Model Standard

Introduction to AASHTO Standards

The term standards applies collectively to specifications, methods of test, and recommended practices that have been adopted by the Operating Subcommittee on Materials and approved by at least a two-thirds majority of member departments.

Book Parts

AASHTO’s Materials Book consists of three parts: Part I contains specifications (M standards) or recommended practices (R standards) pertaining to highway construction materials, Part II contains methods of testing and sampling (T standards), and Provisional Standards (MP, PP, or TP). More information on Provisional Standards can be found in the Developing an AASHTO Materials Standard document.

Standard Types

The standard types are defined as follows:

- **specification**—an explicit set of requirements to be satisfied by a material, product, or system.
- **recommended practice**—a definitive set of instructions for performing specific operations (such as collection, inspection, or sampling) that do not produce a test result.
- **test method**—a definitive procedure (such as identification, measurement, or evaluation of properties) that produces a test result.

Note: Creating a new test method does not require that all formatting be completed as outlined within this model. Provide all of the necessary parts as described below to the best capability of the author’s ability. Once this has been accomplished, provide a copy to the AASHTO Publications staff along with contact information so the staff may communicate with the author to resolve issues.

Categories of Standards

There are two categories of standards within the AASHTO Materials Book: 1) sole ownership by AASHTO and 2) jointly owned with ASTM. Within the document, it is easy to distinguish between these two categories. If there is an ASTM logo, then it is a jointly owned document. Otherwise, it is solely owned by AASHTO.

Sections of an AASHTO Standard

AASHTO standards follow the ASTM Form and Style Manual (commonly called ASTM’s Blue Book) for both structure and editorial quality of standards. Accordingly, AASHTO standards usually contain the following sections, listed in the order of their appearance. Descriptions follow and examples are shown in the Appendix A.

[Add summary table here?]

Opening Sections Common to All Standard Types

**Supertitle [mandatory]**

The “Supertitle” is actually the beginning of the title of each standard and indicates whether the standard is a materials specification, recommended practice, or method of test. The wording of the supertitle is the same for full and provisional standards. The wording is as follows:

- M or MP: “Standard Specification for”
- R or PP: “Standard Practice for”
- T or TP: “Standard Method of Test for”
Title [mandatory]

The title of the test method should be as concise as possible, yet identify the material, product, system, or process covered by the specification.

Designation Number with Year of Issue [mandatory]

The designation numbers of AASHTO Materials standards are comprised of three parts:

1. a capital letter(s) that reflects the type of standard (M, MP, R, PP, T, or TP), followed by a space;
2. the unique number assigned by the AASHTO Publications staff in sequential order according to the SOM ballot, followed by a hyphen; and
3. the two-digit year of the standard’s publication in its current form, and, in some cases, the four-digit year of last reconfirmation without changes in parentheses.

For example, M 248-91 (2000) would be a standard specification, would carry the unique number 248 in the list of specifications, would have been last revised (or initially approved) in 1991, and would have been reconfirmed by technical section, without changes, in 2000.

As of the 2014 meeting, the reconfirmation year in parentheses will reflect the year of publication regardless of the ballot year. This will make it easier for technical sections and AASHTO staff to identify those standards that require reconfirmation in the next edition.

Current AASHTO policy is to publish standards with metric (SI) units first, with U.S. Standard units following in parentheses. When deemed necessary by the technical section, the Materials Book may include two independent versions of a standard, a “hard” metric (SI) and a U.S. Standard version. In such cases, the standard may be published in separate versions, e.g., M 259 and M 259M, or in a combined version such as M 270M/M 270.

Note that for dual unit standards, AASHTO designation numbers list the metric first, whereas ASTM lists them second, for example, T 19M/T 19 (C 29/C 29M).

ASTM Designation Number [if applicable]

The designation numbers of ASTM standards are comprised of three parts:

1. a capital letter that reflects the general subject area (no space following);
2. the unique number assigned by ASTM; and
3. the two-digit year of the ASTM standard’s publication in its current form, which may be followed (with no space between) by any combination of the elements below:
   a. a lowercase letter if more than one revision is issued in that year (no space preceding),
   b. “(Reapproved 20__)” to designate the year of reapproval, if applicable, or
   c. “ϵ” if editorial changes not requiring approval are included.

Introduction

Occasionally, a standard requires an explanatory statement for proper understanding by the user. In such instances, an introduction should be included before the scope of the standard but without a section number.

Scope [mandatory]

The scope of the standard includes information related to the purpose of the recommended practice and the intended use of the recommended practice in the first paragraph of this section. The system of units to be used and any caveats, such as safety hazards, may also be included in subsequent paragraphs of this section. The “Scope” section shall always be numbered “1.”

Referenced Documents

Include the designation numbers without the year dates and with complete titles of all documents specifically referenced within the standard. List any AASHTO standards first, ASTM standards second, and standards from any other organizations after AASHTO and ASTM.
Do not include the supertitle for AASHTO standards because the letter in the designation number already indicates the standard type. Do include it for other organizations` standards.

**Terminology**

Any significant term that may have a meaning more specialized or more restricted than its common dictionary meaning should be defined in this section. This section may include definitions of terms, symbols, or abbreviations. Terms should be listed alphabetically. Do not capitalize terms unless they are proper nouns, symbols, or abbreviations that would be capitalized elsewhere.

If further explanation of a term is necessary, the supplementary information should be included in a subheading titled “Discussion—”

**Body of the Standard: Specification**

Materials specifications (M or MP standards) may include the following types of information, which should be presented in the order listed.

**Classification**

When more than one material, product, or system is specified, organize them first by types, which are distinguished by Roman numerals, based upon some major property, composition, or application of the item. Further subdivision by grades, identified by Arabic numerals, should be according to some pertinent property. If necessary, additional subdivision into classes should be identified by capital letters.

**Ordering Information**

When the specification covers options for purchase, the standard should provide a sample text of the purchase order stating which type, size, alloy, or mass is desired.

**Materials and Manufacture**

This section of the specification should briefly state the general requirements of the materials or products to be used and the process to be followed in manufacture, including such items as the nature and character of alloys, fillers, saturants, antioxidants, coatings, etc. Break individual process steps into separate subsections.

**Chemical Composition**

When necessary, detailed requirements shall be given as to chemical composition and characteristics for the material, product, or system described in the specification.

**Physical Properties**

Present the requirements for electrical, thermal, optical, and similar properties in this section.

**Mechanical Properties**

Identify the requirements for tensile strength, yield strength, elongation, and similar properties in this section.

**Performance Requirements**

Present functional, environmental, and similar requirements in this section.

**Other Requirements**

Include any additional requirements as needed.

**Dimensions, Mass, and Permissible Variations**

Present details of the standard shapes, mass, and size ranges in this section. When referring to permissible variations, make it clear whether the tolerances specified are both plus and minus or apply in only one direction. This sort of information is often best presented in tabular form.
Workmanship, Finish, and Appearance

Requirements covering the workmanship and finish of products include such general requirements as the type of finish, general appearance of color, uniform quality and tempers, etc. Provisions for removal or repair of minor surface imperfections should be stated. For products such as pipe or tile, specify the absence of defects such as fractures, cracks, checks, blisters, shape, etc.

Sampling

In this section, identify which specimens should be taken and describe the procedure for obtaining samples to determine the acceptability of a large shipment of a product. For example, if a specification applies to a unit of a product, such as a coil of wire or a piece of pipe, describe the procedure for obtaining samples. If the specification applies to a lot of bulk material, such as cement, describe the procedure for obtaining samples and state the criteria for determining conformance and the number of increments or test units needed. Break procedural steps into separate subsections.

Number of Tests and Retests

State the number of tests and, if allowed, retests that are required to determine conformance of the material or product.

Specimen Preparation

When special preparation is required for a test specimen, refer to a standard test method or describe a test method in sufficient detail to assure acceptable reproducibility of test results.

Test Methods

List standard test methods for measurement of all requirements of a specification.

Inspection

Establish minimum or standard inspection methods for the material or product in this specification.

Rejection and Rehearing

Establish minimum or standard procedures for rejection of the material or product in this specification. Break procedural steps into separate subsections. Establish rules for a rehearing if a product or material is rejected.

Certification

If a certification section is included, the certification shall include reference to the standard’s designation number and year date.

Product Marking

Specify the information to be marked on the material or included on the package of a product. Such information may include name, brand, trademark of the manufacturer, quantity, size, weight, or AASHTO designation for a specific material.

Packaging and Package Marking

State the requirements, if needed, of any package, box, crate, or wrap required to protect the material or product during shipping or storage.

Special Government Requirements

If needed, identify any special requirements required by government agencies.

Quality Assurance

Specify any requirements to assure quality of a material or product.
Body of the Standard: Recommended Practice

Materials Recommended Practices (R or PP standards) may include the following types of information, which should be presented in the order listed.

Summary of Practice
This section briefly describes the essential features that are necessary for a complete statement of the procedures and sequence described by this recommended practice. Break procedural steps into separate subsections. A brief statement of the principle of the practice may be included.

Significance and Use [mandatory]
The first paragraph of this section explains the relevance and meaning of the recommended practice, states the practical uses for the recommended practice, and explains how the recommended practice is typically used. Limitations of the practice, cases where the practice may not be applicable, or comparisons of the practice to similar procedures may be discussed in subsequent paragraphs of this section.

Reagents
When more than one procedure is included in the recommended practice, list the reagents and materials required for each procedure as a separate section under each subdivision. This section may also discuss the purity of the reagents, specific properties of a grade of water to be used, and the concentration of the reagents.

Procedure
This section includes detailed directions for performing the task outlined in the recommended practice. Break procedural steps into separate subsections.

Test Methods
List standard test methods used for measurement of all requirements of a recommended practice. These may include sampling, chemical analysis, mechanical, electrical, thermal, optical, and other testing procedures. If alternative test methods are cited, state which particular procedure should be used or is preferred. Break procedural steps into separate subsections.

Report
Include detailed information pertaining to calculating, interpreting, and reporting the results of the procedures in this recommended practice. If a practice permits variance in conditions under which the recommended practice is performed, include these conditions in the report.

Body of the Standard: Test Method
Test methods (T or TP standards) may include the following types of information, which should be presented in the order listed.

Summary of Test Method
This section of the test method should include a brief outline of the test method, a brief statement of the principle of the test method, or a description of the type of procedures to be used in test methods pertaining to chemicals. Break procedural steps into separate subsections.

Significance and Use [mandatory]
The first paragraph of this section should explain the relevance and meaning of the test, state the practical uses for the test, and describe how the test is typically employed. Subsections of this section may explain

- the meaning of the test as related to the manufacture and end use of the material;
- the suitability of the test for specification acceptance, design purposes, service evaluation, regulatory statutes, manufacturing control, and development and research;
• the fundamental assumptions inherent in the test method that may affect the usefulness of the results;
• any discretion needed in the interpretation of the results of the test; and
• comparisons of the test to other similar procedures.

**Interferences**

If the successful application of the test method requires the inclusion of explanatory statements on interference effects, list the constituents or properties that are likely to cause interference and the amounts that are known to interfere. Also explain the compensations that must be made in the calculations if the presence of an interfering factor affects the precision or bias of the test results. If these discussions are lengthy, place this information in an annex to the standard instead of in this section.

**Apparatus**

Include in this section a brief description of the essential features of the apparatus and equipment required for the test and any schematic drawings or photographs of the apparatus. Do not list common laboratory apparatus unless especially modified forms or unusual sizes are required. Avoid using trademark items unless a specific manufacturer’s product is required for a well-defined reason.

**Reagents and Materials**

When more than one procedure is included in the test method, list the reagents and materials required for each procedure as a separate section under each subdivision. Regardless, break procedural steps into separate subsections. This section may also discuss the purity of the reagents, specific properties of a grade of water to be used, and the concentration of the reagents.

**Hazards**

This section of the test method should include statements pertaining to

• *Warning statements*—a warning statement begins with “Warning—” followed by a description of a specific hazard and may provide information for avoiding or minimizing a particular hazard.

• *Remedial statements*—a remedial statement that provides recommendations for treating a situation resulting from an unsuccessfully controlled hazard associated with the use of the standard may be included as a “Note” in this section.

**Sampling, Test Specimens, and Test Units**

Give necessary special directions of obtaining sample test units, for the storage and preservation of these specimens, and for any special preparation of the specimens for the test. Include detailed requirements regarding the size, shape, and number of test specimens to be used for both physical and chemical tests.

**Preparation of Apparatus**

Use this section only when detailed instructions are required for the initial assembly, conditioning, or preparation of the apparatus.

**Calibration and Standardization**

Present detailed instructions for the calibration and adjustment of the apparatus necessary for the use of the test method, the standardization and use of reference standards and blanks used in the test method, and the preparation and use of calibration curves or tables.

**Conditioning**

Specify the conditioning atmosphere to be used and the time of exposure to the atmosphere as well as the atmosphere required during the test. Also state whether the conditioning requirements apply to laboratory samples as well as individual specimens. Indicate any requirements for preconditioning.
Procedure [mandatory]

In this section, give detailed, step-by-step instructions for performing the test. Make the text of the procedure concise, to the point, and easily understandable. Specify the size of the test specimen and indicate the degree of precision desired in the weighing. Break procedural steps into separate subsections. Supplementary information regarding the procedure, such as technical details or discussion to amplify the test procedure, or alternative directions, may be included in a note. If alternative procedures are given, indicate which one is the preferred method of testing.

Calculation or Interpretation of Results

Under the heading “Calculation,” state the directions for calculating the results of tests, including any equations or any required significant figures. Use the heading “Interpretation of Results” instead of “Calculation” when the results of the test are expressed in descriptive form, relative terms, or abstract values.

Report

In this section, state the detailed information required in reporting the results of the test. When two or more procedures are described in a test method, the report shall indicate which procedure or which particular conditions were used. Include a standard report form or worksheet if available.

Precision and Bias [mandatory]

Precision is the closeness of agreement between test results obtained under prescribed conditions. A statement on precision allows the user of the test method to assess, in general terms, its usefulness in proposed applications and provides guidelines as to the kind of variability that can be expected between test results when the test method is used in one or more reasonably competent laboratories. The precision statement should include the repeatability and reproducibility standard deviation and the 95% repeatability and reproducibility limits on the difference between two test results.

Ending Sections Common to All Standard Types

Keywords [mandatory]

Identify the words, terms, or phrases (e.g., “back pressure saturation,” “expansion joint,” or “shear strength”) that represent the technical information in the standard. List keywords in alphabetical order, separated by semicolons, and end with a period.

Keywords become the search terms in the book’s index and in electronic standard metadata. This aids Materials Book users in finding a specific standard in the web-based publication or for individual download from the AASHTO Bookstore.

Supplementary Requirements

Supplementary requirements usually apply only when specified by the purchaser, contract, or order.

Annexes

Additional, required information may be included in one or more annexes to the standard. The “Annex” header contains the annex letter and title, and is always followed by the subheader “Mandatory Information.” Annexes include detailed information regarding an apparatus or material that is too lengthy for inclusion in the main text, such as example calculations or applied procedures. Individual annexes are lettered, A, B, C, and so on (not A1, A2, and so on).

Appendixes

Additional, optional information may be included in one or more appendixes to the standard. The “Appendix” header is always followed by the subheader “Nonmandatory Information.” Appendixes include additional information for general use and guidance that does not constitute a mandatory part of the standard. Appendixes are numbered, starting with an “X;” X1, X2, X3, and so on.
References

This listing should include only references to publications supporting or providing needed supplementary information. References that are specifically cited in the standard should be listed in the Referenced Documents section. Include complete bibliographic information.

Page Footer

The footer(s) of all AASHTO standards includes

- the number of the SOM Technical Section responsible for the standard aligned with the left margin;
- the designation number of the standard with the page number of the standard centered in the footer, separated by a hyphen; and
- “AASHTO” aligned with the right margin.

Endnotes

The reference number of the endnote follows the designation number of the AASHTO standard listed on page 1 of the AASHTO standard in the following cases:

A full standard that was first published as a provisional standard shall include an endnote that identifies its former provisional designation number (letter and unique number only) and the year it was first published as a full standard. A provisional standard shall include an endnote that identifies the year it was first published.

Standards that are jointly owned by AASHTO and ASTM may include an endnote that states whether the two standards are identical or different.

Endnotes may also be used to provide information about how to obtain standards listed under referenced documents or any other tangential information that would otherwise be included parenthetically.

Other Elements in Standards

Tables

General

Tables are used to present a large amount of detailed information in a minimum amount of space or to present quantitative or precise numerical values in a concise manner.

In a Word document, the table itself should be inserted in a paragraph style tag named “Table Placeholder” that immediately follows a paragraph style tag named “Table Caption.” The Table Caption tag should utilize the “Keep with next” feature in order to avoid separation between the table caption and the table.

Avoid fills or shading in table cells. If gray shading is necessary to clarify the intended meaning, use a solid “Fill” of “25% Gray.”

Table Captions

The table caption should clearly distinguish its table from other tables. The caption should provide a succinct noun or noun phrase that describes the information provided in the table, but does not provide unnecessary background information nor repeat information found in the text.

Table captions should appear immediately before the table. Use an em dash between the table number and the caption of table. Do not use a period at the end of the table caption. Table captions are set in “Title” case, i.e., all nouns and verbs are capitalized while all conjunctions, prepositions, and articles are lowercase.

Avoid using articles, such as, “A,” “The,” etc., at the beginning of captions.

Capitalize both parts of hyphenated terms within the table caption if the elements are nouns or adjectives or if the element is the final word of the caption. Hyphenated prefixes or suffixes are lowercase unless the element is the final word of the caption. Correct examples would be “State-of-the-Art Report”; “Four-Leg Intersection”; “Conditions Determined to Be Pre-Existing.”

Do not abbreviate “Table.”

Font

Table captions are set in regular New Times Roman type with the table numbering in Arial boldface type.
Numbering

Tables should be numbered consecutively with Arabic numerals throughout the body of the text. Tables in annexes, appendixes, and supplementary requirements are numbered by the designation of the section in which the table appears followed by consecutive numbers beginning with “1.” Refer to the annexes and appendixes of T 307 as examples.

Table captions should be numbered separately from figure captions. Table captions in Word documents can be numbered automatically in the body of the text.

Table Set-Up

Table Orientation

Set all tables vertical (portrait) if possible.

Table Margins

Make sure the tables do not exceed the limits imposed by the printed page.

Table Rules/Borders

Make rules at the top and bottom of the table one point wide. All other rules should be 1/2-point width. Vertical rules should not be used unless absolutely necessary.

Table Text

Table Headings

Table headings, i.e., column heads, spanners, and cut-in heads, can be set in Times New Roman, 8–10 points (7 pt can be used if space must be conserved), boldface. Spanner heads and cut-ins must be centered over the columns they apply to.

When tabular matter demands two or more levels of headings, decked heads must be used. A decked head consists of a spanner head and two or more column heads to which it applies. A horizontal rule (called a spanner rule) is set between the spanner and column heads indicating the columns the spanner applies to. Decked heads should seldom exceed two levels.

Table Stub

The table stub is the far left column of the table that lists the items about which information is provided in the columns to the right. Use Times New Roman, 8–10 pt, initial caps for the stub row text. (Headings in the table stub are set as other headings are.)

In the stub, subheads should be in italics and are aligned flush left. Stub items are usually indented one em under the subhead. Runovers in stub items are indented one em from when the item begins.

With two or more levels of subheads in the stub, the top level may be centered and the second level flush left. Use cut-in heads for the top-level subheads with rules above and below extending all the way across the table.

Table Columns

Vertically align a column of figures on the decimal points. Numerals of 1,000 or more should have commas for U.S. Standard units only. Mathematical operation signs are aligned if they precede quantities in a column of figures. Also, in a column consisting of information expressed in words, make text flush left if longer items. If short, center them.

Table Editing

Use em dashes “—” to indicate breaks. Use en dashes “–” to indicate ranges (2–4). Do not include a space before or after a dash used for these purposes.

For equations, use an en dash “–” as

- a minus sign with a space on either side, or
- a negative value sign with no space between it and the number.
Use “%” to indicate percentages in table cells but spell out “percent” in table footnotes.

Table Footnotes
Footnotes are normally set one size smaller than the body of a table (e.g., 7 points with an 8 point table). The words “Source” and “Notes” are traditionally distinguished typographically from the note that follows.
In “Source:” or “Note:” do not italicize the punctuation (:). Make terms italic and initial caps followed by lowercase running text in roman style font.
Footnotes to a table are of four general kinds and should appear in this order: (1) source notes, (2) other general notes, (3) notes on specific parts of the table, and (4) notes on the level of probability. Leave extra space in between each note item.

Tables Continued on More Than One Page
Use continued lines as needed. Format in italics as follows:

- “Continued on next page” should appear under the rule of the table at the bottom of the page.
- “Table [number]—Continued” (e.g. “Table 5—Continued”) should appear above the top rule of the table on the next page.

Column heads should be repeated on each page, but the title is not.

Figures
Figure Types and File Requirements
Figures may be either photographs or line art. Photographs show exactly how something looks to help readers recognize an object, design, or situation. Line art illustrates specific features of an object or shows how something works, is assembled, or is maintained.
Figures should be inserted in Word documents as “pictures,” NOT as “drawing objects.” The file should be inserted in a paragraph style tag named “Figure Placeholder” that is immediately followed by a paragraph style tag named “Figure Caption.” Use the “Keep with next” style feature with the Figure Placeholder tag so that the picture does not get separated from its caption.
For compound figures including multiple photos or line art and other descriptive text separating the elements, insert the images as separate files, especially photos, so that the text remains editable and high resolution. See Appendix B.

Figure Captions
The figure caption should clearly distinguish its figure from other illustrations. The caption should provide a succinct noun or noun phrase that describes the figure, but does not provide unnecessary background information nor repeat information found in the text.
Figure captions should appear below the figure. Use an em dash between the figure number and the caption of figure. Do not use a period at the end of the figure caption. Figure captions are set in “Title” case, i.e., all nouns and verbs are capitalized while all conjunctions, prepositions, and articles are lowercase.
Avoid using articles, such as, “A,” “The,” etc., at the beginning of captions.
 Capitalize both parts of hyphenated terms within the figure caption if the elements are nouns or adjectives or if the element is the final word of the caption. Hyphenated prefixes or suffixes are lowercase unless the element is the final word of the caption. Correct examples would be “State-of-the-Art Report”; “Four-Leg Intersection”; “Conditions Determined to Be Pre-Existing.”
Do not abbreviate “Figure.”

Font
Figure captions are set in regular New Times Roman type with the table numbering in Arial boldface type. See the section on “Line Art” in the Style Manual for AASHTO Publications for a discussion of fonts used within the figures themselves.
**Numbering**

Figures should be numbered consecutively with Arabic numerals throughout the body of the text. Figures in annexes, appendixes, and supplementary requirements are numbered by the designation of the section in which the figure appears followed by consecutive numbers beginning with “1.” Refer to the annexes and appendixes of T 307 as an example.

Figure captions should be numbered separately from table captions. Figure captions in Word documents are numbered automatically.

**Notes**

Notes in the text shall not include mandatory requirements. Notes set explanatory material apart from the text itself in order to emphasize the information or to offer suggestions that are not properly part of the standard. Notes in the text may refer to similar or companion AASHTO or ASTM standards; limitations of the application of the test; additional apparatus, materials, procedures, or calculations that are not actually required; or explanations of the reasons for a certain requirement or direction.

Notes in the text can be automatically numbered in consecutive order, beginning with the number “1,” throughout the body of the text regardless of the section number in which the note appears.

Notes in annexes, appendixes, and supplementary requirements are numbered differently than the figures, tables, and equations of annexes, appendixes, and supplementary requirements.

- Numbers for notes in Annexes begin with the annex letter followed by consecutive numbers beginning with “1” throughout the annex. Refer to the annexes of T 287 and T 307 in the Appendix as examples.
- Numbers for notes in Appendixes begin with “X” followed by consecutive numbers beginning with “1” throughout the appendixes. Refer to the appendixes of R 9 and T 307 in the Appendix as examples.
- Numbers for notes in Supplementary Requirements begin with “S” followed by consecutive numbers beginning with “1” throughout the supplementary requirements. Refer to the supplementary requirements in M 264 307 in the Appendix for an example.

**Equations and Variables**

**Equation Numbering**

Just as figures and tables, equations should be numbered consecutively with Arabic numerals throughout the body of the text. Equations in annexes, appendixes, and supplementary requirements are numbered by the designation of the section in which the equation appears followed by consecutive numbers beginning with “1.” Refer to Appendix B for examples of numbering in these sections.

Equation numbers are enclosed in parentheses at the right-hand margin. There should be a minimum of one quarter of an inch between the equation number and the last term in the equation. The equation number appears on the same line of a single-line equation and on the last line of a multiline equation.

Unlike table and figure numbers, equation numbers are typed in manually.

**Formatting Equations and In-Text Variables**

All equations, no matter how small, are typeset in MathType. Variables within the text are set in Word using a TrueType font and italicizing to be consistent with those set in MathType.

Roman variables are italicized throughout; Greek variables and Arabic numerals, including superscripts and subscripts, are not.

Except for special symbols, the font is 10 pt Times New Roman Regular. Subscripts or superscripts should be 7 pt Times New Roman.

Standard mathematical notation is used throughout, except as noted below. Fences/enclosures are used in the preferred order listed in *The Chicago Manual of Style*:

```
{ [ ( ) ] }
```

Individual equations are aligned left. Formulas with multiple lines are aligned at the equal sign. If used when working through formulas, the “therefore” symbol, \( \therefore \), appears at the start of a new line.

The negative-value symbol and the subtraction operator are both represented by an en dash (–).
Appendix A—Section Examples

Examples for Opening Sections Common to All Standard Types

Introduction

INTRODUCTION

The principal reasons for measuring pore pressures in highway construction are:
1. To monitor strength increases during construction;
2. To estimate remaining settlements after construction; and
3. To determine existing pore pressures in landslides.

This method consists of installing the pore water pressure measuring device in a soil layer at a
point determined by detailed knowledge of the field conditions and theoretical evaluation of the
need required. Pore pressure measurement may be made by determining the total pore pressure at
the point or determining the differential pore pressure at that point relative to the surrounding
normal groundwater table. The data are usually reduced to “excess” pore pressure, which is the
difference between the measured pore pressure and the “normal” pore pressure under the general
groundwater table for the area at the time of reading.

Interpretation of pore pressure measurements in the field are complicated by the variability both
vertically and horizontally in the soils. Therefore, interpretation of any pore pressure measurement
can be misleading if the complete soil profile, loading history, and detailed soil parameters are not
adequately known.

Scope [mandatory]

1. SCOPE

1.1. This specification provides a compilation of specifications covering commercial grades and
species of lumber and other wood products for highway construction as indicated below. More
detailed requirements will be found in the various specifications cited for specific products:

1.1.1. Lumber,
1.1.2. Structural glued laminated timber,
1.1.3. Piling,
1.1.4. Posts, and
1.1.5. Structural composite lumber.

1.2. The values stated in SI units are to be regarded as the standard.
2. REFERENCED DOCUMENTS

2.1. AASHTO Standards:
- R 30, Mixture Conditioning of Hot Mix Asphalt (HMA)
- T 166, Bulk Specific Gravity ($G_{mb}$) of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface-Dry Specimens
- T 209, Theoretical Maximum Specific Gravity ($G_{mm}$) and Density of Hot Mix Asphalt (HMA)
- T 269, Percent Air Voids in Compacted Dense and Open Asphalt Mixtures
- T 312, Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor
- T 342, Determining Dynamic Modulus of Hot Mix Asphalt (HMA)
- TP 79, Determining the Dynamic Modulus and Flow Number for Hot Mix Asphalt (HMA) Using the Asphalt Mixture Performance Tester (AMPT)

2.2. ASTM Standards:
- A732/A732M, Standard Specification for Castings, Investment, Carbon and Low Alloy Steel for General Application, and Cobalt Alloy for High Strength at Elevated Temperatures
- A781/A781M, Standard Specification for Castings, Steel and Alloy, Common Requirements, for General Industrial Use
- A957/A957M, Standard Specification for Investment Castings, Steel and Alloy, Common Requirements, for General Industrial Use
- E527, Standard Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)

2.3. Military Standards:
- MIL-STD-129, Marking for Shipment and Storage
- MIL-STD-163, Steel Mill Products Preparation for Shipment and Storage

2.4. Federal Standard:
- Fed. Std. No. 123, Marking for Shipment (Civil Agencies)

3. TERMINOLOGY

3.1. Description of Terms Specific to This Standard:

3.1.1. deformed bar—steel bar with protrusions; a bar that is intended for use as reinforcement in reinforced concrete construction.

3.1.1.1. Discussion—The surface of the bar is provided with lugs or protrusions that inhibit longitudinal movement of the bar relative to the concrete surrounding the bar in such construction. The lugs or protrusions conform to the provisions of this specification.

3.1.2. deformations—protrusions on a deformed bar.

3.1.3. plain bar—steel bar without protrusions.

3.1.4. rib—longitudinal protrusion on a deformed bar.

3.1.5. lot—bars of one bar number and pattern of deformation contained in an individual shipping release or shipping order.
3. **TERMINOLOGY**

3.1. **Definitions:**

3.1.1. The following terms and definitions are specific to this specification. ASTM A902 contains other terms and definitions relating to metallic-coated steel products.

3.2. **Definitions of Terms Specific to This Standard:**

3.2.1. *average coating thickness, n*—the average of three specimen coating thicknesses.

3.2.2. *black, adj*—denotes the condition of not galvanized or otherwise coated. For purposes of this specification, the word “black” does not refer to the color or condition of surface, or to a surface deposit or contamination.

3.2.3. *coating thickness grade, n*—the numerical value from Table 1 at the intersection of a material category and a thickness range.

### Table 1—Minimum Average Coating Thickness Grade by Product Category

<table>
<thead>
<tr>
<th>Product Category</th>
<th>$&lt;\frac{1}{2}t_o$</th>
<th>$\frac{1}{4}t_o$ to $&lt;\frac{1}{2}t_o$</th>
<th>$\frac{1}{2}t_o$ to $\frac{3}{4}t_o$</th>
<th>$&gt;\frac{3}{4}t_o$ to $&lt;t_o$</th>
<th>$\geq\frac{3}{4}t_o$ to $&lt;t_o$</th>
<th>$\geq t_o$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Shapes</td>
<td>45</td>
<td>65</td>
<td>75</td>
<td>75</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Strip and Bar</td>
<td>45</td>
<td>65</td>
<td>75</td>
<td>75</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Plate</td>
<td>45</td>
<td>65</td>
<td>75</td>
<td>75</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Pipe and Tubing</td>
<td>45</td>
<td>45</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>Wire</td>
<td>35</td>
<td>50</td>
<td>60</td>
<td>65</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>Reinforcing Bar</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Examples for Ending Sections Common to All Standard Types

**Keywords** [mandatory]

18. **KEYWORDS**

18.1. Blended hydraulic cement; fly ash cement; granulated blast-furnace slag; hydraulic cement; portland blast-furnace slag cement; portland-limestone cement; portland-pozzolan cement; pozzolanic cement; slag cement; ternary blended cement.

**Supplementary Requirements**

**SUPPLEMENTARY REQUIREMENTS**

One or more of the following supplementary requirements shall apply only when specified by the purchaser in the inquiry, contract, or order. Details of these supplementary requirements shall be agreed upon by the manufacturer and the purchaser.

S1. **CHEMICAL COMPOSITION**

Suppliers shall obtain approval of the grade of steel they propose to apply to the order and reach agreement with the purchaser on the ranges of each element specified in the composition.

S2. **SPECIAL FORGING TECHNIQUES**

S2.1. Special forging techniques are required to produce metal flow during the hot-working operation in the direction most favorable for resisting the stresses encountered in service. Verification of forging flow lines shall be by macroetch testing of sample forgings in accordance with ASTM E581.
ANNEX B

(Mandatory Information)

B1. CREEP TESTING AND EXTRAPOLATION PROCEDURES TO DETERMINE RF<sub>CR</sub> FOR GEOSYNTHETIC REINFORCEMENTS

B1.1. General:

B1.1.1. The effect of long-term load/stress on geosynthetic reinforcement strength and deformation characteristics shall be determined from the results of product specific, long-term laboratory creep tests conducted for a range of load levels and durations, adequate for extrapolation purposes to the desired design life, carried out to rupture of the geosynthetic.

B1.2. Creep Testing Requirements:

B1.2.1. Creep testing, unless otherwise specified herein, shall be conducted in accordance with ASTM D5262 or D6992.

APPENDIX

(Nonmandatory Information)

X1. DETERMINING CORRELATED COLOR TEMPERATURE

X1.1. Scope:

X1.1.1. Procedure for determination of correlated color temperature of a projector source of illumination using a tristimulus photoreceptor and standard reference lamp for use in the photometry of retroreflectors.

X1.2. Apparatus:

X1.2.1. Standard reference lamp and holder with voltage and current specified for 2856 K.

X1.2.2. Voltmeter (accurate to 0.5 percent) or ammeter (accurate to 0.25 percent), as appropriate to voltages or currents specified for standard reference lamp.

X1.2.3. Photoreceptor equipped with tristimulus filters (X<sub>r</sub>, X<sub>b</sub>, Y, and Z filters).

X1.2.4. MgO, BaSO<sub>4</sub>, or other neutral white diffusing surface.

X1.2.5. Test enclosure or photometric range.

X1.3. Procedure:

X1.3.1. Set up standard reference lamp, projector to be calibrated, white diffusing surface, and tristimulus receptor in a darkroom as shown in Figure X1.1.

Endnotes

1 Formerly AASHTO Provisional Standard TP 68. First published as a full standard in 2012.
This provisional standard was first published in 2013.

Similar but not technically equivalent to ASTM C 881-10.

Annual Book of ASTM Standards, Volume 04.02.

Annual Book of ASTM Standards, Volume 08.01.

Annual Book of ASTM Standards, Volume 15.06.

Reagent Chemicals, American Chemical Society Specifications, American Chemical Society, Washington, DC. For the testing of reagents not listed by the American Chemical Society, see “Analar” Standards for Laboratory Chemicals, British Drug Houses, Ltd., Poole, U.K., and the United States Pharmacopeia and National Formulary, U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.
### Appendix B—Other Element Examples

#### Table Examples

**Basic**

**Table 2**—Physical Requirements (inch-pound)

<table>
<thead>
<tr>
<th>Class</th>
<th>Weight per Linear Yard (40-Inch Basis), Ounces</th>
<th>Yarns per Inch of Warp</th>
<th>Yarns per Inch of Filling</th>
<th>Weight per Square Yard&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7/2</td>
<td>8 to 11, inclusive</td>
<td>8 to 11, inclusive</td>
<td>6.7</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>9 to 12, inclusive</td>
<td>9 to 11, inclusive</td>
<td>7.2</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>11 to 13, inclusive</td>
<td>10 to 12, inclusive</td>
<td>9.0</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
<td>11 to 13, inclusive</td>
<td>11 to 13, inclusive</td>
<td>10.8</td>
</tr>
</tbody>
</table>

<sup>a</sup> A plus or minus tolerance of 5 percent will be permitted.

**Decked Headings**

**Table 1**—Grading Requirements for Fine Aggregates

<table>
<thead>
<tr>
<th>Sieve Size (Square Openings), Mass, %</th>
<th>Grading No. 1</th>
<th>Grading No. 2</th>
<th>Grading No. 3</th>
<th>Grading No. 4</th>
<th>Grading No. 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.5 mm (3/8 in.)</td>
<td>100</td>
<td>—</td>
<td>—</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>4.75 mm (No. 4)</td>
<td>95 to 100</td>
<td>100</td>
<td>100</td>
<td>80 to 100</td>
<td>80 to 100</td>
</tr>
<tr>
<td>2.36 mm (No. 8)</td>
<td>70 to 100</td>
<td>75 to 100</td>
<td>95 to 100</td>
<td>65 to 100</td>
<td>65 to 100</td>
</tr>
<tr>
<td>1.18 mm (No. 16)</td>
<td>40 to 80</td>
<td>50 to 74</td>
<td>65 to 100</td>
<td>40 to 80</td>
<td>40 to 80</td>
</tr>
<tr>
<td>600 μm (No. 30)</td>
<td>20 to 65</td>
<td>28 to 52</td>
<td>65 to 90</td>
<td>20 to 65</td>
<td>20 to 65</td>
</tr>
<tr>
<td>300 μm (No. 50)</td>
<td>7 to 40</td>
<td>8 to 30</td>
<td>30 to 60</td>
<td>7 to 40</td>
<td>7 to 46</td>
</tr>
<tr>
<td>150 μm (No. 100)</td>
<td>2 to 20</td>
<td>0 to 12</td>
<td>5 to 25</td>
<td>2 to 20</td>
<td>2 to 30</td>
</tr>
<tr>
<td>75 μm (No. 200)</td>
<td>0 to 10</td>
<td>0 to 5.0</td>
<td>0 to 5.0</td>
<td>0 to 10</td>
<td>—</td>
</tr>
</tbody>
</table>

**Table Stub**

**Table 4**—Tensile Requirements

<table>
<thead>
<tr>
<th>Grade Designation No.</th>
<th>Grade 40&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Grade 60</th>
<th>Grade 75</th>
<th>Grade 80</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength, min psi</td>
<td>60,000</td>
<td>90,000</td>
<td>100,000</td>
<td>105,000</td>
</tr>
<tr>
<td>Yield strength, min psi</td>
<td>40,000</td>
<td>60,000</td>
<td>75,000</td>
<td>80,000</td>
</tr>
<tr>
<td>Elongation in 8 in., min %</td>
<td>Bar Designation No. 3</td>
<td>11</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>4, 5</td>
<td>12</td>
<td>9</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>6</td>
<td>12</td>
<td>9</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>7, 8</td>
<td>—</td>
<td>8</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>9, 10, 11</td>
<td>—</td>
<td>7</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>14, 18</td>
<td>—</td>
<td>7</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

<sup>a</sup> Grade 40 bars are furnished only in sizes 3 through 6.
## Table 1—Maximum Allowable Quantity of Material Retained on a Sieve, kg

<table>
<thead>
<tr>
<th>Sieve Opening Size</th>
<th>203.2-mm, dia(^{a})</th>
<th>254-mm, dia(^{a})</th>
<th>304.8-mm, dia(^{a})</th>
<th>350 by 350, mm</th>
<th>372 by 580, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sieving Area, m(^2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>125 mm (5 in.)</td>
<td>0.0285</td>
<td>0.0457</td>
<td>0.0670</td>
<td>0.1225</td>
<td>0.2158</td>
</tr>
<tr>
<td>100 mm (4 in.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90 mm (3 1/2 in.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>75 mm (3 in.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>63 mm (2 1/2 in.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50 mm (2 in.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37.5 mm (1 1/2 in.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25.0 mm (1 in.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19.0 mm (3/4 in.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.5 mm (1/2 in.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.5 mm (3/8 in.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.75 mm (No. 4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^{a}\) Sieve frame dimensions in inch units: 8.0-in. diameter; 10.0-in. diameter; 12.0-in. diameter; 13.8 by 13.8 in. (14 by 14 in. nominal); 14.6 by 22.8 in. (16 by 24 in. nominal).

\(^{b}\) The sieve area for round sieves is based on an effective diameter 12.7 mm (1/2 in.) less than the nominal frame diameter, because M 92 permits the sealer between the sieve cloth and the frame to extend 6.35 mm (1/4 in.) over the sieve cloth. Thus the effective sieving diameter for a 203.2-mm (8.0-in.) diameter sieve frame is 190.5 mm (7.5 in.). Sieves produced by some manufacturers do not infringe on the sieve cloth by the full 6.35 mm (1/4 in.).

\(^{c}\) Sieves indicated have less than five full openings and should not be used for sieve testing.
Table 1—Requirements for Tensile Strength of Gray Cast Irons in Cast Test Bars

<table>
<thead>
<tr>
<th>Class</th>
<th>Tensile Strength, Min, MPa [ksi]</th>
<th>Nominal Test Bar, Dia, mm [in.]</th>
<th>Class</th>
<th>Tensile Strength, Min, MPa [ksi]</th>
<th>Nominal Test Bar, Dia, mm [in.]</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 20A</td>
<td>138 [20]</td>
<td>22.4 [0.88]</td>
<td>No. 45A</td>
<td>310 [45]</td>
<td>22.4 [0.88]</td>
</tr>
<tr>
<td>No. 20B</td>
<td>30.5 [1.2]</td>
<td>No. 45B</td>
<td>30.5 [1.2]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 20C</td>
<td>50.8 [2.0]</td>
<td>No. 45C</td>
<td>50.8 [2.0]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 20S</td>
<td>Bar S&lt;sup&gt;a&lt;/sup&gt;</td>
<td>No. 45S</td>
<td>Bar S&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 25A</td>
<td>172 [25]</td>
<td>22.4 [0.88]</td>
<td>No. 50A</td>
<td>345 [50]</td>
<td>22.4 [0.88]</td>
</tr>
<tr>
<td>No. 25B</td>
<td>30.5 [1.2]</td>
<td>No. 50B</td>
<td>30.5 [1.2]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 25C</td>
<td>50.8 [2.0]</td>
<td>No. 50C</td>
<td>50.8 [2.0]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 25S</td>
<td>Bar S&lt;sup&gt;a&lt;/sup&gt;</td>
<td>No. 50S</td>
<td>Bar S&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 30A</td>
<td>207 [30]</td>
<td>22.4 [0.88]</td>
<td>No. 55A</td>
<td>379 [55]</td>
<td>22.4 [0.88]</td>
</tr>
<tr>
<td>No. 30B</td>
<td>30.5 [1.2]</td>
<td>No. 55B</td>
<td>30.5 [1.2]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 30C</td>
<td>50.8 [2.0]</td>
<td>No. 55C</td>
<td>50.8 [2.0]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 30S</td>
<td>Bar S&lt;sup&gt;a&lt;/sup&gt;</td>
<td>No. 55S</td>
<td>Bar S&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 35A</td>
<td>241 [35]</td>
<td>22.4 [0.88]</td>
<td>No. 60A</td>
<td>414 [60]</td>
<td>22.4 [0.88]</td>
</tr>
<tr>
<td>No. 35B</td>
<td>30.5 [1.2]</td>
<td>No. 60B</td>
<td>30.5 [1.2]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 35C</td>
<td>50.8 [2.0]</td>
<td>No. 60C</td>
<td>50.8 [2.0]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 35S</td>
<td>Bar S&lt;sup&gt;a&lt;/sup&gt;</td>
<td>No. 60S</td>
<td>Bar S&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 40A</td>
<td>276 [40]</td>
<td>22.4 [0.88]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 40B</td>
<td>30.5 [1.2]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 40C</td>
<td>50.8 [2.0]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. 40S</td>
<td>Bar S&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> All dimensions of test bar S shall be as agreed upon between the manufacturer and the purchaser.

---

Table 1—Single-Operator Precision Statements

<table>
<thead>
<tr>
<th>Property as a Function of Nominal Thickness</th>
<th>Thickness, nominal, mm</th>
<th>Distortion, max mm</th>
<th>Britleness Pass&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Compression, kPa, min–max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Property</td>
<td>25 19 13 9.5 6.4</td>
<td>25 25 25 25 25</td>
<td>Pass&lt;sup&gt;a&lt;/sup&gt; Pass&lt;sup&gt;a&lt;/sup&gt; Pass&lt;sup&gt;a&lt;/sup&gt; Pass&lt;sup&gt;a&lt;/sup&gt; Pass&lt;sup&gt;a&lt;/sup&gt;</td>
<td>690–5200 690–5800 690–6400 690–7000 690–7600</td>
</tr>
<tr>
<td>Precision, max accept range</td>
<td>2.93 2.30 5.92 6.03 6.84</td>
<td>2.5 3 4 5</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Water absorption, wt % max</td>
<td>2.5 3 4 5</td>
<td>0.057 0.087 0.400 1.187</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

Precision, maximum acceptable range per C 670, Table 2. Maximum acceptable range between high and low individual measurements.

<sup>a</sup> Not crack or shatter.

<sup>b</sup> No precision statement is necessary for this attribute.
Table 3—Bolt and Nut Requirements

<table>
<thead>
<tr>
<th></th>
<th>Bolts&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Nuts</th>
</tr>
</thead>
<tbody>
<tr>
<td>General dimensions&lt;sup&gt;b&lt;/sup&gt;</td>
<td>ANSI B18.2.3.6M</td>
<td>ANSI B18.2.4.6M</td>
</tr>
<tr>
<td></td>
<td>Heavy Hex</td>
<td>Heavy Hex</td>
</tr>
<tr>
<td>Seam bolts and nuts&lt;sup&gt;c&lt;/sup&gt;</td>
<td>F 568 Class 8.8</td>
<td>A 563 Class 12</td>
</tr>
<tr>
<td>Anchorage bolts and nuts</td>
<td>F 568 Class 4.6</td>
<td>A 563 Class 5</td>
</tr>
<tr>
<td>Zinc coating</td>
<td>M 232/M 232</td>
<td>M 232/M 232</td>
</tr>
<tr>
<td>Nominal diameter, min, metric size&lt;sup&gt;d&lt;/sup&gt;</td>
<td>M 20</td>
<td>M 20</td>
</tr>
</tbody>
</table>

<sup>a</sup> Bolts with special hemispherical base under the head are only available in inch sizes. They are also intended for use with metric plate.

<sup>b</sup> See Section 5.4 for permissible modifications to bearing surface.

<sup>c</sup> Bolts and nuts also used for connecting arch plates to bearing and structural reinforcement to structural plates.

<sup>d</sup> Bolt size of M 22, M 24, or M 27 may be required with thicker plates, especially with 380-by-140-mm corrugation, and shall be furnished when specified in the order.

Tables Continued on More Than One Page

| 58 | 104 | 104 | 117 | 38.6 | 90.0 | 79.5 | 55.0 | 30.7 | —  |
| 57 | 103 | 103 | 115 | 38.1 | 89.4 | 79.2 | 54.4 | 29.7 | —  |
| 56 | 101 | 101 | 114 | 37.7 | 88.8 | 78.8 | 53.7 | 28.7 | —  |
| 55 | 100 | 100 | 112 | 37.2 | 88.2 | 78.5 | 53.0 | 27.7 | —  |
| 54 | —   | —   | 111 | 36.8 | 87.7 | 78.2 | 52.4 | 26.7 | —  |
| 53 | —   | —   | 110 | 36.3 | 87.1 | 77.9 | 51.7 | 25.7 | —  |

Continued on next page.

Figure Examples

Simple

![Figure 3 — Type of Suitable Apparatus for Measurement of Length Changes](image-url)
Group Index (GI) = \((F - 35) \times [0.2 + 0.005 (LL - 40)] + 0.01 (F - 15) (PI - 10)\)

where \(F\) = Percent Passing 75-μm sieve, \(LL\) = Liquid Limit, and \(PI\) = Plasticity Index.

When working with A-2-6 and A-2-7 Subgroups, the Partial Group Index (PGI) is determined from the \(PI\) only.

When the combined Partial Group Indices are negative, the Group Index should be reported as zero.

Example:
82 Percent Passing 75-μm Sieve
\(LL = 38\)
\(PI = 21\)

Then:
PGI = 8.9 for \(LL\)
PGI = 7.4 for \(PI\)
GI = 16

Figure 1—Group Index Chart
Figure 1—Locations of Test Specimens for Various Types of Forgings
<table>
<thead>
<tr>
<th>Required Features</th>
<th>Optional Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Material—Aggregate of dry siliceous sand.</td>
<td>1. Number of test bars in a single mold—Two suggested.</td>
</tr>
<tr>
<td>3. $L$—See Table 3.</td>
<td>3. $P$—50 mm (2 in.), suggested.</td>
</tr>
<tr>
<td>4. $D$—See Table 3.</td>
<td>4. $N$—8 mm ($\frac{3}{16}$ in.) in diameter, suggested.</td>
</tr>
<tr>
<td>5. $W$—Not less than diameter, $D$.</td>
<td>5. $M = 1.5, N$, suggested.</td>
</tr>
</tbody>
</table>

**Figure 1**—Suitable Design and Dimensions for Mold for Separately Cast Cylindrical Tension Test Bars for Gray Iron

**Figure Footnotes**

**Single Note**

Note: Each specimen comprises nominally one third of the total surface area of the article. A minimum of five measurements should be made within the volume of each specimen, as widely dispersed within that volume as is practical so as to represent, as much as possible, the general coating thickness within that specimen volume.

**Figure 2**—Articles Made of Many Components
Note Examples

Regular

Note 1—This specification is regarded as adequate to ensure satisfactory materials for most concrete. It is recognized that, for certain work or in certain regions, it may be either more or less restrictive than needed. For example, where aesthetics are important, more restrictive limits may be considered regarding impurities that would stain the concrete surface. The specifier should ascertain that aggregates specified are or can be made available in the area of the work, with regard to grading, physical, or chemical properties, or combination thereof.

Note 2—Definitions of terms used in this specification may be found in ASTM C 125.
Annex

**Note A2**—Alternative types of mixers can be used if it can be shown that results obtained agree with results produced using an impeller agitator as specified above.
- Balance, readable to 0.1 percent of the mass to be weighed;
- Stopwatch or stopclock, readable to 1 s;
- Test sieve, 2-mm aperture, with guard sieve, if applicable;
- Beaker, glass or plastic, capacity about 1 L or about 2 L;
- Volumetric flask, capacity 1 L;
- Ventilated oven, thermostatically controlled to maintain a temperature of 105 ± 5°C (see Note A2.2);
- Thermometer, readable to 1°C;
- Spatula;
- Desiccator;
- Tinted-glass storage bottle; and
- 63-μm (No. 230) sieve conforming to the requirements of M 92.

A2.5.  **Reagents and Materials:**

A2.5.1. The following materials shall be included to perform this test:
- Methylene blue \((C_{16}H_{18}CIN_{3}S \cdot nH_{2}O (n = 2 to 3))\) purity ≥98.5 percent,
- Kaolinite, and
- Water.

A2.6.  **Procedure:**

A2.6.1. Preparation of methylene blue solution (10 g/L)

A2.6.1.1.  **Determination of Moisture Content of Methylene Blue Powder:**

The determination of the moisture content of methylene blue powder shall be as follows:
1. Weigh 5 ± 0.01 g of methylene blue powder and record the mass.
2. Dry the powder at 100 ± 5°C to constant mass.

**Note A3**—Above 105°C, methylene blue powder can be altered.

---

Appendix

**Note X2**—When layers of expansive clays of less than 0.6 m exist (example: 1.2 to 1.4 m), it is preferable to enter the abscissa on the proper swell curve at 1.2 and 1.4, respectively, and use the difference in the respective ordinate readings as the unmodified swell in the 0.2-m thick layer.

**Note X3**—At optimum conditions, the following relationships are valid from Figure 2:
1. Percent volumetric swell @ 7-kPa surcharge = 0.217 (PI) − 2.9
2. Percent free swell = 0.232 (PI) − 0.5.

---

Equation Examples

**Basic**

\[
M = \frac{100 + W}{10}
\]  \(A2.2\)

where:
- \(M\) = mass of undried (as received) methylene blue powder, g; and
- \(W\) = moisture content of powder as determined in Section A2.6.1.1, percent by mass.
Complex

\[ A_{\sigma 0} = \frac{\sum_{i=1}^{n} \sigma_i'}{n} \]  \hspace{1cm} (4)

\[ A_{\sigma 1} = 2 \frac{\sum_{i=1}^{n} \sigma_i' \cos(\omega_0 t_i)}{n} \]  \hspace{1cm} (5)

\[ B_{\sigma 1} = 2 \frac{\sum_{i=1}^{n} \sigma_i' \sin(\omega_0 t_i)}{n} \]  \hspace{1cm} (6)

where:

- \( A_{\sigma 0} \) = stress offset coefficient, kPa (psi);
- \( \sigma_i' \) = centered stress at point \( i \) in the data array;
- \( A_{\sigma 1} \) = stress in-phase magnitude coefficient, kPa (psi);
- \( \omega_0 \) = frequency of applied stress, rad/s;
- \( t_i \) = time at point \( i \) in the data array, s; and
- \( B_{\sigma 1} \) = stress out-of-phase magnitude coefficient, kPa (psi).

12.4.4. From the stress coefficients, compute the stress magnitude and the stress phase angle.

\[ |\sigma'| = \sqrt{A_{\sigma 1}^2 + B_{\sigma 1}^2} \]  \hspace{1cm} (7)