2.1.3 *Stainless steel*—Provide stainless steel that conforms to ASTM A 167, Type 304, for items listed in Articles 3.2.1.1.2 and 3.2.1.2 of this section.

3.2.1.4 *Coatings for corrosion protection*—Unless otherwise required, protect joint reinforcement, ties, and anchors not meeting the requirements of Article 3.2.1.3 from corrosion by galvanizing in conformance with the following minimum.

- (a) Joint reinforcement, interior walls ASTM A 641 (0.1 oz/ft²)

(b) Joint reinforcement, wire ties, or wire anchors in exterior walls or interior walls exposed to moist environments (e.g. natatoria and food processing) ASTM A 153 (1.50 oz/ft²)

(c) Sheet metal ties or anchors in exterior walls or interior walls exposed to moist environments (e.g. natatoria and food processing) ASTM A 153 Class B

(d) Sheet metal ties or anchors in interior walls ASTM A 525 Class G60

(e) Steel plates and bars (or applicable to size and form indicated) ASTM A 123 or ASTM A 153, Class B

3.2.1.5 *Aluminum*—Do not embed aluminum conduits, pipes, and accessories in masonry, grout, or mortar, unless effectively coated or covered to prevent aluminum cement chemical reaction or electrolytic action between aluminum and steel.

3.2.2 *Fabrication*

3.2.2.1 Fabricate bars used in masonry reinforcement in accordance with the fabricating tolerances of ACI 315.

3.2.2.2 Unless otherwise required, bend bars cold and do not heat bars.

3.2.2.3 The minimum inside diameter of bend for stirrups shall be five bar diameters.

3.2.2.4 Do not bend grade 40 bars in excess of 180 deg. The minimum inside diameter of bend is five bar diameters.

3.2.2.5 The minimum inside diameter of bend for bars not covered by Articles 3.2.2.3 and 3.2.2.4 of this section is as follows:

- (a) #3 through #8 6 bar diameters
- (b) #9, #10, and #11 8 bar diameters

3.2.2.6 Provide standard hooks that conform to the following:

(a) A standard 180 deg hook: 180 deg bend plus a minimum extension of 4 bar diameters or 2½ in., whichever is greater.

(b) A standard 135 deg hook: a 135 deg bend plus a minimum extension of 6 bar diameters or 4 in., whichever is greater.

(c) A standard 90 deg hook: 90 deg bend plus a minimum extension of 12 bar diameters.

(d) For stirrups: A 90 or 135 deg bend plus a minimum of 6 bar diameters or 2½ in., whichever is greater.

3.2.2.7 Manufacture joint reinforcement, anchors, and ties in accordance with the Contract Documents and with the published specifications of the accepted manufacturer.

3.3—Execution

3.3.1 Inspection

3.3.1.1 The provisions of Article 2.3.1 apply to this section.

3.3.2 Preparation

3.3.2.1 Clean all reinforcement by removing mud, oil, or other materials that will adversely affect or reduce the bond at the time mortar or grout is placed. Reinforcement with rust, mill scale, or a combination of both will be accepted as being satisfactory without cleaning or brushing provided the dimensions and weights, including heights of deformations, of a cleaned sample are not less than required by the ASTM specification covering this reinforcement in this specification.

3.3.3 Placement

3.3.3.1 Basic requirements—Place reinforcement and accessories in accordance with the sizes, types, and locations indicated on the Project Drawings, and as specified. Do not place dissimilar metals in contact with each other.

3.3.3.2 Tolerances for placing reinforcement

(a) Tolerances for the placement of steel in walls and flexural elements shall be $\pm \frac{1}{2}$ in. when the distance from the centerline of steel to the opposite face of masonry, d , is equal to 8 in. or less, ± 1 in. for d equal to 24 in. or less but greater than 8 in., and $\pm 1\frac{1}{4}$ in. for d greater than 24 in.

(b) In walls, for vertical bars, 2 in. from the location along the length of the wall indicated on the Project Drawings.

(c) If it is necessary to move bars to avoid interference with other reinforcing steel, conduits, or embedded items and bars are moved more than one bar diameter, or enough to exceed the specified tolerances, notify the Architect/Engineer for acceptance of the resulting arrangement of bars.

3.3.3.3 Securing reinforcement—Support and fasten reinforcement together to prevent displacement by construction loads or by placement of grout or mortar beyond the tolerances allowed by Article 3.3.3.2.

3.3.3.4 Details of reinforcement

(a) Maintain clear distance between reinforcing bars and any face of masonry unit or formed surface, as indicated on the Project Drawings, but not less than $\frac{1}{4}$ in. for fine grout or $\frac{1}{2}$ in. for coarse grout.

(b) Splice, only where indicated on the Project Drawings, unless otherwise acceptable.

(c) Unless accepted by the Architect/Engineer, do not bend reinforcement after it is embedded in grout or mortar.

(d) Place joint reinforcement so that longitudinal wires are embedded in mortar with a minimum cover of $\frac{1}{2}$ in. when not exposed to weather or earth and

$\frac{3}{8}$ in. when exposed to weather or earth. (See also Article 3.3.3.1.)

3.3.3.5 Wall ties

(a) Embed the ends of wall ties in mortar joints. Embed wall tie ends at least $\frac{1}{2}$ in. into the outer face shell of hollow units. Embed wire wall ties at least $1\frac{1}{2}$ in. into the mortar bed of solid masonry units or solid grouted hollow units.

(b) Unless otherwise required, bond wythes not bonded by headers with wall ties as follows:

Wire Size	Minimum number of ties required
W1.7	One wall tie wire per 2.67 ft ²
W2.8	One wall tie wire per 4.50 ft ²

The maximum spacing between ties is 36 in. horizontally and 24 in. vertically.

(c) Unless accepted by the Architect/Engineer, do not bend wall ties after being embedded in grout or mortar.

(d) Unless otherwise required, install adjustable ties in accordance with the following requirements:

1. One tie for each 1.77 ft² of wall area
2. Do not exceed 16 in. horizontal or vertical spacing
3. The maximum misalignment of bed joints from one wythe to the other is $1\frac{1}{4}$ in.
4. The maximum clearance between connecting parts of the ties is $1/16$ in.
5. When pintle legs are used, provide ties with at least two legs made of wire size W2.8.

SECTION 4—GROUT

4.1—General

4.1.1 Description—This section covers the furnishing and placement of grout to be used in construction.

4.1.2 Submittals

4.1.2.1 Conform to the provisions of Part 1.4 and comply with requirements of Articles 2.1.2.1(c), (d), (h), and 2.1.2.2.

4.1.2.2 When required submit the following in addition to the submittals specified under Article 4.1.2.1.

(a) Type and proportions of the ingredients composing the grout mixture(s) to be used in construction.

(b) Letter certifying that cement conforms to the requirements of the Contract Documents.

(c) Weight slips at time of delivery.

4.1.3 Quality assurance—In compliance with Articles 1.5.2 and 1.6.2, and when required, the designated testing agency will sample and test grout in accordance with ASTM C 1019 for each 5000 ft² of masonry wall surface.

4.1.4 Delivery, handling and storage—The provisions of Article 2.1.4 apply to this section.

4.2—Products

4.2.1 Materials—Unless otherwise required, provide grout that conforms to the requirements of ASTM C 476. Do not use admixtures unless acceptable.

4.2.2 Proportioning and mixing

4.2.2.1 Unless otherwise required, proportion and mix grout in accordance with the requirements of ASTM C 476.

4.2.2.2 Unless otherwise required, mix grout to a consistency which has a slump between 8 and 11 in.

4.3—Execution**4.3.1 Inspection**

4.3.1.1 The provisions of Article 2.3.1 apply to this section.

4.3.2 Preparation

4.3.2.1 Debris—Construct grout spaces free of mortar dropping, debris, loose aggregates, and any material deleterious to masonry grout.

4.3.2.2 Reinforcement

(a) The provisions of Section 3 apply to this section.

(b) Place reinforcement and ties in grout spaces prior to grouting.

4.3.2.3 Cleanouts—Provide cleanouts in the bottom course of masonry for each grout pour, when the grout pour height exceeds 5 ft.

4.3.2.3.1 Where required by Article 4.3.2.3, construct cleanouts adjacent to each vertical bar. In solid grouted masonry, space cleanouts horizontally a maximum of 32 in. on center.

4.3.2.3.2 Construct cleanouts with an opening of sufficient size to permit removal of debris. The minimum opening dimension shall be 3 in.

4.3.2.3.3 After cleaning, close cleanouts with closures braced to resist grout pressure.

4.3.3 Placement

4.3.3.1 Placing time—Place grout within 1½ hr from introducing water in the mixture and prior to initial set.

4.3.3.2 Cold weather—The provisions of Article 2.3.2.2 apply to this section.

4.3.3.3 Confinement—Confine grout to the areas indicated on the Project Drawings. Use material to confine grout that permits bond between masonry units and mortar.

4.3.3.4 Grout pour height—Do not exceed the maximum grout pour height given in Table 4.3.3.4.

Table 4.3.3.4

Specified grout type*	Maximum grout pour height, ft	Minimum width of grout space, in.†‡	Minimum grout space dimensions for grouting cells of hollow units,‡§ in. x in.
Fine	1	¾	1½ x 2
Fine	5	2	2 x 3
Fine	12	2½	2½ x 3
Fine	24	3	3 x 3
Coarse	1	1½	1½ x 3
Coarse	5	2	2½ x 3
Coarse	12	2½	3 x 3
Coarse	24	3	3 x 4

* Fine and coarse grouts are defined in ASTM C 476. Grout shall attain a minimum compressive strength of 2000 psi at 28 days.

† For grouting between masonry wythes.

‡ Grout space dimension is the clear dimension between any masonry protrusion and shall be increased by the diameters of the horizontal bars within the cross section of the grout space.

§ Area of vertical reinforcement shall not exceed 6 percent of the area of the grout space.

4.3.3.5 Grout lift height—Place grout in lifts not exceeding 5 ft.

4.3.3.6 Consolidation—Consolidate grout at the time of placement.

4.3.3.6.1 Consolidate grout pours 12 in. or less in height by mechanical vibration or by puddling.

4.3.3.6.2 Consolidate pours exceeding 12 in. in height by mechanical vibration and reconsolidate by mechanical vibration after initial water loss and settlement has occurred.

Standard Specifications for Tolerances for Concrete Construction and Materials (ACI 117-90)

Reported by ACI Committee 117

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This specification provides standard tolerances for concrete construction. This document is intended to be used as the reference document for establishing tolerances for concrete construction by specification writers and ACI committees writing Standards.

Keywords: bending (reinforcing steels); building codes; concrete construction; concrete piles; concretes; floors; formwork (construction); masonry; mass concrete; piers; precast concrete; prestressed concrete; reinforcing steels; specifications; splicing; standards; tolerances (mechanics).

FOREWORD

F1. This foreword is included for explanatory purposes only; it is not a part of Standard Specification 117.

F2. Standard Specification 117 is a Reference Standard which the Architect/Engineer may cite in the Project Specifications for any construction project, together with supplementary requirements for the specific project.

This standard is not intended to apply to special structures not cited in the standard such as nuclear reactors and containment vessels, bins and silos, and prestressed circular structures. It is also not intended to apply to the specialized construction procedure of shotcrete.

F3. Standard Specification 117 addresses each of the *Three-Part Section Format* of the Construction Specifications Institute, organized by structural elements, structural components and types of structures; the numbering system reflects this organization. The language is imperative and terse to preclude an alternative.

F4. A Specification Checklist is included as a preface to, but not forming a part of, Standard Specification 117. The purpose of this Specification Checklist is to assist the Architect/Engineer in properly choosing and specifying the necessary mandatory and optional requirements for the Project Specification.

PREFACE TO SPECIFICATION CHECKLIST

P1. Standard Specification 117 is intended to be used in its entirety by reference in the Project Specification. Individual sections, articles, or paragraphs should not be copied into the Project Specifications since taking them out of context may change their meaning.

P2. Building codes establish minimum requirements necessary to protect the public. Some of the requirements in this Standard Specification may be more stringent than the minimum in order to insure the level of quality and performance that the Owner expects the structure to provide. Adjustments to the needs of a particular project should be made by the Architect/Engineer by reviewing each of the items in the Specification Checklist and then including the Architect/Engineer's decision on each item as a mandatory requirement in the Project Specifications.

P3. These mandatory requirements should designate the specific qualities, procedures, materials, and performance criteria for which alternatives are permitted or for which provisions were not made in the Standard Specification. Exceptions to the Standard Specification should be made in the Project Specifications, if required.

P4. A statement such as the following will serve to make Standard Specification ACI 117 an official part of the Project Specifications:

Tolerances for Concrete Construction and Materials shall conform to all requirements of ACI 117, Standard Specifications for Tolerances for Concrete Construction and Materials, published by the American Concrete Institute, Detroit, Michigan, except as modified by the requirements of these Contract Documents.

Adopted as a Standard of the American Concrete Institute in November 1989 in accordance with the Institute's standardization procedures.

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*Chairman during initial development of this document.



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P5. The Specification Checklist that follows is addressed to each item of the Standard Specification where the Architect/Engineer must or may make a choice of alternatives; may add provisions if not indicated; or may take exceptions. The Specification

Checklist consists of two columns; the first identifies the sections, parts, and articles of the Standard Specification and the second column contains notes to the Architect/Engineer to indicate the type of action required by the Architect/Engineer.

MANDATORY SPECIFICATION CHECKLIST

Section/Part/Article	Notes to the Architect/Engineer
Section 2—Materials 2.2—Reinforcement	Tolerances for fabrication, placement, and lap splices for welded wire fabric must be specified by the specifier.
Section 3—Foundations 3.1.1 Drilled piers	Specify category of caisson. The designer should be aware that the recommended vertical alignment tolerance of 1.5 percent of the shaft length indicated in Category B caissons is based on experience in a wide variety of soil situations combined with a limited amount of theoretical analysis using the beam on elastic foundation theory and minimum assumed horizontal soil restraint.
Section 4—Cast-in-place concrete for buildings 4.5.4 Form offsets	Designate class of surface (A, B, C, D): Class A — For surfaces prominently exposed to public view where appearance is of special importance. Class B — Coarse-textured concrete-formed surfaces intended to receive plaster, stucco, or wainscoting. Class C — General standard for permanently exposed surfaces where other finishes are not specified. Class D — Minimum quality surface where roughness is not objectionable, usually applied where surfaces will be concealed.
4.5.5 Floor finish	Specify floor finish tolerance measurement method (either Section 4.5.6 or Section 4.5.7).
4.5.5.1 For Section 4.5.6	Designate floor classification (15/13; 20/15; 30/20; or, 50/30).
4.5.5.2 For Section 4.5.7	Designate maximum gap under a freestanding straightedge ($\frac{1}{2}$ in., $\frac{3}{8}$ in., $\frac{1}{4}$ in., or $\frac{1}{8}$ in.).

OPTIONAL SPECIFICATION CHECKLIST

Section 1 — General 1.1.2 Scope	Tolerance values affect construction cost. Specific use of a tolerated item may warrant less or more stringent tolerances than contained in the specification. Such variances must be individually designated by the specifier in the contract documents.
1.1.2 Scope	Tolerances in this specification are for standard concrete construction and construction procedures. Specialized concrete construction or construction procedures require specifier to include specialized tolerances. ACI committee documents covering specialized construction may provide guidance on specialized tolerances. The tolerances in this Specification do not apply to special structures or procedures not cited in the document such as nuclear reactors and containment vessels, bins and silos, circular prestressed concrete tank structures and shotcrete.
1.2.3 Requirements	Where a specific application uses multiply tolerated items that together yield a tolerated result, the specifier must analyze the tolerance envelope with respect to practical limits and design assumptions and specify its value where the standard tolerances values in this specification are inadequate or inappropriate.

OPTIONAL SPECIFICATION CHECKLIST, continued

Section 2 — Materials	
2.2.2 Concrete cover	The tolerance for reduction in cover in reinforcing steel may require a reduction in magnitude where the reinforced concrete is exposed to chlorides or the environment. Where possible excess cover or other protection of the reinforcing steel should be specified in lieu of reduced tolerance because of the accuracy of locating reinforcing steel utilizing standard fabrication accessories and installed procedures. Tolerance given is for general application. Specific design use of embedded items may require the specifier to designate tolerances of reduced magnitude for various embedded items.
2.3.2 Embedded items	
Section 3 — Cast-in-place concrete for foundations	
3.4.1.2 Footings	Plus tolerance for the vertical dimensions is not specified because no limit is imposed. Specifier must designate plus tolerance if desired.
Section 4 — Cast-in-place concrete for buildings	
4.5.5 Floor finish	The procedures for specifying and measuring floor finish tolerances set forth herein are not appropriate for narrow aisle warehouse floors with defined traffic lanes designed for use by specialized wheeled equipment. Consult specific equipment manufacturers for their recommendations.
Section 5 — Precast concrete	
5.1.4 Camber	The tolerances for precast concrete are intended to apply to all types of precast concrete construction cast onsite (<i>including tilt-up</i>) and offsite except as set forth below. Variations to these tolerances may be advisable after consideration of panel size and construction techniques required. Tolerances set forth herein are not intended to apply to plant production of patented or copyrighted structural systems and/or elements. Designers, specifiers and contractors should contact the Licensors of such systems and/or products for applicable tolerances. For members with a span-to-depth ratio equal to or exceeding 30, the stated camber tolerance may require special production measures and result in cost premiums. Where feasible, a greater tolerance magnitude should be utilized where the span-to-depth ratio is equal to or greater than 30.
5.3 Planer elements	Industrial precast products may not conform to the planar tolerances. Manufacturers should be consulted for appropriate tolerances for their products.

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SECTION 1 — GENERAL REQUIREMENTS

1.1 — Scope

1.1.1 This specification designates standard tolerances for concrete construction.

1.1.2 The indicated tolerances govern unless otherwise specified.

1.2 — Requirements

1.2.1 Concrete construction shall meet the specified tolerances.

1.2.2 Tolerances shall not extend the structure beyond legal boundaries.

1.2.3 Tolerances are not cumulative. The most restrictive tolerance controls.

1.2.4 Plus (+) tolerance increases the amount or dimension to which it applies, or raises a level alignment. Minus (−) tolerance decreases the amount or dimension to which it applies, or lowers a level alignment. A nonsigned tolerance means + or −. Where only one signed tolerance is specified (+ or −), there is no limit in the other direction.

1.3 — Definitions

Arris — The line, edge, or hip in which two straight or curved surfaces of a body, forming an exterior angle, meet; a sharp ridge, as between adjoining channels of a Doric column.

Bowing — The displacement of the surface of a planar element from a plane passing through any three corners of the element.

Clear distance — In reinforced concrete, the least distance between the surface of the reinforcement and the referenced surface, i.e., the form, adjacent reinforcement, embedment, concrete, or other surface.

Concealed surface — Surface not subject to visual observation during normal use of the element.

Contract documents — The project contract, the project drawings, and the project specifications.

Cover — In reinforced concrete, the least distance between the surface of the reinforcement and the outer surface of the concrete.

Flatness — The degree to which a surface approximates a plane.

Lateral alignment — The location relative to a specified horizontal line or point in a horizontal plane.

Level alignment — The location relative to a specified horizontal plane. When applied to roadways, bridge decks, slabs, ramps, or other nominally horizontal surfaces established by elevations, level alignment is defined as the vertical location of the surface relative to the specified profile grade and specified cross slope.

Levelness — The degree to which a line or surface parallels horizontal.

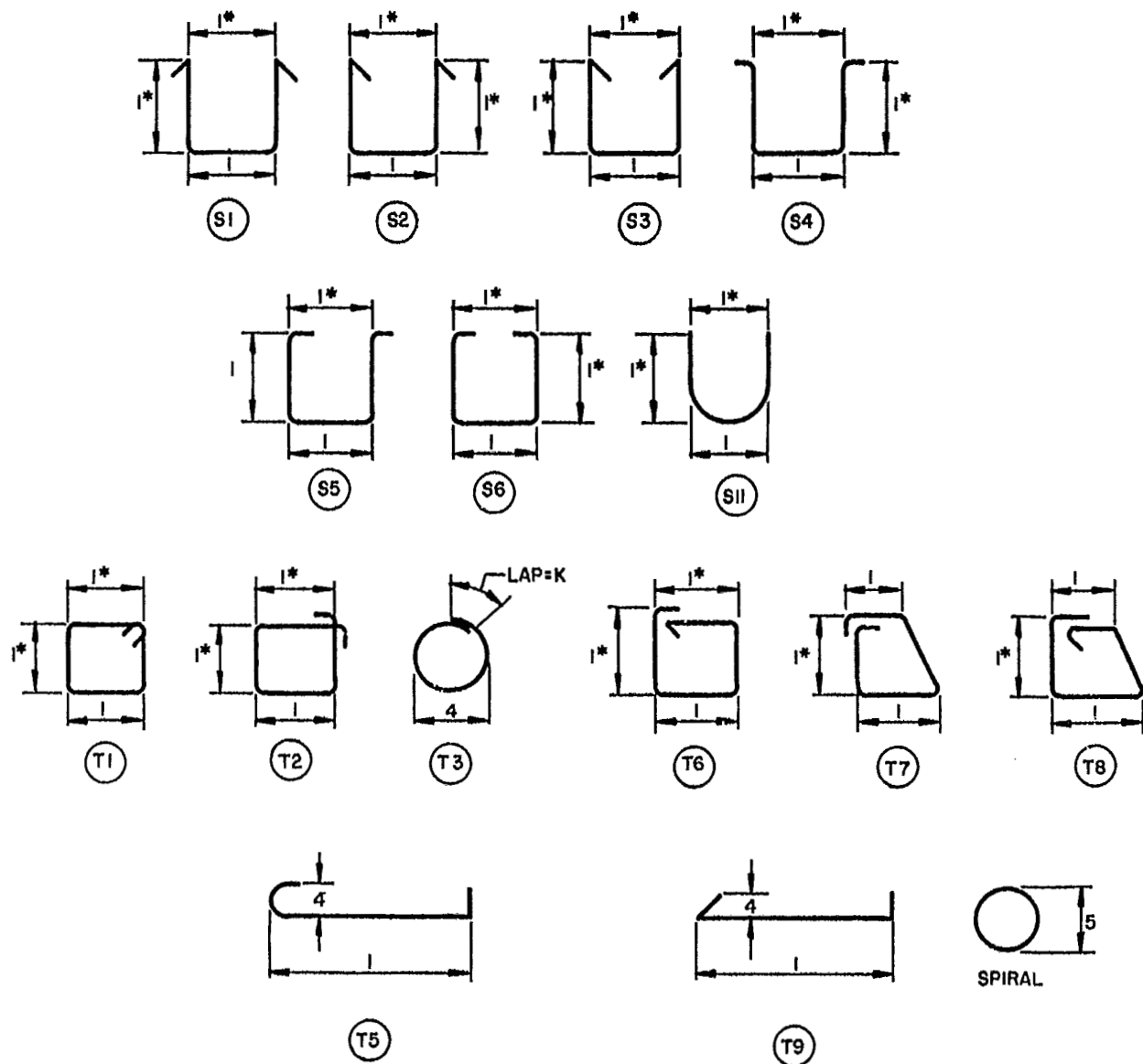
Precast linear element — Beam, column, or similar unit.

Precast planar element — Wall panel, floor panel, or similar unit.

Project Specifications — The building specifications which employ ACI 117 by reference, and which serve as the instrument for making the mandatory and optional selections available under these and for specifying items not covered herein.

Relative alignment — The distance between two or more elements in any plane, or the distance between adjacent elements, or the distance between an element and a defined point or plane.

Spiral — As used in circular stave silo construction is defined as the distortion that results when the staves are misaligned so that their edges are inclined while their outer faces are vertical. The resulting assembly



NOTES:

Entire shearing and bending tolerances are customarily absorbed in the extension past the last bend in a bent bar.

All tolerances single plane and as shown. Tolerances for Types S1 through S6, S11, and T1 through T9 apply only the Bar Sizes #3 through #8.

*Dimensions on this line are to be within tolerance shown, but are not to differ from opposite parallel dimension more than 1/2 in.

Angular deviation—Maximum plus or minus 2 1/2 deg or plus or minus 1/2 in. per ft, but not less than 1/2 in., on all 90-deg hooks and bends.

TOLERANCE SYMBOLS:

1. Bar Sizes #3, #4, #5:
= plus or minus 1/2 in. when gross bar length < 12 ft
= plus or minus 1 in. when gross bar length ≥ 12 ft
2. Plus or minus 1 in.
3. Plus 0, minus 1/2 in.
4. Plus or minus 1/2 in.
5. Plus or minus 1/2 in. for diameter ≤ 30 in.
Plus or minus 1 in. for diameter > 30 in.
6. Plus or minus 1.5 percent of o dimension ≥ plus or minus 2 in. minimum. If application of positive tolerance to Type 9 results in a chord length equal to or greater than the arc or bar length, the bar may be shipped straight.

Fig. 2.1(a) — Standard fabricating tolerances for bar sizes #3 through #11

horizontal location of the surface relative to the specified profile.

Warping — The displacement of the surface, portion, or edge of a planar element from a plane passing through any three corners of the element.

SECTION 2 — MATERIALS

2.1 — Reinforcing steel fabrication

For bars #3 and #11 in size, see Fig. 2.1(a).

For bars #14 and #18 in size, see Fig. 2.1(b).

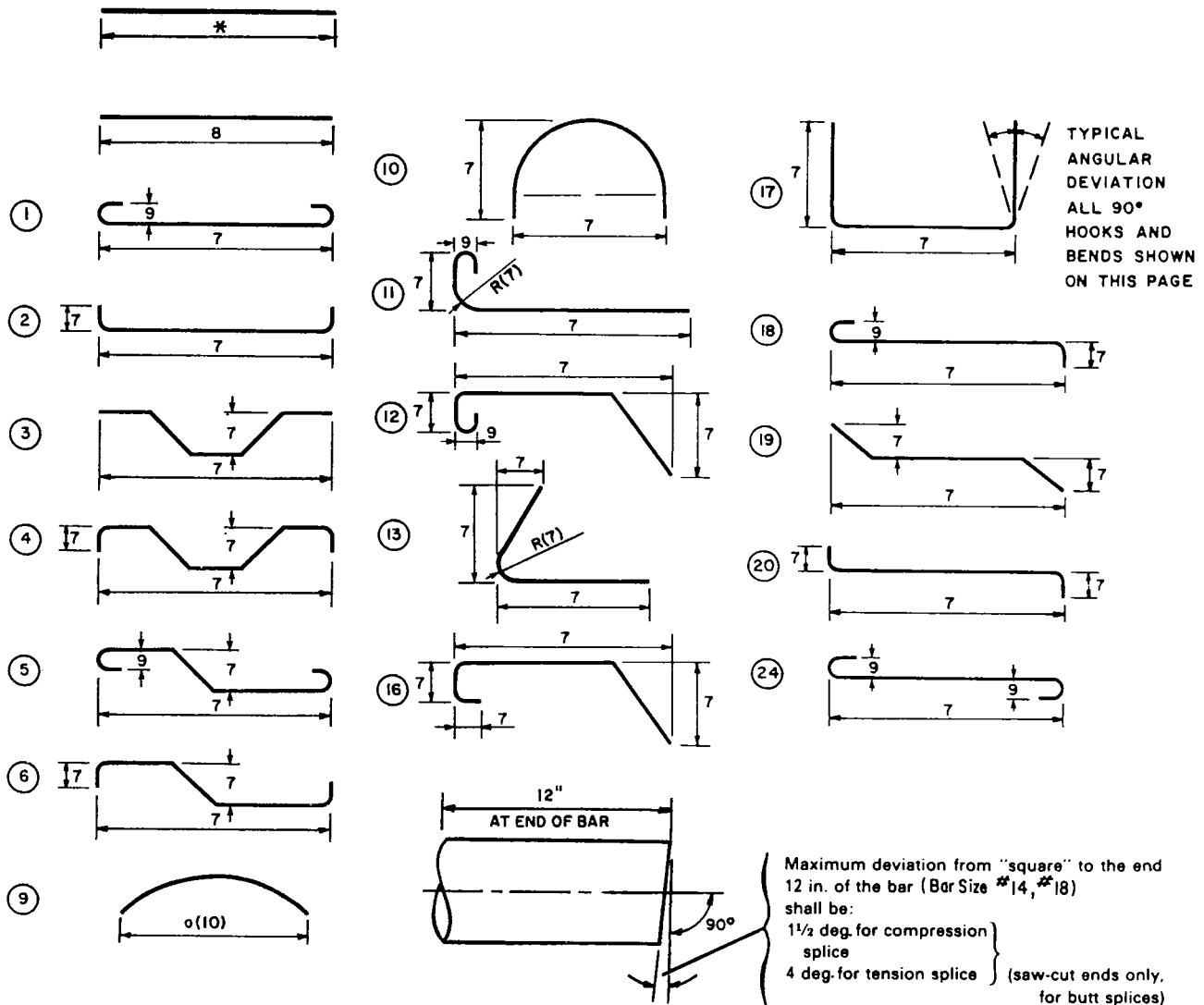


Fig. 2.1(b) — Standard fabricating tolerances for bar sizes #14 and #18

2.2 — Reinforcement placement

2.2.1 Tolerances shall not permit a reduction in cover except as set forth in Section 2.2.2 hereof.

2.2.2 Clear distance to side forms and resulting concrete surfaces and clear distance to formed and resulting concrete soffits in direction of tolerance

When member size is 4 in. or less + 1/4 in.
..... - 3/8 in.

When member size is over 4 in. but not over 12 in. 3/8 in.

When member size is over 12 in. but not over 2 ft 1/2 in.

When member size is over 2 ft 1 in.

2.2.3 Concrete cover measured perpendicular to concrete surface in direction of tolerance

When member size is 12 in. or less - 3/8 in.

When member size is over 12 in. - 1/2 in.

Reduction in cover shall not exceed one-third specified concrete cover.

Reduction in cover to formed soffits shall not exceed 1/4 in.

2.2.4 Distance between reinforcement:

One-quarter specified distance not to exceed

..... 1 in.

Providing that distance between reinforcement shall not be less than the greater of the bar di-

iameter or 1 in. for unbundled bars.

For bundled bars, the distance between bundles shall not be less than the greater of 1 in. or 1.4 times the individual bar diameter for 2 bar bundles, 1.7 times the individual bar diameter for 3 bar bundles and 2 times the individual bar diameter for 4 bar bundles.

2.2.5 Spacing of nonprestressed reinforcement, deviation from specified location

In slabs and walls other than stirrups and ties
.....3 in.

Stirrups depth of beam in inches/12 × 1 in.

Ties

.....least width of column in inches/12 × 1 in.

However, total number of bars shall not be less than that specified.

2.2.6 Placement of prestressing reinforcement or prestressing steel ducts

2.2.6.1 Lateral placement

Member depth (or thickness) 24 in. or less

..... ½ in.

Member depth (or thickness) over 24 in. 1 in.

2.2.6.2 Vertical placement

Member depth (or thickness) 8 in. or less

..... ¼ in.

Member depth (or thickness) over 8 in. but not

over 24 in. ¾ in.

Member depth (or thickness) more than 24

in. ½ in.

2.2.7 Longitudinal location of bends and ends of bars:

At discontinuous ends of members 1 in.

At other locations 2 in.

2.2.8 Embedded length of bars and length of bar laps:

#3 through #11 bar sizes - 1 in.

#14 and #18 bar sizes (embedment only) - 2 in.

2.2.9 Bearing plate for prestressing tendons, deviation from specified plane..... 1 degree

2.3 — Placement of embedded items

2.3.1 Clearance to reinforcement the greater of the bar diameter or 1 in.

2.3.2 Vertical alignment, lateral alignment, and level alignment.....1 in.

2.4 — Concrete batching

See Table 2.4.

2.5 — Concrete properties

2.5.1 Slump, where specified as "maximum" or "not to exceed," for all values..... + 0 in.

Specified slump 3 in. or less - 1 ½ in.

Specified slump more than 3 in. - 2 ½ in.

Slump, when specified as a single value

Specified slump 4 in. or less 1 in.

Specified slump more than 4 in. 1 ½ in.

Where range is specified there is no tolerance.

2.5.2 Air content, where no range is specified and specified air content by volume is 4 percent or greater..... 1 ½ percent

Where range is specified, there is no tolerance.

SECTION 3 — FOUNDATIONS

3.1 — Vertical alignment

3.1.1 Drilled piers

3.1.1.1 *Category A* — For unreinforced shafts extending through materials offering no or minimal lateral restraint (i.e., water, normally consolidated organic soils, and soils that might liquefy during an earthquake) — 12.5 percent of shaft diameter.

3.1.1.2 *Category B* — For unreinforced shafts extending through materials offering lateral restraint (soils other than those indicated in Category A) — not more than 1.5 percent of the shaft length.

3.1.1.3 *Category C* — For reinforced concrete shafts — not more than 2.0 percent of the shaft length.

3.2 — Lateral alignment

3.2.1 Footings

As cast to the center of gravity as specified; 0.02 times width of footing in direction of misplacement but not more than 2 in.

Supporting masonry 2 in.

3.2.2 Drilled piers

3.2.2.1 ¼ of shaft diameter but not more than

.....3 in.

Table 2.4

Material	Tolerance
Cementitious materials 30% of scale capacity or greater Less than 30% of scale capacity	1% of cumulative weight - 0% to + 4% of the required cumulative weight
Water Added water or ice	1% of the total water content which includes added water, ice, and water on aggregates
Total water content	3% of total water content
Aggregates a) Cumulative batching Over 30% of scale capacity 30% of scale capacity or less	1% of the required cumulative weight 0.3% of scale capacity or 3% of the required cumulative weight, whichever is less
b) Individual material batching	2% of the required weight
Admixtures	3% of the required amount

Floor profile quality classification	Minimum $F_r F_l$ number required			
	Test area		Minimum local F number	
	Flatness F_r	Level F_l	Flatness F_r	Level F_l
Conventional				
Bullfloated	15	13	13	10
Straightedged	20	15	15	10
Flat	30	20	15	10
Very flat	50	30	25	15

3.3 — Level alignment**3.3.1 Footings**3.3.1.1 Top of footings supporting masonry $\frac{1}{2}$ in.3.3.1.2 Top of other footings + $\frac{1}{2}$ in.
..... - 2 in.**3.3.2 Drilled piers**3.3.2.1 Cut-off elevation + 1 in.
..... - 3 in.**3.4 — Cross-sectional dimensions****3.4.1 Footings**3.4.1.1 Horizontal dimension of formed members
..... + 2 in.
..... - $\frac{1}{2}$ in.

3.4.1.2 Horizontal dimension of unformed members cast against soil

2 ft. or less + 3 in.
..... - $\frac{1}{2}$ in.Greater than 2 ft. but less than 6 ft. + 6 in.
..... - $\frac{1}{2}$ in.Over 6 ft. + 12 in.
..... - $\frac{1}{2}$ in.

3.4.1.3 Vertical dimension (thickness) - 5 percent

3.5 — Relative alignment

3.5.1 Footing side and top surfaces may slope with respect to the specified plane at a rate not to exceed the following amounts in 10 ft. 1 in.

SECTION 4 — CAST-IN-PLACE CONCRETE FOR BUILDINGS**4.1 — Vertical alignment****4.1.1 For heights 100 ft or less**Lines, surfaces, and arrises 1 in.
Outside corner of exposed corner columns and control joint grooves in concrete exposed to view $\frac{1}{2}$ in.**4.1.2 For heights greater than 100 ft**Lines, surfaces, and arrises, $\frac{1}{1000}$ times the height but not more than 6 in.
Outside corner of exposed corner columns and control joint grooves in concrete, $\frac{1}{2000}$ times the height but not more than 3 in.**4.2 — Lateral alignment**

4.2.1 Members 1 in.

4.2.2 In slabs, centerline location of openings 12 in. or smaller and edge location of larger openings .. $\frac{1}{2}$ in.4.2.3 Sawcuts, joints, and weakened plane embeddings in slabs $\frac{3}{4}$ in.**4.3 — Level alignment****4.3.1 Top of slabs:**4.3.1.1 Elevation of slabs-on-grade $\frac{3}{4}$ in.4.3.1.2 Elevation of top surfaces of formed slabs before removal of supporting shores $\frac{3}{4}$ in.4.3.2 Elevation of formed surfaces before removal of shores $\frac{3}{4}$ in.4.3.3 Lintels, sills, parapets, horizontal grooves, and other lines exposed to view $\frac{1}{2}$ in.**4.4 — Cross-sectional dimensions**

4.4.1 Members, such as columns, beams, piers, walls (thickness only), and slabs (thickness only)

12 in. dimension or less + $\frac{3}{8}$ in.
..... - $\frac{1}{4}$ in.More than 12 in. dimension but not over 3 ft dimension + $\frac{1}{2}$ in...... - $\frac{3}{8}$ in.Over 3 ft dimension + 1 in.
..... - $\frac{3}{4}$ in.**4.5 — Relative alignment****4.5.1 Stairs**Difference in height between adjacent risers $\frac{1}{8}$ in.Difference in width between adjacent trends $\frac{1}{4}$ in.**4.5.2 Grooves**Specified width 2 in. or less $\frac{1}{8}$ in.Specified width more than 2 in. but not more than 12 in. $\frac{1}{4}$ in.

4.5.3 Formed surfaces may slope with respect to the specified plane at a rate not to exceed the following amounts in 10 ft

4.5.3.1 Vertical alignment of outside corner of exposed corner columns and control joint grooves in concrete exposed to view $\frac{1}{4}$ in.4.5.3.2 All other conditions $\frac{3}{8}$ in.

4.5.4. The offset between adjacent pieces of formwork facing material shall not exceed:

Class of surface:

Class A $\frac{1}{8}$ in.Class B $\frac{1}{4}$ in.Class C $\frac{1}{2}$ in.

Class D 1 in.

4.5.5 Floor finish tolerances shall meet the requirements of either Section 4.5.6 or 4.5.7, as set forth by the specifier.

4.5.6 Floor finish tolerances as measured in accordance with ASTM E 1155-87 Standard Test Method for Determining Floor Flatness and Levelness Using the F-Number System (Inch-Pound Units)

4.5.6.1 The F_L levelness tolerance shall not apply to slabs placed on unshored form surfaces and/or shored form surfaces after the removal of shores. F_L levelness tolerances shall not apply to cambered or inclined surfaces and shall be measured within 72 hr after slab concrete placement.

4.5.7 Floor finish tolerances as measured by placing a freestanding (unleveled) 10 ft. straightedge anywhere on the slab and allowing it to rest upon two high spots within 72 hr after slab concrete placement. The gap at any point between the straightedge and the floor (and between the highspots) shall not exceed:

Classification:

Conventional

Bullfloated $\frac{1}{2}$ in.Straightedged $\frac{1}{6}$ in.**Documents**

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SECTION 6 — MASONRY**6.1 — Vertical alignment**

- In surface of wall $\frac{3}{4}$ in.
 In alignment of head joints $\frac{1}{2}$ in.

6.2 — Lateral alignment

- 6.2.1 *Vertical members* $\frac{1}{2}$ in.

6.3 — Level alignment

- 6.3.1 *In bed joints and top of wall,*
exposed $\frac{1}{2}$ in.
Not exposed 1 in.
 6.3.2 *Top of wall used for a bearing surface* ... $\frac{1}{2}$ in.
 6.3.3 *Top of wall, other than a bearing surface*
 $\frac{3}{4}$ in.

6.4 — Cross-sectional dimensions

- 6.4.1 *Multiwythed walls* + $\frac{1}{2}$ in.
 - $\frac{1}{4}$ in.
 6.4.2 *Other members* + $\frac{1}{2}$ in.
 $\frac{1}{4}$ in.
 6.4.3 *Joint thickness* $\frac{1}{8}$ in.

6.5 — Relative alignment

- 6.5.1 *Masonry surfaces may slope with respect to the specified plane at a rate not to exceed the following amounts in 10 ft*

- 6.5.1.1 *Walls and columns* $\frac{1}{4}$ in.
 6.5.1.2 *Bed joints, head joints,*
and top of wall $\frac{1}{4}$ in.
 6.5.1.3 *Top of wall* $\frac{1}{4}$ in.

SECTION 7 — CAST-IN-PLACE, VERTICALLY SLIPFORMED BUILDING ELEMENTS**7.1 — Vertical alignment**

- 7.1.1 *Translation and rotation from a fixed point at the base of the structure:*

- For heights 100 ft. or less 2 in.
 For heights greater than 100 ft., 1/600 times the height but not more than 8 in.

7.2 — Lateral alignment

- Between adjacent elements 2 in.

7.3 — Cross-sectional dimensions

- Walls + $\frac{3}{4}$ in.
 - $\frac{3}{8}$ in.

7.4 — Relative alignment

- Formed surfaces may slope with respect to the specified plane at a rate not to exceed the following amount in 10 ft. $\frac{1}{4}$ in.

SECTION 8 — MASS CONCRETE STRUCTURES OTHER THAN BUILDINGS**8.1 — Vertical alignment**

- 8.1.1 *Surfaces*
 Visible surfaces $1\frac{1}{4}$ in.
 Concealed surfaces $2\frac{1}{2}$ in.
 8.1.2 *Side walls for radial gates and similar watertight joints* $\frac{3}{16}$ in.

8.2 — Lateral alignment

- Visible surfaces $1\frac{1}{4}$ in.
 Concealed surfaces $2\frac{1}{2}$ in.

8.3 — Level alignment**8.3.1 General**

- Visible flatwork and formed surfaces $\frac{1}{2}$ in.
 Concealed flatwork and formed surfaces ... 1 in.

- 8.3.2 *Sills for radial gates and similar watertight joints* $\frac{1}{16}$ in.

8.4 — Relative alignment

- 8.4.1 *Formed surfaces may slope with respect to the specified plane at a rate not to exceed the following amount in 10 ft*

8.4.1.1 Slopes in lateral and level alignments

- Visible surfaces $\frac{1}{4}$ in.
 Concealed surfaces $\frac{1}{2}$ in.

8.4.1.2 Slopes in vertical alignment

- Visible surfaces $\frac{1}{2}$ in.
 Concealed surfaces 1 in.

SECTION 9 — CANAL LINING**9.1 — Lateral alignment**

- 9.1.1 *Alignment of tangents* 2 in.
 9.1.2 *Alignment of curves* 4 in.
 9.1.3 *Width of section at any height: 0.0025 times specified width W plus one in.* $0.0025W + 1$ in.

9.2 — Level alignment

- 9.2.1 *Profile grade* 1 in.
 9.2.2 *Surface of invert* $\frac{1}{4}$ in.
 9.2.3 *Surface of side slope* $\frac{1}{2}$ in.
 9.2.4 *Height of lining: 0.005 times established height H plus one in.* $0.005H + 1$ in.

9.3 — Cross-sectional dimensions

- Thickness of lining cross section: 10 percent of specified thickness provided average thickness is maintained as determined by daily batch volumes.

SECTION 10 — MONOLITHIC SIPHONS AND CULVERTS**10.1 — Lateral alignment**

- 10.1.1 *Centerline alignment* 1 in.
 10.1.2 *Inside dimensions:*
 0.005 times inside dimension

10.2 — Level alignment

- 10.2.1 *Profile grade* 1 in.
 10.2.2 *Surface of invert* $\frac{1}{4}$ in.
 10.2.3 *Surface of side slope* $\frac{1}{2}$ in.

10.3 — Cross-sectional dimensions**10.3.1 Cross section at any point**

- Increase thickness: greater of 0.05 times thickness, or + $\frac{1}{2}$ in.
 Decrease thickness: greater of 0.25 times thickness, or - $\frac{1}{4}$ in.

SECTION 11 — CAST-IN-PLACE BRIDGES**11.1 — Vertical alignment**

- 11.1.1 *Exposed surfaces* $\frac{3}{4}$ in.
 11.1.2 *Concealed surfaces* $1\frac{1}{2}$ in.

11.2 — Lateral alignment

- Centerline alignment 1 in.

11.3 — Level alignment

- 11.3.1 *Profile grade* 1 in.
 11.3.2 *Top of other concrete surfaces and horizontal grooves*
 Exposed $\frac{3}{4}$ in.
 Concealed $1\frac{1}{2}$ in.
 11.3.3 *Mainline pavements in longitudinal direction, the gap below a 10 ft unleveled straightedge resting on highspots shall not exceed* $\frac{1}{8}$ in.
 11.3.4 *Mainline pavements in transverse direction, the gap below a 10 ft unleveled straightedge resting on highspots shall not exceed* $\frac{1}{4}$ in.
 11.3.5 *Ramps, sidewalks, and intersections, in any direction, the gap below a 10 ft unleveled straightedge resting on highspots shall not exceed* $\frac{1}{4}$ in.

11.4 — Cross-sectional dimensions

- 11.4.1 *Bridge slabs vertical dimension (thickness)* $+\frac{1}{4}$ in.
 $-\frac{1}{4}$ in.
 11.4.2 *Members such as columns, beams, piers, walls, and other (slabs thickness only)* $+\frac{1}{2}$ in.
 $-\frac{1}{4}$ in.
 11.4.3 *Openings through concrete members* $\frac{1}{2}$ in.

11.5 — Relative alignment

- 11.5.1 *Location of openings through concrete members* $\frac{1}{2}$ in.
 11.5.2 *Formed surfaces may slope with respect to the specified plane at a rate not to exceed the following amounts in 10 ft*
 Watertight joints $\frac{1}{8}$ in.
 Other exposed surfaces $\frac{1}{2}$ in.
 Concealed surfaces 1 in.
 11.5.3 *Unformed exposed surfaces, other than pavements and sidewalks, may slope with respect to the specified plane at a rate not to exceed the following amounts*
 In 10 ft $\frac{1}{4}$ in.
 In 20 ft $\frac{3}{8}$ in.

SECTION 12 — PAVEMENTS AND SIDEWALKS**12.1 — Lateral alignment**

- 12.1.1 *Placement of dowels* 1 in.
 12.1.2 *Alignment of dowels, relative to centerline of pavement, 18 in. or less projection* $\frac{1}{4}$ in.
 greater than 18 in. projection
 Not established

12.2 — Level alignment

- 12.2.1 *Mainline pavements in longitudinal direction, the gap below a 10 ft unleveled straightedge resting on*

highspots shall not exceed $\frac{1}{8}$ in.

12.2.2 *Mainline pavements in transverse direction, the gap below a 10 ft unleveled straightedge resting on highspots shall not exceed* $\frac{1}{4}$ in.

12.2.3 *Ramps, sidewalks, and intersections, in any direction, the gap below a 10 ft unleveled straightedge resting on highspots shall not exceed* $\frac{1}{4}$ in.

SECTION 13 — CHIMNEYS AND COOLING TOWERS**13.1 — Vertical alignment**

Translation, rotation or variance from vertical axis the greater of 1/1000 times the height at time of measurement, or 1 in.

In any 10 ft of height the centerpoint shall not change more than 1 in.

13.2 — Diameter

Outside shell diameter 1/1000 times the specified diameter plus 1 in.

13.3 — Wall thickness

The average of four wall thickness measurements taken over a 60 deg arc.

- Specified wall thickness 10 in. or less* $-\frac{1}{4}$ in.
 $+\frac{1}{2}$ in.
Specified wall thickness greater than 10 in. $-\frac{1}{2}$ in.
 $+1$ in.

SECTION 14 — NONREINFORCED CAST-IN-PLACE PIPE**14.1 — Wall thickness**

Minimum wall thickness at any point shall be 1/12 times the specified internal diameter of the pipe plus $\frac{1}{2}$ in., but in no case less than 2 in.

14.2 — Pipe diameter

The internal diameter at any point shall not be less than 95 percent of the specified diameter, the average of any four measurements taken at 45 deg intervals shall not be less than the specified diameter.

14.3 — Offsets

- At formlaps and horizontal edges shall not exceed:
For pipe with an internal diameter not greater than 42 in. $\frac{1}{2}$ in.
For pipe with an internal diameter 43 through 72 in. $\frac{3}{4}$ in.
For pipe with an internal diameter greater than 72 in. 1 in.

14.4 — Surface indentations

Maximum allowable $\frac{1}{2}$ in.



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This standard was submitted to letter ballot of the committee and approved in accordance with the Institute's balloting procedures.



Designation: A 36/A 36M – 90

Standard Specification for Structural Steel¹

This standard is issued under the fixed designation A 36/A 36M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

^{ε1} NOTE—Table 3, Footnote B, was corrected editorially and the designation date changed effective Sept. 28, 1990.

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1. Scope

1.1 This specification² covers carbon steel shapes, plates, and bars of structural quality for use in riveted, bolted, or welded construction of bridges and buildings, and for general structural purposes.

1.2 Supplemental requirements are provided where improved internal quality and notch toughness are important. These shall apply only when specified by the purchaser in the order.

1.3 When the steel is to be welded, it is presupposed that a welding procedure suitable for the grade of steel and intended use or service will be utilized.

1.4 The purchaser should consider specifying supplemental requirements, such as fine austenitic grain size and Charpy V-Notch Impact requirements, when Group 4 or Group 5 wide flange shapes are specified for use in other than column or compression applications.

1.5 The values stated in either inch-pound units or SI (metric) units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents, therefore, each system must be used independent of the other. Combining values from the two systems may result in nonconformance with this specification.

2. Referenced Documents

2.1 ASTM Standards:

- A 6/A 6M Specification for General Requirements for Rolled Steel Plates, Shapes, Sheet Piling, and Bars for Structural Use³
- A 27/A 27M Specification for Steel Castings, Carbon, for General Application⁴
- A 283/A 283M Specification for Low and Intermediate Tensile Strength Carbon Steel Plates³
- A 307 Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength⁵

¹ This specification is under the jurisdiction of ASTM Committee A-1 on Steel, Stainless Steel, and Related Alloys, and is the direct responsibility of Subcommittee A01.02 on Structural Steel for Bridges, Buildings, Rolling Stock, and Ships.

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² For ASME Boiler and Pressure Vessel Code Applications, see related Specifications SA-36 in Section II of that Code.

³ Annual Book of ASTM Standards, Vol 01.04.

⁴ Annual Book of ASTM Standards, Vol 01.02.

⁵ Annual Book of ASTM Standards, Vol 15.08.

A 325 Specification for High-Strength Bolts for Structural Steel Joints⁵

A 325M Specification for High-Strength Bolts for Structural Steel Joints [Metric]⁵

A 500 Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes³

A 501 Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing³

A 502 Specification for Steel Structural Rivets⁵

A 563 Specification for Carbon and Alloy Steel Nuts⁵

A 563M Specification for Carbon and Alloy Steel Nuts [Metric]⁵

A 570/A 570M Specification for Steel, Sheet and Strip, Carbon, Hot-Rolled, Structural Quality³

A 668 Specification for Steel Forgings, Carbon and Alloy, for General Industrial Use⁶

F 568 Specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners⁵

3. Appurtenant Materials

3.1 Unless otherwise provided in the order, the current edition of the specifications of ASTM listed in Table 1 shall govern the delivery of otherwise unspecified materials not available in the product forms covered by this specification when included with material purchased under this specification. Unless otherwise specified, all plain and threaded bars used for anchorage purposes shall be subjected to mechanical tests and shall conform to the tensile requirements of Section 8; headed bolts used for anchorage purposes shall conform to Specification A 307 or F 568; and all nuts shall conform to the requirements of Specification A 563, Grade A, or A 563M, Class 5.

4. General Requirements for Delivery

4.1 Material furnished under this specification shall conform to the applicable requirements of the current edition of Specification A 6/A 6M.

5. Bearing Plates

5.1 Unless otherwise specified, plates used as bearing plates for bridges shall be subjected to mechanical tests and shall conform to the tensile requirements of Section 8.

⁶ Annual Book of ASTM Standards, Vol 01.05.



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TABLE 1 Appurtenant Material Specifications

NOTE—The specifier should be satisfied of the suitability of these materials for the intended application. Composition and/or mechanical properties may be different than specified in A 36/A 36M.

Material	ASTM Designation
Plate to be bent or formed cold	A 283/A 283M, Grade C
Steel rivets	A 502, Grade 1
Bolts	A 307, Grade A or F 568, Class 4.6
High-strength bolts	A 325 or A 325M
Steel nuts	A 563 or A 563M
Cast steel	A 27/A 27M, Grade 65–35 [450–240]
Forgings (carbon steel)	A 668, Class D
Hot-rolled sheets and strip	A 570/A 570M, Grade 36
Cold-formed tubing	A 500, Grade B
Hot-formed tubing	A 501

5.2 Unless otherwise specified, mechanical tests shall not be required for plates over 1½ in. [40 mm] in thickness used as bearing plates in structures other than bridges, subject to the requirement that they shall contain 0.20 to 0.33 % carbon by heat analysis, that the chemical composition shall conform to the requirements of Table 2 in phosphorus and sulfur content, and that a sufficient discard shall be made to secure sound plates.

6. Process

6.1 The steel shall be made by one or more of the following processes: open-hearth, basic-oxygen, or electric-furnace.

6.2 No rimmed or capped steel shall be used for plates and bars over ½ in. [12.5 mm] thick or for shapes other than Group 1.

7. Chemical Requirements

7.1 The heat analysis shall conform to the requirements prescribed in Table 2, except as specified in 5.2.

7.2 The steel shall conform on product analysis to the requirements prescribed in Table 2, subject to the product analysis tolerances in Specification A 6/A 6M, except as specified in 7.3.

7.3 Product analysis is not applicable for bar-size shapes

or flat bars ½ in. [12.5 mm] and under in thickness.

7.4 When tension tests are waived in accordance with 8.2, chemistry consistent with the requirements in Table 2, and with the mechanical properties desired must be applied.

8. Tensile Requirements

8.1 The material as represented by the test specimen, except as specified in 5.2 and 8.2, shall conform to the requirements as to the tensile properties prescribed in Table 3.

TABLE 3 Tensile Requirements^A

Plates, Shapes, ^B and Bars:	
Tensile strength, ksi [MPa]	58–80 [400–550]
Yield point, min, ksi [MPa]	36 [250] ^C
Plates and Bars ^{D,E} :	
Elongation in 8 in. [200 mm], min, %	20 ^F
Elongation in 2 in. [50 mm], min, %	23 ^G
Shapes:	
Elongation in 8 in. [200 mm], min, %	20 ^F
Elongation in 2 in. [50 mm], min, %	21 ^{B,G}

^A For plates wider than 24 in. [600 mm], the test specimen is taken in the transverse direction. See Orientation under the Tension Tests section of Specification A 6/A 6M.

^B For wide flange shapes over 426 lb/ft [634 kg/m], the 80 ksi [550 MPa] maximum tensile strength does not apply and a minimum elongation in 2 in. [50 mm] of 19 %, applies.

^C Yield point 32 ksi [220 MPa] for plates over 8 in. [200 mm] in thickness.

^D Elongation not required to be determined for floor plate.

^E For plates wider than 24 in. [600 mm], the elongation requirement is reduced two percentage points.

^F For nominal thicknesses or diameters under ¾ in. [8 mm], a deduction from the specified percentage of elongation in 8 in. [200 mm] shall be made for decreases of the nominal thickness or diameter below ¾ in. [8 mm]. See elongation requirement adjustments under the Tension Tests section of Specification A 6/A 6M for deduction values.

^G For nominal thicknesses or diameters over 3.5 in. [90 mm], a deduction from the specified percentage of elongation in 2 in. [50 mm] shall be made for increases of the nominal thickness or diameter above 3.5 in. [90 mm]. See elongation requirement adjustments under the Tension Tests section of Specification A 6/A 6M for deduction values.

8.2 Shapes less than 1 in.² [645 mm²] in cross section and bars, other than flats, less than ½ in. [12.5 mm] in thickness or diameter need not be subjected to tension tests by the manufacturer.

TABLE 2 Chemical Requirements

Product	Shapes ^A	Plates ^B					Bars			
		To ¾ [20], incl	Over ¾ to 1½ [20 to 40], incl	Over 1½ to 2½ [40 to 65], incl	Over 2½ to 4 [65 to 100], incl	Over 4 [100]	To ¾ [20], incl	Over ¾ to 1½ [20 to 40], incl	Over 1½ to 4 [100], incl	Over 4 [100]
Thickness, in. [mm]	All									
Carbon, max, %	0.26	0.25	0.25	0.26	0.27	0.29	0.26	0.27	0.28	0.29
Manganese, %	...	...	0.80–1.20	0.80–1.20	0.85–1.20	0.85–1.20	...	0.60–0.90	0.60–0.90	0.60–0.90
Phosphorus, max, %	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Sulfur, max, %	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Silicon, %	...	...	...	0.15–0.40	0.15–0.40	0.15–0.40	...	...	...	...
Copper, min, % when copper steel is specified	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20

^A Manganese content of 0.85–1.35 % and silicon content of 0.15–0.40 % is required for shapes over 426 lb/ft [634 kg/m].

^B For each reduction of 0.01 % below the specified carbon maximum, an increase of 0.06 % manganese above the specified maximum will be permitted up to the maximum of 1.35 %.

SUPPLEMENTARY REQUIREMENTS

These requirements shall not apply unless specified in the order.

Standardized supplementary requirements for use at the option of the purchaser are listed in Specification A 6/A 6M. Those that are considered suitable for use with this specification are listed by title:

S5. Charpy V-Notch Impact Test.

S14. Bend Test.

ADDED SUPPLEMENTARY REQUIREMENTS

In addition, the following optional supplementary requirements are also suitable for use with this specification.

S91. Fine Austenitic Grain Size

S91.1 The steel shall be killed and have a fine austenitic grain size.

S97. Limitation on Rimmed or Capped Steel

S97.1 The steel shall be other than rimmed or capped.

S98. Information Reporting of Unspecified Elements

S98.1 Test reports, shall include for information the chemical analyses for copper, columbium, chromium, nickel, molybdenum, and vanadium. When the amount of an element present is less than 0.02 %, the analysis may be reported as equal to or less than 0.02 %.

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If not listed in the current combined index, will appear in the next edition.

Standard Specification for Steel Wire, Plain, for Concrete Reinforcement¹

This standard is issued under the fixed designation A 82; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This specification covers cold-drawn steel wire, as-drawn or galvanized, to be used as such, or in fabricated form, for the reinforcement of concrete, in sizes not less than 0.080 in. (2.03 mm) nominal diameter.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are provided for information purposes only.

2. Referenced Documents

2.1 ASTM Standards:

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products²

A 641 Specification for Zinc-Coated (Galvanized) Carbon Steel Wire³

A 700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Domestic Shipment⁴

E 83 Practice for Verification and Classification of Extensometers⁵

2.2 U.S. Military Standards:

MIL-STD-129 Marking for Shipment and Storage⁶

MIL-STD-163 Steel Mill Products Preparation for Shipment and Storage⁶

2.3 U.S. Federal Standard:

Fed. Std. No. 123 Marking for Shipments (Civil Agencies)⁶

3. General Requirements

3.1 When wire for concrete reinforcement is ordered by size number, the following relation between size number, diameter, and area shall apply:

Size Number	Nominal Diameter, in. (mm)	Nominal Area, in. ² (mm ²)
W0.5	0.080 (2.03)	0.005 (3.23)
W1.2	0.124 (3.15)	0.012 (7.74)
W1.4	0.134 (3.40)	0.014 (9.08)
W2	0.160 (4.06)	0.020 (12.90)
W2.5	0.178 (4.52)	0.025 (16.13)
W2.9	0.192 (4.88)	0.029 (18.70)
W3.5	0.211 (5.36)	0.035 (22.58)

Size Number	Nominal Diameter, in. (mm)	Nominal Area, in. ² (mm ²)
W4	0.226 (5.74)	0.040 (25.81)
W4.5	0.239 (6.07)	0.045 (29.03)
W5	0.252 (6.40)	0.050 (32.26)
W5.5	0.265 (6.73)	0.055 (35.48)
W6	0.276 (7.01)	0.060 (38.71)
W8	0.319 (8.10)	0.080 (51.61)
W10	0.357 (9.07)	0.100 (64.52)
W12	0.391 (9.93)	0.120 (77.42)
W14	0.422 (10.72)	0.140 (90.32)
W16	0.451 (11.46)	0.160 (103.25)
W18	0.479 (12.17)	0.180 (116.13)
W20	0.505 (12.83)	0.200 (129.03)
W22	0.529 (13.44)	0.220 (141.90)
W24	0.553 (14.05)	0.240 (154.80)
W26	0.575 (14.61)	0.260 (167.70)
W28	0.597 (15.16)	0.280 (180.60)
W30	0.618 (15.70)	0.300 (193.50)
W31	0.628 (15.95)	0.310 (200.00)

NOTE 1—These sizes represent the most commonly used items in both welded wire fabric and wire usage. Other sizes can be used.

4. Ordering Information

4.1 Orders for material to this specification should include the following information:

4.1.1 Quantity (weight),

4.1.2 Name of material (cold-drawn steel wire for concrete reinforcement),

4.1.3 Wire size number,

4.1.4 Packaging (see Section 15), and

4.1.5 ASTM designation and year of issue.

NOTE 2—A typical ordering description is as follows: 100 000 lb cold-drawn steel wire for concrete reinforcement, Size No. W5 in 500 lb secured coils, to ASTM A 82 - ____.

5. Materials and Manufacture

5.1 The steel shall be made by one of the following processes: open-hearth, electric furnace, or basic-oxygen.

5.2 The wire shall be cold drawn from rods that have been hot rolled from billets.

5.3 Unless otherwise specified, the wire shall be supplied uncoated. When specified as galvanized, it shall be galvanized at finish size.

6. Mechanical Property Requirements

6.1 Tension Tests:

6.1.1 When tested as described in Test Methods and Definitions A 370, the material, except as specified in 6.1.2, shall conform to the tensile property requirements in Table 1 based on nominal area of wire.

6.1.2 The yield strength shall be determined as described in Test Methods and Definitions A 370 at an extension of

¹ This specification is under the jurisdiction of ASTM Committee A-1 on Steel, Stainless Steel, and Related Alloys and is the direct responsibility of Subcommittee A01.05 on Steel Reinforcement.

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² Annual Book of ASTM Standards, Vol 01.03.

³ Annual Book of ASTM Standards, Vol 01.06.

⁴ Annual Book of ASTM Standards, Vol 01.05.

⁵ Annual Book of ASTM Standards, Vol 03.01.

⁶ Available from Standardization Documents Order Desk, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094.

TABLE 1 Tension Test Requirements

Tensile strength, min, ksi (MPa)	80 (550)
Yield strength, min, ksi (MPa)	70 (485)
Reduction of area, min, %	30 ^A

^A For material testing over 100 ksi (690 MPa) tensile strength, the reduction of area shall be not less than 25 %.

0.005 in./in. of gage length. The manufacturer is not required to test for yield strength, but is responsible for supplying a product that will meet the stipulated limit when tested in conformance with the provisions of 11.3. For determining the yield strength, use a Class B-1 extensometer as described in Practice E 83. The extensometer should be removed from the specimen after the yield strength has been determined.

6.1.3 For material to be used in the fabrication of welded fabric, the tensile and yield strength properties shall conform to the requirements given in Table 2, based on nominal area of the wire.

6.1.4 The material shall not exhibit a definite yield point as evidenced by a distinct drop of the beam or halt in the gage of the testing machine prior to reaching ultimate tensile load. The purchaser may opt to accept this feature as sufficient evidence of compliance with the specified minimum yield strength tests covered in 11.3.

6.2 *Bend Test*—The bend test specimen shall stand being bent at room temperature through 180° without cracking on the outside of the bent portion, as prescribed in Table 3.

6.3 *Reduction of Area Test*—The reduction of area shall be determined as described in Test Methods and Definitions A 370, and the wire shall conform to the reduction of area requirements in Table 1 and Table 2.

7. Permissible Variation in Wire Diameter

7.1 The permissible variation in the diameter of the wire shall conform to the requirements given in Table 4.

7.2 The difference between the maximum and minimum diameters, as measured on any given cross section of the wire, shall be no more than the tolerances listed in Table 4 for the given wire size.

8. Workmanship, Finish, and Appearance

8.1 The wire shall be free of detrimental imperfections and shall have a workmanlike finish.

8.2 Galvanized wire shall be produced as described in Specification A 641, regular coating.

8.3 Rust, surface seams, or surface irregularities shall not be a cause for rejection provided the requirements of 8.4 are met, and the minimum dimensions and mechanical properties of a hand wire-brushed test specimen are not less than the requirements of this specification.

TABLE 2 Tension Test Requirements (Material for Welded Fabric)

	Size W1.2 and Larger	Smaller than Size W1.2
Tensile strength, min, ksi (MPa)	75 (515)	70 (485)
Yield strength, min, ksi (MPa)	65 (450)	58 (385)
Reduction of area, min, %	30 ^A	30 ^A

^A For material testing over 100 ksi (690 MPa) tensile strength, the reduction of area shall be not less than 25 %.

TABLE 3 Bend Test Requirements

Size Number of Wire	Bend Test
W7 and smaller	Bend around a pin the diameter that is equal to the diameter of the specimen
Coarser than W7	Bend around a pin the diameter that is equal to twice the diameter of the specimen

8.4 Wire intended for welded fabric shall be sufficiently free of rust and drawing lubricant so as not to interfere with electric resistance welding.

9. Sampling

9.1 Test specimens for testing mechanical properties shall be full wire sections and shall be obtained from ends of wire coils as drawn or as galvanized. The specimens shall be of sufficient length to perform testing described in 6.1 and 6.2.

9.2 If any test specimen exhibits obvious isolated imperfections not representative of the product, it may be discarded and another specimen substituted.

10. Number of Tests

10.1 One tension and one bend test shall be made from each 10 tons (9070 kg) or less of each size of wire or fraction thereof in a lot, or a total of seven samples, whichever is less. A lot shall consist of all the coils of a single size offered for delivery at the same time.

11. Inspection

11.1 The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works that concern the manufacture of the material ordered. The manufacturer shall afford the inspector all reasonable facilities to assure that the material is being furnished in accordance with this specification.

11.2 Except for yield strength, all tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified. Such tests shall be so conducted as not to interfere unnecessarily with the operation of the works.

11.3 If the purchaser considers it desirable to determine compliance with the yield strength requirements in 6.1, yield strength tests may be made in a recognized laboratory, or their representative may make the test at the mill if such tests do not interfere unnecessarily with the mill operations.

11.4 *For U. S. Government Procurement Only*—Except as otherwise specified in the contract, the contractor is responsible for the performance of all inspection and test requirements specified herein. Except as otherwise specified in the

TABLE 4 Permissible Variation in Wire Diameter

Size Number	Nominal Diameter, in. (mm)	Permissible Variation Plus and Minus, in. (mm)
Smaller than W5	under 0.252 (6.40)	0.003 (0.08)
W5 to W12, incl	0.252 (6.40) to 0.391 (9.93), incl	0.004 (0.10)
Over W12 to W20, incl	over 0.391 (9.93) to 0.505 (12.83), incl	0.006 (0.15)
Over W20	over 0.505 (12.83)	0.008 (0.20)



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contract, the contractor may use his own or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless disapproved by the purchaser at the time of purchase. The purchaser shall have the right to perform any of the inspections and tests at the same frequency as set forth in this specification where such inspections are deemed necessary to ensure that material conforms to prescribed requirements.

12. Rejection

12.1 Material that shows detrimental imperfections subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

12.2 Failure of any of the test specimens to comply with the requirements of this specification shall constitute grounds for rejection of the lot represented by the specimen. The lot may be resubmitted for inspection by testing every coil for the property in which the specimen failed and sorting out nonconforming coils.

12.3 Any rejection based on tests made in accordance with the specification shall be reported to the manufacturer within a reasonable period of time. The material must be adequately protected and correctly identified in order that the producer may make a proper investigation.

13. Rehearing

13.1 Rejected materials shall be preserved for a period of at least two weeks from the date of inspection, during which time the manufacturer may make claim for a rehearing and retesting.

14. Certification

14.1 When specified in the purchase order or contract, a producer's or supplier's certification shall be furnished to the purchaser that the material was manufactured, sampled, tested, and inspected in accordance with this specification and has been found to meet the requirements. When specified in the purchase order or contract, a report of the test results shall be furnished. The certification shall include the specification number, year-date of issue, and revision letter, if any.

15. Packaging and Marking

15.1 The size of the wire, ASTM specification, and name or mark of the manufacturer shall be marked on a tag securely attached to each coil of wire.

15.2 Unless otherwise specified, packaging, marking, and loading for shipment shall be in accordance with Practices A 700.

15.3 When specified in the contract or order, and for direct procurement by or direct shipment to the U.S. government, when Level A is specified, preservation, packaging, and packing shall be in accordance with the Level A requirement of MIL-STD-163.

15.4 When specified in the contract or order, and for the direct procurement by or direct shipment to the U.S. government, marking for shipment, in addition to requirements specified in the contract or order, shall be in accordance with MIL-STD-129 for military agencies and in accordance with Fed. Std. No. 123 for civil agencies.

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This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.

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AMERICAN SOCIETY FOR TESTING AND MATERIALS

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Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products¹

This standard is issued under the fixed designation A 123; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This specification has been approved for use by agencies of the Department of Defense. Consult the DOD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

^{ε1} NOTE—Paragraph 4.6 was corrected editorially in February 1990.

1. Scope

1.1 This specification covers the requirements for zinc coating (galvanizing) by the hot-dip process on iron and steel products made from rolled pressed and forged shapes, castings, plates, bars, and strips.

1.2 This specification covers both unfabricated products and fabricated products, for example, assembled steel products, structural steel fabrications, large tubes already bent or welded before galvanizing, and wire work fabricated from uncoated steel wire. This specification also covers steel forgings and iron castings incorporated into pieces fabricated before galvanizing or which are too large to be centrifuged (or otherwise handled to remove excess galvanizing bath metal).

NOTE 1—This specification covers those products previously addressed in Specifications A 123-78 and A 386-78.

1.3 This specification does not apply to wire, pipe, tube, or steel sheet which is galvanized on specialized or continuous lines, or to steel less than 22 gage (0.0299 in.) (0.76 mm) thick.

1.4 The galvanizing of hardware items that are to be centrifuged or otherwise handled to remove excess zinc (such as bolts and similar threaded fasteners, castings and rolled, pressed and forged items) shall be in accordance with Specification A 153.

1.5 The values stated in inch-pound units are to be regarded as the standard.

2. Referenced Documents

2.1 ASTM Standards:

- A 47 Specification for Malleable Iron Castings²
- A 90 Test Method for Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles³
- A 143 Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement³

¹ This specification is under the jurisdiction of ASTM Committee A-5 on Metallic Coated Iron and Steel Products and is the direct responsibility of Subcommittee A05.13 on Structural Shapes and Hardware Specifications.

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² Annual Book of ASTM Standards, Vol 01.02.

³ Annual Book of ASTM Standards, Vol 01.06.

A 153 Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware³

A 384 Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies³

A 385 Practice for Providing High-Quality Zinc Coatings (Hot-Dip)³

A 780 Practice for Repair of Damaged Hot-Dip Galvanized Coatings³

B 6 Specification for Zinc (Slab Zinc)⁴

B 602 Test Method for Attribute Sampling of Metallic and Inorganic Coatings⁵

E 376 Practice for Measuring Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Test Methods⁶

3. Ordering Information

3.1 Orders for coatings provided under this specification shall include the following:

3.1.1 Quantity (number of pieces to be galvanized) and total weight.

3.1.2 Description (type and size of products) and weight.

3.1.3 ASTM specification designation and year of issue.

3.1.4 Material identification (see 4.1) and surface condition or contamination.

3.1.5 Sampling plan, if different from 6.3.

3.1.6 Special test requirements (see 7.1).

3.1.7 Special requirements (special stacking, heavier coating weight, etc.).

3.1.8 Tagging or piece identification method.

4. Materials and Manufacture

4.1 *Steel or Iron*—The specification, grade, or designation and type and degree of surface contamination of the iron or steel in articles to be galvanized shall be supplied by the purchaser to the hot-dip galvanizer prior to galvanizing.

NOTE 2—The presence in steels and weld metal, in certain percentages, of some elements such as silicon, carbon, and phosphorus tends to accelerate the growth of the zinc-iron alloy layer so that the coating may have a matte finish with little or no outer zinc layer. The galvanizer has only limited control over this condition. The mass, shape, and amount

⁴ Annual Book of ASTM Standards, Vol 02.04.

⁵ Annual Book of ASTM Standards, Vol 02.05.

⁶ Annual Book of ASTM Standards, Vol 03.03.

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of cold working of the product being galvanized may also affect this condition. Practice A 385 provides guidance on steel selection and discusses the effects of various elements in steel compositions (for example, silicon), that influence coating weight and appearance.

4.2 Fabrication—The design and fabrication of the product to be galvanized are the responsibilities of the designer and the fabricator. Practice A 143, Practice A 384, and Practice A 385 provide guidance for steel fabrication for optimum hot dip galvanizing and shall be compiled with in both design and fabrication. Consultation between the designer, fabricator, and galvanizer is desirable at appropriate stages in the design and fabrication process.

4.3 Castings—The composition and heat treatment of iron and steel castings shall conform to specifications designated by the purchaser. Some types of castings have been known to show potential problems with predisposition to being embrittled during the normal thermal cycle of hot-dip galvanizing. It is the responsibility of the purchaser to heat treat or otherwise allow for the possibility of such embrittling phenomena. The requirements for malleable iron castings to be galvanized shall be as stated in Specification A 47.

4.4 Zinc—The zinc used in the galvanizing bath shall conform to Specification B 6. If a zinc alloy is used as the primary feed to the galvanizing bath, then the base material used to make that alloy shall conform to Specification B 6.

4.5 Bath Composition—The molten metal in the working volume of the galvanizing bath shall contain not less than an average value of 98.0 % zinc by weight.

NOTE 3—The galvanizer may choose to add trace amounts of certain elements (for example, aluminum, nickel, and tin) to the zinc bath to help in the processing of certain reactive steels or to enhance the cosmetic appearance of the finished product. The use of these trace elements is permitted provided that the bulk chemistry of the galvanizing bath is at least 98.0 % zinc by weight. The elements can be added to the galvanizing bath as part of a prealloyed zinc feed, or they can be added to the bath by the galvanizer using a master feed alloy.

4.6 Surfaces which remain uncoated on individual pieces after galvanizing which are (a) 1 in. or less in its narrowest dimension, and (b) totalling $\frac{1}{2}$ of 1 % of the surface area to be coated, or 36 in.² per ton of weight, whichever is less, may be renovated by use of the methods found in Practice A 780. The thickness of the repair shall be 50 % greater than the thickness of galvanized coating required for the type of galvanized surface but not greater than 4.0 mils.

5. Coating Properties

5.1 Coating Thickness—The thickness of the coating shall conform to the requirements of Table 1 for thickness of the material being galvanized. Where welded products consisting

TABLE 1 Minimum Coating Thickness Grade^A by Steel Category
Steel Thickness Range (Measured), in. (mm)

Steel Category	Under $\frac{1}{16}$ (1.6)	$\frac{1}{16}$ to under $\frac{1}{8}$ (3.2)	$\frac{1}{8}$ to $\frac{3}{16}$ (4.8)	Over $\frac{3}{16}$ to under $\frac{1}{4}$ (6.4)	$\frac{1}{4}$ or over (6.4)
Structural Shape	45	65	85	85	100
Strip	45	65	75	85	100
Pipe	...	...	75	75	75
Wire	45	45	65	65	85

^A Average of all specimens tested. Minimum coating thickness grade for any individual specimen or computed value of at least 5 spot measurements made in accordance with 7.2.1 (magnetic thickness measurements) is one coating grade (see Table 2) less than that required in Table 1.

TABLE 2 Coating Thickness Grade Conversions^B

Thickness Grade	mils	oz/ft ²	μ m	g/m ²
35	1.5	0.8	35	250
45	1.9	1.1	45	320
55	2.1	1.2	55	390
65	2.5	1.5	65	460
75	2.9	1.7	75	515
85	3.4	2.0	85	605
100	3.9	2.3	100	710

^B The values for oz/ft², μ m, and g/m² are calculated values and are for convenience purposes only.

of various material thicknesses are galvanized, the coating thickness for each thickness of material shall be as shown in Table 1 (see also Table 2). The specification of coating thicknesses heavier than those required by Table 1 shall be subject to mutual agreement between the galvanizer and purchaser.

NOTE 4—The coating thicknesses in Table 1 represent the minimum values obtainable with a high level of confidence for steels typically hot-dip galvanized. Most coating thicknesses will be in excess of those values. Purchasers desiring a guarantee of heavier coatings should use special requirements (see 3.1.7) under ordering information to specify the heavier coating thickness.

NOTE 5—One mil of coating thickness corresponds to 0.6 oz/ft² of surface and one micrometer of coating thickness corresponds to 7.1 g/m², based on mathematical calculation. For convenience, the weight per unit area is shown in Table 1.

5.2 Finish—The coating shall be continuous, and as reasonably smooth and uniform in thickness as the weight, size, and shape of the item, and necessary handling of the item during the dipping and draining operations at the galvanizing kettle will permit. The distribution of the zinc coating shall be determined by visual inspection. Except for local excess coating thickness which would interfere with the use of the product, or make it inconvenient or dangerous to handle (edge tears or spikes), rejection for nonuniform coating shall be made only for plainly visible excess coating not related to design factors such as holes, joints, or special drainage problems (Note 6). Since surface smoothness is a relative term, minor roughness that does not interfere with the intended use of a part or roughness that is related to the as-received (ungalvanized) surface condition shall not be grounds for rejection (Note 7).

NOTE 6—The requirements for the finish of a galvanized product address themselves to a visual type of inspection. They do not address the matter of measured coating thickness variations that can be encountered because of different steels or different thicknesses of a given steel being used in an assembly.

NOTE 7—Items which are prepared for galvanizing by abrasive cleaning will generally develop a thicker coating with a moderately rougher surface.

5.2.1 Threaded Components in Assemblies—The zinc coating on external threads shall not be subjected to a cutting, rolling, or finishing tool operation, unless specifically authorized by the purchaser. Internal threads may be tapped or retapped after galvanizing. Coatings shall conform to the requirements of Specification A 153.

5.3 Appearance—Galvanized articles shall be free from uncoated areas, blisters, flux deposits, acid and black spots, and dross inclusions. Lumps, projections, globules, or heavy deposits of zinc which will interfere with the intended use of

the material will not be permitted. All holes shall be clean and reasonably free from excess zinc. Marks in the zinc coating caused by tongs or other items used in handling the article during the galvanizing operation shall not be cause for rejection unless such marks have exposed the base metal or have scraped the zinc from the surface. The pieces shall be handled so that after galvanizing they will not freeze together on cooling.

5.4 Adherence—The zinc coating shall withstand handling consistent with the nature and thickness of the coating and the normal use of the article, without peeling or flaking.

NOTE 8—Although some material may be formed after galvanizing, in general the zinc coating on the articles covered by this specification is too heavy to permit severe bending without damaging the coating.

6. Sampling

6.1 Sampling of each lot shall be performed for conformance with the requirements of this specification.

6.2 A lot is a unit of production or shipment from which a sample may be taken for testing. Unless otherwise agreed upon by galvanizer and purchaser, or established within this specification, the lot shall be as follows: For testing at a galvanizer's facility, a lot is one or more articles of the same type and size comprising a single order or a single delivery load, whichever is the smaller, or any number of articles identified as a lot by the galvanizer, when these have been galvanized within a single production shift and in the same bath. For test by purchaser after delivery, the lot consists of the single order or the single delivery load, whichever is the smaller, unless the lot identity, established in accordance with the above, is maintained and clearly indicated in the shipment by the galvanizer.

6.3 The method of selection and number of test specimens shall be agreed upon by the galvanizer and purchaser. Otherwise, the test specimens shall be selected at random from each lot. In this case, the minimum number of specimens from each lot shall be as follows:

Number of Pieces in Lot	Number of Specimens
3 or less	all
4 to 500	3
501 to 1200	5
1201 to 3200	8
3201 to 10 000	13
10 001 and over	20

NOTE 9—Where a number of identical items are to be galvanized, a statistical sampling plan may be desired. Such a plan is contained in Test Method B 602 which addresses sampling procedures for the inspection of electrodeposited metallic coatings and related finishes. If Test Method B 602 is used, the level of sampling shall be agreed to by the galvanizer and purchaser at the time the coating order is placed.

6.4 A test specimen which fails to conform to a requirement of this specification shall not be used to determine the conformance to other requirements.

7. Test Methods

7.1 Test Requirements—The following tests shall be conducted to ensure that the zinc coating is being furnished in accordance with this specification. The specifying of tests for adhesion and embrittlement shall be subject to mutual agreement between the galvanizer and purchaser.

7.2 Thickness of Coating Test—The thickness of coating

is determined by one or more of the three methods described as follows.

7.2.1 Magnetic Thickness Measurements—The thickness of the coating may be determined by magnetic thickness gage measurements in accordance with Practice E 376. A minimum of five readings shall be taken (in each location) near the ends and in the middle of each piece being tested. For large product such as tapered poles, transmission towers, or structural shapes, the minimum of five readings (in each location) shall be taken peripherally about 4 in. (100 mm) from each end and in the approximate center of the member. The average of the thickness values taken at each location shall be not less than the value listed in Table 1 under the heading "Any Individual Specimen or Computed Value." The average coating thickness for the item shall be the average of the values obtained in the three locations and shall be not less than the value listed in Table 1 under the heading "Average of Specimens Tested." If these coating thickness measurements are made on an article with different thicknesses of steel, then the values in Table 1 shall apply to each thickness of steel on the article.

7.2.2 Stripping Method—The average weight of zinc coating may be determined by stripping an entire piece in accordance with Test Method A 90, or alternatively, the average weight of coating may be determined by stripping test pieces from the sample specimen, each with a measurable area of coated surface of at least 10 in.² (64.5 cm²). Cut one specimen approximately 4 in. (100 mm) from each end of the member and a third specimen from the approximate center of the member. The weight of coating obtained at each location shall be not less than the value listed in Table 1 under the heading "Any Individual Specimen or Computed Value." The average weight of coating for the item shall be the average of the values obtained in the three locations and shall be not less than the value listed in Table 1 under the heading "Average of Specimens Tested." If these coating weight measurements are made on an article with different thicknesses of steel, then the values in Table 1 shall apply to each thickness of steel on the article.

7.2.3 Weighing Before and After Galvanizing—The average weight of the zinc coating may be determined by weighing the articles before and after galvanizing, subtracting the first weight from the second, and dividing the result by the surface area. The first weight shall be determined after pickling and drying, the second after cooling to ambient temperature.

NOTE 10—This method does not take into account the weight of iron reacted from the article that is incorporated into the coating. It may thus underestimate coating weight by as much as approximately 10 %. Base metal reactivity will affect the extent of underestimation.

7.2.4 Referee Method—In the event of dispute over any weight of coating measurement, the dispute shall be resolved by Test Method A 90. If not feasible, and if mutually agreeable to the galvanizer and the purchaser the dispute may be resolved by the use of magnetic thickness gages which have been calibrated for accuracy against standard reference material thickness standards.

7.3 Finish and Appearance—Visual inspection of the zinc coating shall be made for compliance with the requirements of 5.2 and 5.3.

7.4 Adhesion:

7.4.1 Determine adhesion of the zinc coating to the surface of the base metal by cutting or prying with the point of a stout knife, applied with considerable pressure in a manner tending to remove a portion of the coating. The adhesion shall be considered inadequate if the coating flakes off in the form of a layer of the coating so as to expose the base metal in advance of the knife point. Do not use testing carried out at edges or corners (points of lowest coating adhesion) to determine adhesion of the coating. Likewise, do not use removal of small particles of the coating by paring or whittling to determine failure.

7.5 *Embrittlement*—Test for embrittlement may be made in accordance with Practice A 143.

8. Inspection

8.1 *Inspection by the Galvanizer*—It is the responsibility of the galvanizer to ensure compliance with this specification. This can be achieved by an in-plant inspection program designed to maintain the coating thickness, finish, and appearance within the requirements of this standard.

8.2 *Inspection by the Purchaser*—The purchaser may accept or reject material by inspection. The inspector representing the purchaser shall have access at all times to those areas of the galvanizer's facility which concern the application of the zinc coating to the material ordered while work on the contract of the purchaser is being performed. The galvanizer shall afford the inspector all reasonable facilities to satisfy him that the zinc coating is being furnished in accordance with this specification.

8.3 *Location*—The material shall be inspected at the galvanizer's plant prior to shipment. However, by agreement

the purchaser may make the tests which govern the acceptance or rejection of the materials in his own laboratory or elsewhere.

9. Rejection and Retest

9.1 When inspection of materials to determine conformity with visual requirements of Section 5 warrants rejection of a lot, the galvanizer may sort the lot and submit it once again for acceptance after he has removed any nonconforming articles and replaced them with conforming articles.

9.2 The sampling plan that was used when the lot was first inspected shall be used for resampling of a sorted lot.

9.3 If the thickness of coating does not conform to the requirements specified in Table 1, retests of a mutually agreeable number of additional members shall be made. Failure of the retest to meet the requirements of Table 1 constitutes ground for rejection of the lot, unless the members are accepted by test on an individual basis.

9.4 Materials that have been rejected for reasons other than embrittlement may be stripped and regalvanized and again submitted for inspection and test at which time they shall conform to the requirements of this specification.

10. Certification

10.1 When specified in the purchase order or contract, the purchaser shall be furnished certification that samples representing each lot have been either tested or inspected as directed by this specification and the requirements have been met. When specified in the purchase order or contract, a report of the test results shall be furnished.

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Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware¹

This standard is issued under the fixed designation A 153; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This specification has been approved for use by agencies of the Department of Defense and for listing in the DoD Index of Specifications and Standards.

1. Scope

1.1 This specification covers zinc coatings applied by the hot-dip process on iron and steel hardware.

1.2 This document is intended to be applicable to hardware items that are centrifuged or otherwise handled to remove excess galvanizing bath metal (free zinc). Coating weight requirements reflect this.

NOTE 1—If the galvanized material covered by this specification is bent or otherwise fabricated to the degree that causes the zinc coatings to stretch or compress beyond the limit of elasticity, some cracking or flaking of the coating may occur.

1.3 The values stated in inch-pound units are to be regarded as standard. The equivalent SI units may only be approximate.

2. Referenced Documents

2.1 ASTM Standards:

- A 90 Test Method for Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles²
- A 143 Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement²
- A 385 Practice for Providing High-Quality Zinc Coatings (Hot-Dip)²
- B 6 Specification for Zinc (Slab Zinc)³
- B 602 Test Method for Attribute Sampling of Metallic and Inorganic Coatings⁴
- E 376 Practice for Measuring Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Test Methods⁵

3. Classification (See Table 1)

3.1 Class A hardware includes castings of malleable iron and steel.

3.2 Class B hardware includes rolled, pressed, and forged articles that are not included under 3.3 and 3.4.

3.3 Class C hardware includes threaded fasteners over $\frac{3}{8}$ in. (9.52 mm) in diameter and washers $\frac{3}{16}$ in. and $\frac{1}{4}$ in. (4.76 mm and 6.35 mm) thick.

3.4 Class D hardware includes threaded fasteners $\frac{3}{8}$ in. (9.52 mm) and under in diameter, rivets, nails, and similar articles and washers under $\frac{3}{16}$ in. (4.76 mm) thick.

4. Materials and Manufacture

4.1 *Steel or Iron*—Ferrous articles to be hot-dip zinc coated shall conform to specifications designated by the purchaser.

4.2 *Zinc*—The zinc used for the coating shall conform to the Specification B 6 and shall be at least equal to the grade designated as “Prime Western.”

NOTE 2—Aluminum is sometimes added to a galvanizing bath. Approximately 0.01 % Al is considered an upper operating limit. Should this amount be exceeded because of poor distribution within the bath or because of intentional additions, two types of operating problems can be experienced, namely: (1) reaction between aluminum and zinc chloride (a major flux ingredient) can cause physical deterioration of a flux blanket, and (2) it may not be possible to form coatings that meet specified thickness requirements on some types of steel.

4.3 *Coating Weight*—The weight of the coating shall conform to the requirements prescribed in Table 1 for the class and thickness of material in which the article belongs (see Section 3).

4.4 *Threaded Articles*—The zinc coating on threads shall not be subjected to a cutting, rolling, or finishing-tool operation, unless specifically authorized by the purchaser. Threads in nuts may be tapped after galvanizing.

5. Workmanship, Finish, and Appearance

5.1 The zinc-coated articles shall be free from uncoated areas, blisters, flux deposits, black spots, dross inclusions, and other types of projections that would interfere with the intended use of the articles, or other defects not consistent with good galvanizing practice.

5.2 The zinc coating shall be smooth and reasonably uniform in thickness.

NOTE 3—Smoothness of surface is a relative term. Minor roughness that does not interfere with the intended use of the part, or roughness that is related to the as-received (ungalvanized) surface condition of the part, shall not be grounds for rejection.

NOTE 4—Since this specification is applicable to items that are centrifuged or otherwise handled to remove excess bath metal (see 1.2), irregular coating distribution is not normally encountered. Drainage problems, which manifest themselves as local excess coating thickness that would interfere with function or as edge tears or spikes that present a safety hazard because of their sharpness, are grounds for rejection under the terms of 5.1.

5.3 Steel that is cold-worked may become embrittled, depending on such factors as the type of steel and the

¹ This specification is under the jurisdiction of ASTM Committee A-5 on Metallic Coated Iron and Steel Products and is the direct responsibility of Subcommittee A05.13 on Structural Shapes and Hardware Specifications.

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² Annual Book of ASTM Standards, Vol 01.06.

³ Annual Book of ASTM Standards, Vols 02.02, 02.03, 02.04, and 02.05.

⁴ Annual Book of ASTM Standards, Vol 02.05.

⁵ Annual Book of ASTM Standards, Vols 01.06 and 03.03.

TABLE 1 Weight of Zinc Coating for Various Classes of Material

NOTE 1—Length of the piece, stated in Classes B-1, B-2, and B-3, refers to the overall dimension and not to its developed length.

NOTE 2—Based upon mathematical calculations, 1 oz /ft² of zinc surface corresponds to an average coating thickness of 1.7 mil. (Based upon mathematical calculations, 1 g/m² of zinc surface corresponds to an average coating thickness of 0.141 μ m; seven times the coating thickness in micrometres is approximately equal to the coating in g/m².)

Class of Material	Minimum Weight of Zinc Coating, oz/ft ² (g/m ²) of Surface ^A	
	Average of Specimens Tested ^B	Any Individual Specimen
Class A—Castings—Malleable Iron, Steel	2.00 (610)	1.80 (550)
Class B—Rolled, pressed, and forged articles (except those which would be included under Classes C and D):		
B-1— $\frac{3}{16}$ in. (4.76 mm) and over in thickness and over 15 in. (381 mm) in length	2.00 (610)	1.80 (550)
B-2—under $\frac{3}{16}$ in. (4.76 mm) in thickness and over 15 in. (381 mm) in length	1.50 (458)	1.25 (381)
B-3—any thickness and 15 in. (381 mm) and under in length	1.30 (397)	1.10 (336)
Class C—Fasteners over $\frac{3}{8}$ in. (9.52 mm) in diameter and similar articles. Washers $\frac{3}{16}$ in. and $\frac{1}{4}$ in. (4.76 and 6.35 mm) in thickness	1.25 (381)	1.00 (305)
Class D—Fasteners $\frac{3}{8}$ in. (9.52 mm) and under in diameter, rivets, nails and similar articles. Washers under $\frac{3}{16}$ in. (4.76 mm) in thickness	1.00 (305)	0.85 (259)

^A In the case of long pieces, such as anchor rods and similar articles over 5 ft (1.52 m) in length, the weight of coating shall be determined at each end and the middle of the article. In no case shall individual measurements be below the minimum shown in the "Any Individual Specimen" column.

^B The number of specimens to be tested per order shall be as specified in Section 7.

characteristics), thickness, and degree of cold work. Galvanizing may accelerate embrittlement. Precautions against embrittlement shall be taken by the designer, the fabricator, and the galvanizer. The precautions to fabricate properly and prepare the material for galvanizing to prevent embrittlement are described in Recommended Practice A 143.

NOTE 5—Low service temperatures increase the risk of brittle failure of all plain carbon steels including those which have been galvanized. This temperature embrittling effect varies with type of steel. The expected service temperature should thus be taken into account when selecting steels for galvanizing.

5.4 Malleable castings shall be of such composition as will preclude the possibility that they become embrittled by the galvanizing process, or they shall be either cooled from the anneal, or subsequently heat-treated so as to immunize them against embrittlement.

5.5 The zinc coating shall adhere tenaciously to the surface of the basis metal (see Section 8).

6. Sampling

6.1 Method B 602 addresses itself to sampling procedures for the inspection of electrodeposited metallic coatings and related finishes. It is recommended that the procedures outlined therein be considered in the case of this specification.

7. Specimen Preparation

7.1 Test specimens shall be selected at random from each inspection lot. An inspection lot is defined as a collection of galvanized articles of the same kind that has been galvanized at approximately the same time, in the same manner, and in the same pot, and that is being submitted for acceptance as a group.

7.2 The number of test specimens selected from each inspection lot as being representative of that lot shall be agreed to between the galvanizer and the purchaser. In no case shall it be less than three.

8. Test Methods

8.1 Tests shall be made to ensure that the zinc coating is being furnished in accordance with this specification and as specified for the following:

8.1.1 Weight of coating in 4.3.

8.1.2 Finish and appearance in 5.1 and 5.2.

8.1.3 Embrittlement in 5.3 and 5.4.

8.1.4 Adherence in 5.5.

8.2 *Weight of Coating:*

8.2.1 The average weight of the zinc coating may be determined by weighing specimens after pickling and drying and again after galvanizing.

NOTE 6—This method does not take into account the weight of iron reacted from the article that is incorporated into the coating. It will thus underestimate coating weight by up to approximately 10 %. Base metal reactivity will affect the extent of underestimation.

8.2.2 In the case of materials inspected after galvanizing, the weight of coating may be determined by stripping one or more specimens in accordance with Methods A 90, or the average weight of coating may be determined with the use of a magnetic thickness gage in conformity with Recommended Practice E 376.

8.2.2.1 In the case of fasteners such as bolts, nuts, and screws, the determination of the weight of coating shall be made on a portion of the article that does not include any threads.

8.3 *Embrittlement*—Test for embrittlement in accordance with Recommended Practice A 143.

8.4 *Adherence:*

8.4.1 Determine adherence of the zinc coating to the surface of the base metal by cutting or prying with the point of a stout knife, applied with considerable pressure in a manner tending to remove a portion of the coating. The adherence shall be considered inadequate if the coating flakes off in the form of a layer or skin so as to expose the base metal in advance of the knife point. Do not use testing carried out at edges or corners (points of lowest coating adherence) to determine adherence of coating. Likewise, do not use removal of small particles of the coating by paring or whittling to determine failure.



Documents

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8.4.2 The pivoted hammer test may be used as an alternative to determine the adherence of the zinc coating on products fabricated from angles or plates of $\frac{3}{16}$ -in. (7.94-mm) thickness or heavier steel. This test is applicable to flat surfaces only and shall not be used on round or curved surfaces. The hammer used shall conform to the drawing shown in Fig. 1 (Note 7). Control the hammer blow by clamping or holding the pivoted base of the handle firmly on a horizontal surface of the galvanized member and allowing the hammer head to swing freely through an arc from vertical position to strike the horizontal surface. As illustrated in Fig. 1, the test shall consist of two or more standard blows forming parallel impressions with $\frac{1}{4}$ -in. (6.35-mm) spacing along a common axis so located that no part of an impression shall be closer than $\frac{1}{2}$ in. (12.7 mm) to the edge of the member. Removal or lifting of the coating in the area between the impressions shall constitute failure. Disregard an extruded ridge less than $\frac{1}{16}$ in. (1.6 mm) wide immediately adjacent to the impression. Test the specimen in several places throughout its length.

NOTE 7—The commercial standard 7-oz (200-g) riveting hammer can be easily modified to conform to the test requirements. A minimum friction pivot joint with minimum play should be used so that the test impressions can be located accurately.

NOTE 8—Refer to Section 3 of Recommended Practice A 385 wherein the effects of steel chemistry on the type of galvanized coating formed are discussed. The presence of some elements in the steel accelerates coating growth. There is evidence that coatings resulting

from this accelerated growth are more brittle and less adherent than normal coatings. It is important that the purchaser recognize and consider the fact that such coatings may not pass the "hammer test." Consequently it is recommended that the purchaser and galvanizer discuss the use of the pivoted hammer test.

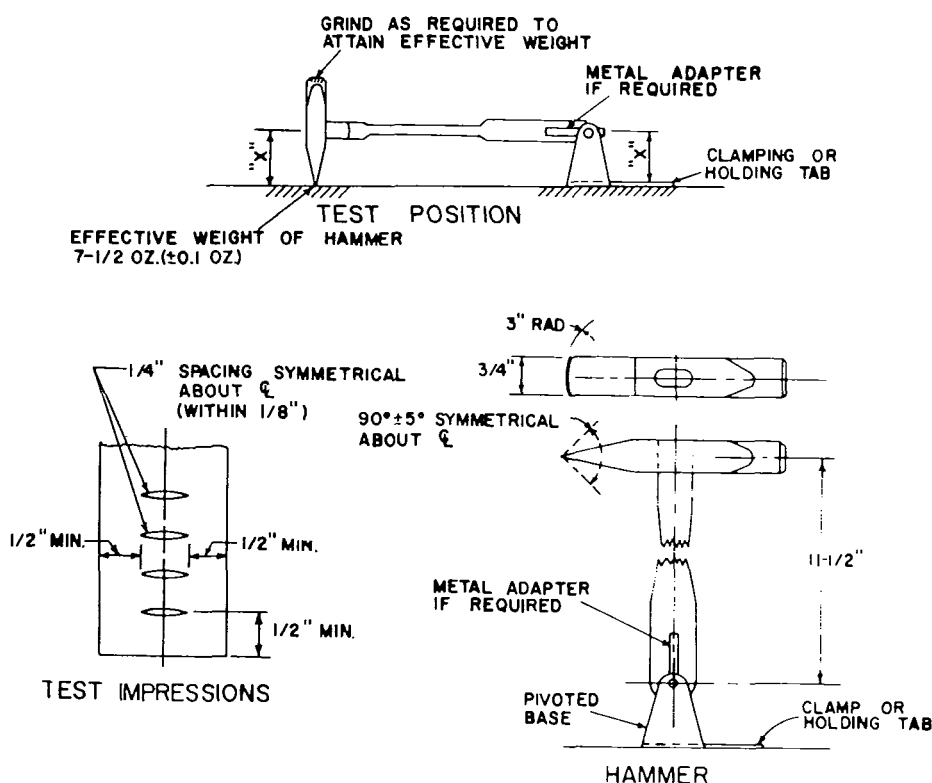
9. Inspection

9.1 The inspector representing the purchaser shall have access at all times while work on the contract of the purchaser is being performed, to those areas of the manufacturer's work which concern the application of the zinc coating to the material ordered. The manufacturer shall afford the inspector all reasonable facilities to satisfy him that the zinc coating is being furnished in accordance with this specification. All inspection and tests shall be made at the place of manufacture prior to shipments, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

10. Rejection and Retest

10.1 When partial inspection of materials to determine conformity with visual requirements of Section 5 warrants rejection of a lot, the galvanizer may sort the lot and submit it once again for inspection.

10.2 The number of specimens in a sample of a lot permitted to fail to conformance tests shall be agreed upon between the galvanizer and the purchaser.



Inch-Pound Units	SI Units	Inch-Pound Units	SI Units
$\frac{1}{4}$ in.	6.35 mm	$\frac{3}{4}$ in.	19.0 mm
$\frac{1}{8}$ in.	3.18 mm	$1\frac{1}{2}$ in.	292.1 mm
$\frac{1}{2}$ in.	12.7 mm	$7\frac{1}{2}$ (±0.1) oz	212.5 (±2.8) g

FIG. 1 Pivoted Hammer

10.3 If a set of test specimens fails to conform to the requirements of this specification, two additional sets shall be tested, both of which shall conform to the requirements in every respect, or the lot of material represented by the specimens shall be rejected.

10.4 Materials that have been rejected for reasons other than embrittlement may be stripped and regalvanized and again submitted for test and inspection. They shall then conform to the requirements of this specification.

11. Packaging

11.1 The supplier shall employ such methods of packaging zinc-coated articles as may reasonably be required to ensure their receipt by the purchaser in satisfactory condition, the use to be made of the article being taken into consideration.

11.2 Zinc-coated items should not be packed in unventilated containers, especially if these are fabricated from unseasoned wood.

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This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.



Designation: A 167 – 90

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Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip¹

This standard is issued under the fixed designation A 167; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This specification covers stainless and heat-resisting chromium nickel steel plate, sheet, and strip.

1.2 The values stated in inch-pound units are to be regarded as the standard.

2. Referenced Documents

2.1 ASTM Standards:

A 370 Test Methods and Definitions for Mechanical Testing of Steel Products²

A 480/A 480M Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip²

E 527 Practice for Numbering Metals and Alloys (UNS)³

2.2 SAE Standard:

J1086 Numbering Metals and Alloys (UNS)⁴

3. General Requirements

3.1 The following requirements for orders for material

furnished under this specification shall conform to the applicable requirements of the current edition of Specification A 480/A 480M.

- 3.1.1 Definitions,
- 3.1.2 General requirements for delivery,
- 3.1.3 Ordering information,
- 3.1.4 Process,
- 3.1.5 Heat treatment,
- 3.1.6 Special tests,
- 3.1.7 Dimensions and permissible variations,
- 3.1.8 Workmanship, finish and appearance,
- 3.1.9 Number of tests,
- 3.1.10 Specimen preparation,
- 3.1.11 Retreatment,
- 3.1.12 Inspection,
- 3.1.13 Rejection and reheating,
- 3.1.14 Material test report,
- 3.1.15 Certification, and
- 3.1.16 Packaging, marking, and loading.

4. Chemical Composition

4.1 The steel shall conform to the requirements as to chemical composition specified in Table 1, and shall conform to applicable requirements specified in Specification A 480/A 480M.

5. Mechanical Properties

5.1 The material shall conform to the mechanical properties specified in Table 2.

¹ This specification is under the jurisdiction of ASTM Committee A-1 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.17 on Flat Stainless Steel Products.

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² Annual Book of ASTM Standards, Vol 01.03.

³ Annual Book of ASTM Standards, Vols 01.01 and 01.03.

⁴ Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

TABLE 1 Chemical Requirements^A

UNS Designation ^B	Type	Composition, %								
		Carbon	Manganese	Phosphorus	Sulfur	Silicon	Chromium	Nickel	Molybdenum	Other Elements
S30100	301	0.15	2.00	0.045	0.030	0.75	16.00-18.00	6.00-8.00	...	...
S30200	302	0.15	2.00	0.045	0.030	0.75	17.00-19.00	8.00-10.00	...	N 0.10 max
S30215	302B	0.15	2.00	0.045	0.030	2.00-3.00	17.00-19.00	8.00-10.00	...	N 0.10 max
S30400	304	0.08	2.00	0.045	0.030	0.75	18.00-20.00	8.00-10.50	...	N 0.10 max
S30403	304L	0.030	2.00	0.045	0.030	0.75	18.00-20.00	8.00-12.00	...	N 0.10 max
S30415	...	0.04-0.06	0.80	0.045	0.030	1.00-2.00	18.00-19.00	9.00-10.00	0.50 max	N 0.12-0.18 Cb 0.03-0.08
S30453	304LN	0.030	2.00	0.045	0.030	0.75	18.00-20.00	8.00-12.00	...	N 0.10-0.16
S30500	305	0.12	2.00	0.045	0.030	0.75	17.00-19.00	10.50-13.00	...	...
S30600	...	0.018	2.0	0.02	0.02	3.7-4.3	17.0-18.5	14.0-15.5	0.20 max	...
S30800	308	0.08	2.00	0.045	0.030	0.75	19.00-21.00	10.00-12.00	...	...
S30815	...	0.05-0.10 0.20	0.80	0.040	0.030	1.40-2.00	20.00-22.00	10.00-12.00	...	N 0.14-0.20 Ce 0.03-0.08
S30900	309	0.08	2.00	0.045	0.030	0.75	22.00-24.00	12.00-15.00	...	...
S30908	309S	0.08	2.00	0.045	0.030	0.75	22.00-24.00	12.00-15.00	...	...
S30940	309Cb	...	2.00	0.045	0.030	0.75	22.00-24.00	12.00-16.00	...	Cb + Ta 10 × C min; 1.10 max
S31000	310	0.25	2.00	0.045	0.030	1.50	24.00-26.00	19.00-22.00	...	...
S31040	310Cb	0.08	2.00	0.045	0.030	1.50	24.00-26.00	19.00-22.00	...	Cb + Ta 10 × C min; 1.10 max
S31008	310S	0.08	2.00	0.045	0.030	1.50	24.00-26.00	19.00-22.00	...	...
S31254	...	0.020	1.00	0.030	0.010	0.75	19.50-20.50	17.50-18.50	6.00-6.50	Cu 0.50-1.00; N 0.180-0.220
S31600	316	0.08	2.00	0.045	0.030	0.75	16.00-18.00	10.00-14.00	2.00-3.00	...
S31640	316Cb	0.08	2.00	0.045	0.030	0.75	16.00-18.00	10.00-14.00	Mo 2.0-3.0	N 0.10 max; Cb + Ta 10 × C min; 1.10 max
S31603	316L	0.030	2.00	0.045	0.030	0.75	16.00-18.00	10.00-14.00	2.00-3.00	...
S31653	316LN	0.030	2.00	0.045	0.030	0.75	16.00-18.00	10.00-14.00	2.00-3.00	N 0.10-0.16
S31635	316Ti	0.08	2.00	0.045	0.030	0.75	16.00-18.00	10.00-14.00	Mo 2.0-3.0	N 0.10 max Ti 5 × (C + N) min; 0.70 max
S31700	317	0.08	2.00	0.045	0.030	0.75	18.00-20.00	11.00-15.00	3.00-4.00	...
S31725	...	0.030	2.00	0.045	0.030	0.75	18.00-20.00	13.50-17.50	4.00-5.00	N 0.10 max
S31726	...	0.030	2.00	0.045	0.030	0.75	17.00-20.00	13.50-17.50	4.00-5.00	N 0.10-0.20
S31703	317L	0.030	2.00	0.045	0.030	0.75	18.00-20.00	11.00-15.00	3.00-4.00	...
S31753	317LN	0.030	2.00	0.045	0.030	0.75	18.00-20.00	11.00-15.00	3.00-4.00	N 0.10-0.22
S32100	321	0.08	2.00	0.045	0.030	0.75	17.00-19.00	9.00-12.00	...	N 0.10 max; Ti 5 × (C + N) min; 0.70 max
S32109	321H	0.04-0.10	2.00	0.045	0.030	0.75	17.00-19.00	9.00-12.00	...	N 0.10 max; Ti 4 × (C + N) min; 0.70 max
S34700	347	0.08	2.00	0.045	0.030	0.75	17.00-19.00	9.00-13.00	...	Cb + Ta 10 × C min; 1.00 max
S34800	348	0.08	2.00	0.045	0.030	0.75	17.00-19.00	9.00-13.00	...	Cb + Ta 10 × C min; 1.00 max; Ta 0.10 max; Co 0.20 max
S38100	XM-15	0.08	2.00	0.030	0.030	1.50-2.50	17.00-19.00	17.50-18.50	...	...

^A Maximum unless range or minimum is indicated.^B New designation established in accordance with Practice E 527 and SAE J 1086.

CHROMIUM-NICKEL STEEL (ASTM A 167)

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TABLE 2 Mechanical Property Requirements

UNS Designation ^A	Type	Tensile Strength, min		Yield Strength, min ^B		Elongation in 2 in. or 50 mm, min, %	Hardness, max ^C	
		ksi	MPa	ksi	MPa		Brinell	Rockwell B
S30100	301	75	515	30	205	40.0	201	92
S30200	302	75	515	30	205	40.0	201	92
S30215	302B	75	515	30	205	40.0	217	95
S30400	304	75	515	30	205	40.0	201	92
S30403	304L	70	485	25	170	40.0	183	88
S30415	...	87	600	42	290	40.0	217	95
S30453	304LN	75	515	30	205	40.0	201	92
S30500	305	70	485	25	170	40.0	183	88
S30600	...	78	540	35	240	40.0	...	...
S30800	308	75	515	30	205	40.0	183	88
S30815	...	87	600	45	310	40.0	217	95
S30900	309	75	515	30	205	40.0	217	95
S30940	309Cb	75	515	30	205	40.0	217	95
S30908	309S	75	515	30	205	40.0	217	95
S31000	310	75	515	30	205	40.0	217	95
S31040	310Cb	75	515	30	205	40.0	217	95
S31008	310S	75	515	30	205	40.0	217	95
S31600	316	75	515	30	205	40.0	217	95
S31640	316Cb	75	515	30	205	30.0	217	95
S31603	316L	70	485	25	170	40.0	217	95
S31653	316LN	75	515	30	205	40.0	217	95
S31635	316Ti	75	515	30	205	40.0	217	95
S31700	317	75	515	30	205	35.0	217	95
S31725	...	75	515	30	205	40.0	217	95
S31726	...	80	550	35	240	40.0	223	96
S31703	317L	75	515	30	205	40.0	217	95
S31753	317 LN	80	550	35	240	40.0	217	95
S32100	321	75	515	30	205	40.0	217	95
S32109	321H	75	515	30	205	40.0	217	95
S34700	347	75	515	30	205	40.0	201	92
S34800	348	75	515	30	205	40.0	201	92
S38100	XM-15	75	515	30	205	40.0	217	95
S31254	...	94	650	44	300	35.0	223	96

^A New designation established in accordance with Practice E 527 and SAE J 1086.^B Yield strength shall be determined by the offset method at 0.2 % in accordance with Test Methods and Definitions A 370. Unless otherwise specified, an alternative method of determining yield strength may be based on a total extension under load of 0.5 %.^C Either Brinell or Rockwell B hardness is permissible.

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Designation: A 185 - 90a

AMERICAN SOCIETY FOR TESTING AND MATERIALS

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Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement¹

This standard is issued under the fixed designation A 185; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This specification covers welded wire fabric to be used for the reinforcement of concrete.

1.2 The values stated in inch-pound units are to be regarded as the standard.

2. Referenced Documents

2.1 ASTM Standards:

A 82 Specification for Steel Wire, Plain, for Concrete Reinforcement²

A 700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Domestic Shipment²

2.2 Military Standards:

MIL-STD-129 Marking for Shipment and Storage³

MIL-STD-163 Steel Mill Products Preparation for Shipment and Storage³

2.3 Federal Standard:

Fed. Std. No. 123 Marking for Shipments (Civil Agencies)³

3. Terminology

3.1 Descriptions of Terms Specific to This Standard:

3.1.1 *convoluted wire*—when wire for welded fabric is formed into a sinusoidal wave shape, it is commonly referred to as convoluted wire. The wire is used in the manufacture of cages for certain applications of concrete pipe reinforcing.

3.1.2 *welded wire fabric*—as used within the scope and intent of this specification, designates a material composed of cold-drawn steel wire, as-drawn or galvanized, fabricated into sheets or rolls by the process of electric resistance welding. The finished material shall consist essentially of a series of longitudinal and transverse wires arranged substantially at right angles to each other, and welded together at points of intersection.

4. Ordering Information

4.1 Orders for material to this specification should include the following information:

4.1.1 Quantity (weight or square area),

4.1.2 Name of material (welded wire fabric for concrete reinforcement),

4.1.3 Wire spacings and sizes,

4.1.4 Exclusion of oversteeling, if required (see 9.4.2),

4.1.5 Length and width of sheets or rolls,

4.1.6 Packaging (see Section 16), and

4.1.7 ASTM designation and year of issue.

NOTE 1—A typical ordering description is as follows: 10 000 ft² welded wire fabric for concrete reinforcement, 4 × 12-W15 × W6, in flat sheets 96 in. wide by 240 in. long, in secured lifts, to ASTM A 185—.

5. Materials

5.1 The wire used in the manufacture of welded wire fabrics shall conform to Specification A 82.

5.2 Welded wire fabric shall be furnished either in flat sheets, or in rolls, as specified by the purchaser.

6. Manufacture

6.1 The wires shall be assembled by automatic machines or by other suitable mechanical means which will assure accurate spacing and alignment of all members of the finished fabric.

6.2 Longitudinal and transverse members shall be securely connected at every intersection by a process of electrical-resistance welding which employs the principle of fusion combined with pressure.

6.3 Wire of proper grade and quality when fabricated in the manner herein required shall result in a strong, serviceable mesh-type product having substantially square or rectangular openings. It shall be fabricated and finished in a workmanlike manner, shall be free from injurious defects, and shall conform to this specification.

NOTE 2—A variation of manufacturing includes the application of one or more longitudinal convoluted wires at one edge of fabric for concrete pipe reinforcing cages. This shape allows the cage ends to be expanded to a larger diameter to accommodate the bell-shaped ends of concrete pipe.

7. Mechanical Property Requirements

7.1 *Tensile*—Wire for the production of welded wire fabric is described in Specification A 82. Tensile tests may be made on wire cut from the welded wire fabric and tested either across or between the welds; no less than 50 % shall be across welds. Tensile tests across a weld shall have the welded joint located approximately at the center of the wire being tested and the cross wire forming the welded joint shall extend approximately 1 in. (25 mm) beyond each side of the welded joint.

NOTE 3—Tensile, reduction of area, and bend testing are normally done at the time the wire is drawn. The manufacturer's finished product still must satisfy the mechanical properties when tested in the final

¹ This specification is under the jurisdiction of ASTM Committee A-1 on Steel, Stainless Steel, and Related Alloys and is the direct responsibility of Subcommittee A01.05 on Steel Reinforcement.

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² Annual Book of ASTM Standards, Vol 01.04.

³ Available from Standardization Documents, Order Desk, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094.