UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF COLUMBIA

AMERICAN SOCIETY FOR TESTING AND MATERIALS d/b/a/ ASTM INTERNATIONAL; NATIONAL FIRE PROTECTION ASSOCIATION, INC.; and AMERICAN SOCIETY OF HEATING, REFRIGERATING, AND AIR CONDITIONING ENGINEERS, Plaintiffs/ Counter-Defendants, v. PUBLIC.RESOURCE.ORG, INC., Defendant/ Counter-Plaintiff.	Case No. 1:13-cv-01215-TSC

DECLARATION OF THOMAS B. O'BRIEN, JR.

Pursuant to 28 U.S.C. § 1746, I, Thomas B. O'Brien, Jr., declare the following statements to be true under the penalties of perjury:

1. I am over the age of 18 years and am fully competent to testify to the matters stated in this Declaration.

2. This declaration is based on my personal knowledge. If called to do so, I would and could testify to the matters stated herein.

3. I am Vice President and General Counsel at ASTM International ("ASTM"). I have worked at ASTM since 2003.

4. My responsibilities include developing legal policies and procedures and addressing all legal matters for ASTM, including ASTM's copyright registrations, trademark registrations, and enforcement efforts related to ASTM's intellectual property.

5. ASTM has a copyright registration for ASTM D86-07 (Standard Test Methods for Distillation of Petroleum Products at Atmospheric Pressure) that identifies ASTM as the owner. Attached as Exhibit 1 is a true and correct copy of the certificate of registration for this standard.

6. ASTM has a copyright registration for ASTM D975-07 (Standard Specification for Diesel Fuel Oils) that identifies ASTM as the owner. Attached as Exhibit 2 is a true and correct copy of the certificate of registration for this standard.

7. ASTM publishes an Annual Book of ASTM Standards every year that is composed of a number of volumes and includes the current version of each of its standards.

8. Between 1980 and 2011, ASTM obtained copyright registrations for each volume of its Book of Standards.

9. ASTM D396-98 and ASTM D1217-93(98) were published in Volume 5.01 of the 1999 Annual Book of ASTM Standards. Attached as Exhibit 3 are true and correct copies of pages from the index of the 1999 Annual Book of ASTM Standards showing the volume in which these standards appeared.

10. ASTM has a copyright registration for Volume 5.01 of the 1999 Annual Book of ASTM Standards that identifies ASTM as the owner. The date of first publication for this work was February 22, 1999 and the effective date of registration is March 10, 1999. Attached as Exhibit 4 is a true and correct copy of the certificate of registration for the standards included in this volume.

11. The published version of each of ASTM's standards includes a copyright notice alerting the public (including the individuals who participated in the creation of the standards) to the fact that the copyright is owned by ASTM.

12. ASTM knows of no individual or other person who claims to own any copyright interest in any ASTM standard.

13. ASTM routinely grants permission to researchers, academics and others to reproduce its standards at no cost for non-commercial purposes.

14. ASTM has not licensed Defendant's use of ASTM's standards.

15. ASTM developed a guide entitled "Form and Style for ASTM Standards," which is a guide to promote uniformity of form and style in ASTM standards ("ASTM Form and Style Guide"). This guide describes certain conventions that must be followed when drafting an ASTM standard. Attached as Exhibit 5 is a true and correct copy of the ASTM Form and Style Guide.

16. The ASTM Form and Style Guide describes certain components and provides the text for certain language that must be included in every ASTM standard.

17. As part of the process of developing a draft standard, ASTM staff members add language and components that are required by the ASTM Form and Style Guide to the draft prepared by the task group.

18. For example, Standard D86-07 contains numerous components that were authored by ASTM employees. Attached as Exhibit 6 is a true and correct copy of ASTM D86-07.

19. The title of the standard (Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure) appears at the top of the first page of ASTM D86-07. Directly below the title, there is an explanation of what the designation number for the standard means. This language was drafted by an ASTM employee.

20. Footnote 1 is a standard footnote that is authored by an ASTM employee, which provides information about which committee and subcommittee have jurisdiction over the

standard. ASTM Form and Style Guide Section A26.2 lays out the requirements for the content of this footnote.

21. Footnote 2 explains how to obtain access to ASTM standards referenced in the document. This language was drafted by an ASTM employee.

22. Section 1.5 of ASTM D86-07 states: "This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use." This language comes directly from the Section F2.1 of the ASTM Form and Style Guide and was written by an ASTM employee.

23. On the last page of ASTM D86-07, there is a summary of the differences between this version of the standard and the previous version, which was compiled by ASTM employees.

24. At the very bottom of the last page of D86-07, there are three italicized paragraphs. The text of the first two paragraphs comes directly from ASTM's Form and Style Guide, which was written by ASTM employees. *See* Form and Style Guide Sections F3.2 and F2.3.

25. The third italicized paragraph at the end of D86-07 is a statement of ASTM's ownership of the copyright and information about how to purchase copies, which was also authored by an ASTM employee.

26. As another example, ASTM standard D975-07 contains numerous sections that were authored by ASTM employees. Attached as Exhibit 7 is a true and correct copy of ASTM D975-07.

27. Underneath the title of the standard (Standard Specification for Diesel Fuel Oils), there is an explanation of what the designation number for the standard means. This language was drafted by an ASTM employee.

28. Footnote 1 of ASTM D975-07 provides information about the committee and subcommittee that have jurisdiction over this standard. This language is required by Section B28.2 of the ASTM Form and Style Guide and was drafted by an ASTM employee.

29. Section 1.3 of ASTM D975-07 states "The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only." This language was taken verbatim from Section H3.1.1.1 of the ASTM Form and Style Guide.

30. Like ASTM D86-07, the last page of ASTM D975-07 provides a summary of changes made to the previous version of this standard and includes three italicized paragraphs, all of which were drafted by ASTM employees.

31. ASTM D396-98 also contains content that was drafted by ASTM employees. Attached as Exhibit 8 is a true and correct copy of ASTM D396-98.

32. Underneath the title of the standard (Standard Specification for Fuel Oils), there is an explanation of what the designation number for the standard means. This language was drafted by an ASTM employee.

33. Footnote 1 of ASTM D396-98 provides information about the committee and subcommittee that have jurisdiction over this standard. This language is required by Section B28.2 of the ASTM Form and Style Guide and was drafted by an ASTM employee.

34. On the last page of ASTM D396-98 there are two italicized paragraphs that were drafted by ASTM employees.

35. ASTM D1217-93(98) contains content that was drafted by ASTM employees. Attached as Exhibit 9 is a true and correct copy of ASTM D1217-93(98).

36. Underneath the title of the standard (Standard Test Method for Density and Relative Density (Specific Gravity) of Liquids by Bingham Pycnometer), there is an explanation of what the designation number for the standard means. This language was drafted by an ASTM employee.

37. Footnote 1 of ASTM D1217-93(98) provides information about the committee and subcommittee that have jurisdiction over this standard. This language is required by Section B28.2 of the ASTM Form and Style Guide and was drafted by an ASTM employee.

38. Section 1.5 of ASTM D1217-93(98) states: "This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use." This language comes directly from the Section F2.1 of the ASTM Form and Style Guide and was written by an ASTM employee.

39. On the last page of ASTM D1217-93(98) there are two italicized paragraphs that were drafted by ASTM employees.

40. There are a number of ways in which ASTM members assign their copyrights in the standards they help to develop to ASTM.

41. Since 2005, new members and members renewing their memberships online to ASTM agree to the following language: "I agree, by my participation in ASTM and enjoyment of the benefits of my annual membership, to have transferred and assigned any and all interest I possess or may possess, including copyright, in the development or creation of ASTM standards or ASTM IP to ASTM." Attached as Exhibit 10 is a true and correct copy of the online new

membership form and attached as Exhibit 11 is a true and correct copy of the online membership renewal form.

42. Some members of ASTM renew their memberships using paper forms that contain substantially the same language as the language in the online forms. Attached as Exhibit 12 is a true and correct copy of a paper membership renewal form.

43. Michael Collier was the technical contact for the revision of ASTM D86 that was completed in 2007.

44. Michael Collier renewed his ASTM membership every year between 2007-2014 using the online membership renewal form.

45. John Chandler was the technical contact for the revision of ASTM D975 that was completed in 2007 and for the revision of ASTM D398 that was completed in 1998.

46. John Chandler renewed his ASTM membership every year between every year between 2007-2014 using the online membership renewal form.

47. Jimmy King was the technical contact for the 1998 reapproval of ASTM D1217.

48. Jimmy King renewed his ASTM membership in 2007.

49. When an individual registers a "work item," which starts the process of developing a new standard or amending an existing standard, that individual must agree to the following language: "I hereby grant and assign to ASTM International all and full intellectual property rights, including copyright, in the proposed draft standard/text and any contributions I make to ASTM International in connection with this proposal" and "By submitting this form, I acknowledge that all copyrights to this document, as a draft and an approved ASTM standard, are the sole and exclusive property of ASTM, in accordance with the Intellectual Property

policies of the Society." Attached as Exhibit 13 is a true and correct copy of the online form an individual must complete to register a work item.

50. ASTM engages in quality control procedures to ensure the quality and integrity of the content of the standards.

51. ASTM staff editors edit the language of the standard to ensure that it conforms to the requirements in the Form and Style Guide.

52. ASTM staff also submits the final version to the technical committee for reviews to make sure it matches the content approved through the balloting process.

53. ASTM staff proofreads the XML versions of standards before posting them on the internet to ensure that the conversion of the text and diagrams into XML format has not altered the content of the standard.

54. ASTM has not received any complaints about lack of accessibility of its standards other than from Defendant.

55. ASTM owns a U.S. federal trademark registration for the trademark ASTM (U.S. Trademark Reg. No. 2,679,320) in connection with books featuring information on standardization of specifications and the methods of testing for various materials and products; promoting public awareness of the need for standards; educational services; and providing a website on global computer networks featuring information in the field of specifications and methods of testing for various materials and products. ASTM has used this trademark since 1962. ASTM filed a Section 15 declaration in support of the incontestability of this registration. Attached as Exhibit 14 are true and correct copies of the Certificate of Registration and the Section 15 declaration.

56. ASTM owns U.S. federal trademark registrations for the trademarks ASTM INTERNATIONAL (U.S. Trademark Reg. No. 2,685,857) and the following logo:

(U.S. Reg. No. 2,651,796) in connection with similar goods and services. ASTM has used these trademarks since 2001. ASTM filed Section 15 declarations in support of the incontestability of these registrations. Attached as Exhibit 15 are true and correct copies of the Certificates of Registration and the Section 15 declarations.

57. ASTM also owns a registration for the following logo:

(U.S. Reg. Nos. 4,079,772) in connection with publications relating to testing methods, specifications and standards in engineering, industrial and allied fields. ASTM has used this trademark since 1965. The application for this registration was filed on May 10, 2011. The Examining Attorney who reviewed the application approved it for registration without requesting proof of secondary meaning. Attached as Exhibit 16 is a true and correct copy of the Certificate of Registration.

58. ASTM expends considerable resources marketing and promoting its goods and services in connection with these trademarks every year. For example, ASTM spent over $3 million marketing and promoting the sales of copies of its standards that feature its trademarks in catalogs, brochures, and in mail and email correspondence between 2010-2012, which were the three years immediately prior to Defendant's infringement.

59. ASTM's longstanding use of its trademarks in connection with its high quality standards has resulted in the public's association of ASTM's marks with a certain quality.

60. ASTM provides the public with free, read-only access to all ASTM standards that ASTM is aware have been incorporated by reference into federal regulations.

61. ASTM provides the public with free, read-only access to all ASTM standards that are the subject of Plaintiffs' Motion for Summary Judgment. Attached as Exhibit 17 are true and correct copies of screen shots demonstrating the availability of ASTM standards on ASTM's online Reading Room.

62. ASTM identifies standards that have been incorporated by reference into federal regulations from the database created by the National Institute of Standards and Technology.

63. ASTM publicizes the free read-only access provided on its website.

64. During the notice and comment period regarding proposed federal regulations, upon request by the relevant federal agency, ASTM provides free, read-only access to standards that are incorporated by reference in proposed regulations.

65. ASTM has not received any complaints about lack of accessibility of its standards other than from Defendant.

66. Defendant submitted comments reflecting his beliefs in connection with proposed rulemaking regarding the procedures of the Office of the Federal Register and the National

Archives and Records Administration, proposed amendments to the Office of Management and Budget's Circular A-119, and a study by the Administrative Conference of the United States.

67. During the course of this litigation, Defendant has continued to post versions of additional standards owned by ASTM that use ASTM's trademarks on its website, including as recently as October 2015.

68. Defendant has posted html versions of certain ASTM standards since Plaintiffs filed their Complaint that do not use the ASTM logo marks. Attached as Exhibit 18 is a true and correct copy of a version of ASTM F977 that Defendant posted on its website in October 2015 that does not use an ASTM logo.

69. On or about November 10, 2015, Defendant removed its versions of the standards at issue in this case from its website and from the Internet Archive at the suggestion of the Court.

70. Since the standards were taken down from Defendant's website and the Internet Archive, ASTM has not received any complaints from persons regarding any alleged inability to access ASTM's standards that have been incorporated by reference.

Dated: November 17, 2015

Thomas O'Brien

EXHIBIT 1

Certificate of Registration

This Certificate issued under the seal of the Copyright Office in accordance with title 17, *United States Code*, attests that registration has been made for the work identified below. The information on this certificate has been made a part of the Copyright Office records.

Register of Copyrights, United States of America

Registration Number
TX 7-685-941

Effective date of registration:
March 5, 2013

Title

Title of Work: ASTM D86-07 Standards Test Methods for Distillation of Petroleum Products at Armospheric Pressure

Completion/Publication

Year of Completion: 2007

Date of 1st Publication: March 1, 2007 **Nation of 1st Publication:** United States

Author

- **Author:** ASTM International

Author Created: Entire Text

Work made for hire: Yes

Domiciled in: United States

Copyright claimant

Copyright Claimant: ASTM International

100 Barr Harbor Drive, West Conshohocken, PA, 19428, United States

Limitation of copyright claim

Material excluded from this claim: text

Previous registration and year: TX 6-563-072 2007

TX 6-342-584 2006

New material included in claim: text, editing

Rights and Permissions

Organization Name: ASTM International

Name: Kathleen Hooper

Email: khooper@astm.org **Telephone:** 610-832-9634

Address: 100 Barr Harbor Drive

West Conshohocken, PA 19428 United States

Certification

Name: Kathleen Hooper

Date: March 1, 2013

EXHIBIT 2

Certificate of Registration

This Certificate issued under the seal of the Copyright Office in accordance with title 17, *United States Code*, attests that registration has been made for the work identified below. The information on this certificate has been made a part of the Copyright Office records.

Register of Copyrights, United States of America

Registration Number
TX 7-685-915

Effective date of registration:
March 5, 2013

Title

Title of Work: ASTM D975-07 Standards Specificaiton for Diesel Fuel Oils

Completion/Publication

Year of Completion: 2007

Date of 1st Publication: April 1, 2007 **Nation of 1st Publication:** United States

Author

- **Author:** ASTM International

Author Created: Entire Text

Work made for hire: Yes

Domiciled in: United States

Copyright claimant

Copyright Claimant: ASTM International

100 Barr Harbor Drive, West Conshohocken, PA, 19428, United States

Limitation of copyright claim

Material excluded from this claim: text

Previous registration and year: TX 6-563-072 2007

TX 6-342-584 2006

New material included in claim: text, editing

Rights and Permissions

Organization Name: ASTM International

Name: Kathleen Hooper

Email: khooper@astm.org **Telephone:** 610-832-9634

Address: 100 Barr Harbor Drive

West Conshohocken, PA 19428 United States

Certification

EXHIBIT 3

Alphanumeric List

ASTM Standards

Standards:

Specifications	2911
Test Methods	7403
Terminology	186
Total	10,500

Each ASTM standard has a unique serial designation. It is comprised of a capital letter indicating general classification (A, ferrous metals; B, nonferrous metals; C, cementitious, cermanic, concrete, and masonry materials; D, miscellaneous materials; E, miscellaneous subjects; F, materials for specific applications; G, corrosion, deterioration, and degradation of materials; ES, emergency standards; P, proposals; PS, provisional standards), a serial number (one to four digits), a dash, and the year of issue.

In each serial designation, the number following the dash indicates the year of original adoption as standard or, in the case of revision, the year of last revision. Thus, standards adopted or revised during the year 1999 have as their final number, 99. A letter following this number indicates more than one revision during that year, that is 99a indicates the second revision in 1999, 99b the third revision, etc. Standards that have been reapproved without change are indicated by the year of last reapproval in parentheses as part of the designation number, for example, (1999). A superscript epsilon indicates an editorial change since the last revision or reapproval; ϵ1 for the first change, ϵ2 for the second, etc.

If a standard is written in acceptable metric units and has a companion standard written in inch-pound units (or other units), the metric standard is identified by a letter M after the serial number; this standard contains "hard metric" units.

If a standard is written in inch-pound units (or other units) and acceptable metric units, the document is identified by a dual alphanumeric designation.

When reference is made to a standard, the *complete* designation should be given. Best practice is to state the *designation and title*.

The boldface number(s) following the title refer to the volume(s) of the *Annual Book of ASTM Standards* in which the standard appears.

This list includes only those standards which appear in the 1999 edition of each volume of the *Annual Book of ASTM Standards*. New and revised standards that were approved after the closing date for the volume are available as separate reprints and will be listed in next year's edition.

Each ASTM standard is available as a separate reprint from ASTM. Price and order information are available from ASTM Customer Service, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, 610-832-9585.

D 308 Discontinued 1940; Method of Test for Oil Content of Petroleum Waxes; Replaced by D 721
D 309 Discontinued 1943; Specification for Crushed Stone, Crushed Slag, and Gravel for Bituminous Concrete Base and Surface Courses of Pavements; Replaced by D 692
D 310 Discontinued 1988; Test Method for Size of Anthracite; Replaced by D 4749
D 311 Discontinued 1988; Method for Sieve Analysis of Crushed Bituminous Coal; Replaced by D 4749
D 312–95a Specification for Asphalt Used in Roofing, **04.04**
D 313 Discontinued 1982; Method of Test for Coarse Particles in Mixtures of Asphalt and Mineral Matter
D 314 Discontinued 1970; Method of Test for Hardness of Rubber; Replaced by D 1415
D 315–95 Specification for Woven Asbestos Tape, **04.05**
D 316 Discontinued 1938; Methods of Test for Chafer Tire Fabrics Other Than Cord Fabrics
D 317 Discontinued 1956; Specification for Oil Putty for Glazing
D 318 Discontinued 1976; Specification for Amyl Acetate (Synthetic) (85 to 88% grade)
D 319–95 Specification for Amyl Alcohol (Synthetic), **06.04**
D 320 Discontinued 1953; Specification for Butyl Propionate (90 to 93% grade)
D 321 Discontinued 1953; Specification for Ethyl Lactate (Synthetic)
D 322–97 Test Method for Gasoline Diluent in Used Gasoline Engine Oils by Distillation, **05.01**
D 323–94 Test Method for Vapor Pressure of Petroleum Products (Reid Method), **05.01**
D 324 Discontinued 1964; Definitions of Terms Relating to Timber Preservatives
D 325 Discontinued 1945; Method of Test for Comparing Thermal Conductivities of Solid Electrical Insulating Materials
D 326 Discontinued 1935; Method of Compression Testing of Natural Building Stone
D 327 Redesignated C 99
D 328 Redesignated C 97
D 329–95 Specification for Acetone, **06.04**
D 330–93(1997) Specification for 2-Butoxyethanol, **06.04**
D 331–95 Specification for 2-Ethoxyethanol, **06.04**
D 332–87(1997)$^{\epsilon 1}$ Test Method for Relative Tinting Strength of White Pigments by Visual Observation, **06.01**
D 333–96 Test Methods for Clear and Pigmented Lacquers, **06.02**
D 334 Discontinued 1967; Methods of Test for Cotton Goods for Rubber and Pyroxylin Coating
D 335 Discontinued 1989; Specification for Cotton Tapes Woven for Electrical Purposes
D 336 Discontinued 1938; Methods of Test for Tire Fabrics Other Than Cord Fabrics
D 337 Redesignated E 337
D 338 Discontinued 1935; Method of Test for Modulus of Elasticity of Natural Building Stone
D 339 Discontinued 1935; Method of Shear Testing of Natural Building Stone
D 340 Discontinued 1935; Definitions of Terms Relating to Natural Building Stone
D 341–93(1998) Viscosity-Temperature Charts for Liquid Petroleum Products, **05.01**
D 342 Discontinued 1936; Specification for Acetate Ester of Ethylene Glycol Monoethyl Ether (90 to 91% Grade)
D 343 Discontinued 1982; Specification for 2-Ethoxyethyl Acetate (95% Grade)
D 344–97 Test Method for Relative Hiding Power of Paints by the Visual Evaluation of Brushouts, **06.01**
D 345–97 Test Method for Sampling and Testing Calcium Chloride for Roads and Structural Applications, **04.03**
D 346–90(1998) Practice for Collection and Preparation of Coke Samples for Laboratory Analysis, **05.05**
D 347–97 Tables for Volume and Specific Gravity Correction for Creosote, Creosote-Coal Tar Solutions, and Coal Tar, **04.10**
D 348–95 Test Methods for Rigid Tubes Used for Electrical Insulation, **10.01**
D 349–92(1997) Test Methods for Laminated Round Rods Used for Electrical Insulation, **10.01**
D 350–96 Test Methods for Flexible Treated Sleeving Used for Electrical Insulation, **10.01**
D 351–97 Classification for Natural Muscovite Block Mica and Thins Based on Visual Quality, **10.01**
D 352–97 Test Methods for Pasted Mica Used in Electrical Insulation, **10.01**
D 353 Discontinued 1995; Specification for Natural Rubber Insulation for Wire and Cable, 60°C Operation
D 354 Discontinued 1967; Methods of Testing Tolerances for Tubular Sleeving and Braids
D 355 Discontinued 1936; Method of Sampling Natural Building Stone and Sample for Testing
D 356 Discontinued 1935; Method of Tension Testing of Natural Building Stone and Sample for Testing
D 357 Discontinued 1970; Method of Test for Knock Characteristics of Motor Fuels Below 100 Octane Number by the Motor Method; Replaced by D 2700
D 358–98 Specification for Wood to Be Used as Panels in Weathering Tests of Coatings, **06.02**
D 359 Discontinued 1940; Specification for Shellac Varnish; Replaced by D 360
D 360–89(1996)$^{\epsilon 1}$ Specification for Shellac Varnishes, **06.03**
D 361 Discontinued 1968; Specification for Industrial 90 Benzene
D 362 Discontinued 1991; Specification for Industrial Grade Toluene
D 363–90(1995) Specification for Tricresyl Phosphate, **06.04**
D 364 Discontinued 1982; Specification for Industrial Grade Xylene
D 365–84(1996)$^{\epsilon 1}$ Test Methods for Soluble Nitrocellulose Base Solutions, **06.02**
D 366 Discontinued 1938; Specification for Concrete for Pavements
D 367–94 Test Method for Xylene-Insoluble Matter in Creosote, **04.10**
D 368–89(1995)$^{\epsilon 1}$ Test Method for Specific Gravity of Creosote and Oil-Type Preservatives, **04.10**
D 369–84(1995)$^{\epsilon 1}$ Test Method for Specific Gravity of Creosote Fractions and Residues, **04.10**
D 370–84(1995)$^{\epsilon 1}$ Test Method for Dehydration of Oil-Type Preservatives, **04.10**
D 371–89(1996) Specification for Asphalt Roll Roofing (Organic Felt) Surfaced with Mineral Granules; Wide Selvage, **04.04**
D 372–90(1995)$^{\epsilon 1}$ Specification for Flexible Treated Sleeving Used for Electrical Insulation, **10.01**
D 373 Discontinued 1994; Specification for Black and Yellow Straight-Cut and Bias-Cut Varnished Cotton Cloth and Tape for Electrical Insulation
D 374–94 Test Methods for Thickness of Solid Electrical Insulation, **10.01**
D 374M–94 Test Methods for Thickness of Solid Electrical Insulation [Metric], **10.01**
D 375–95 Specification for Asbestos Roving, **04.05**
D 376 Discontinued 1976; Methods of Test for Holland Cloth
D 377 Discontinued 1976; Methods of Test for Small Amounts of Copper and Manganese in Textiles
D 378–91 Test Methods for Rubber Belting, Flat Type, **09.02**
D 379 Discontinued 1938; Methods of Test for rubber hose; Replaced by D 380
D 380–94 Methods of Testing Rubber Hose, **09.02**
D 381–94$^{\epsilon 1}$ Test Method for Existent Gum in Fuels by Jet Evaporation, **05.01**
D 382 Discontinued 1940; Specification for Titanium Barium Pigment; Replaced by D 476
D 383 Discontinued 1940; Specification for Titanium Calcium Pigment; Replaced by D 476
D 384 Discontinued 1939; Specification for Titanium Dioxide; Replaced by D 476
D 385 Discontinued 1940; Specification for Zinc Sulfate Pigment; Replaced by D 477
D 386 Discontinued 1940; Specification for Zinc Oxide; Replaced by D 477
D 387–86(1994) Test Method for Color and Strength of Color Pigments with a Mechanical Muller, **06.01**
D 388–98a Classification of Coals by Rank, **05.05**
D 389 Discontinued 1963; Specification for Classification of Coals by Grade
D 390–92 Specification for Coal-Tar Creosote for the Preservative Treatment of Piles, Poles, and Timbers of Marine, Land, and Fresh Water Use, **04.10**
D 391–94 Specification for Creosote-Coal Tar Solution, **04.10**
D 392 Discontinued 1963; Methods of Testing Molding Powders Used in Manufacturing Molded Electrical Insulators
D 393 Discontinued 1938; Specification for Insulated Wire and Cable: Class A, 30% Heavy Rubber Compound
D 394 Discontinued 1970; Method of Test for Abrasion Resistance of Rubber Compounds
D 395–98 Test Methods for Rubber Property—Compression Set, **09.01**
D 396–98 Specification for Fuel Oils, **05.01**
D 397 Discontinued 1951; Specification for Emulsified Asphalt; Replaced by D 977
D 398 Discontinued 1950; Specification for Emulsified Asphalt; Replaced by D 977
D 399 Discontinued 1950; Specification for Emulsified Asphalt; Replaced by D 977
D 400 Discontinued 1937; Specification for Emulsified Asphalt (Heavy Premix-Winter Grade)
D 401 Discontinued 1949; Specification for Emulsified Asphalt; Replaced by D 977
D 402–97 Test Method for Distillation of Cut-Back Asphaltic (Bituminous) Products, **04.03**
D 403 Discontinued 1953; Methods of Testing and Tolerances for Yarns Containing Wool; Replaced by D 1285
D 404 Discontinued 1953; Methods of Testing and Tolerances for Yarns Containing Wool; Replaced by D 1285
D 405 Discontinued 1982; Specification for Blue Lead; Basic Sulfate
D 406 Discontinued 1961; Method of Test for Relative Dry Hiding Power of White Pigments in Linseed Oil Vehicle
D 407 Discontinued 1977; Definitions of Terms Relating to Gross Calorific Value and Net Calorific Value of Solid and Liquid Fuels; Replaced by D 121
D 408 Discontinued 1951; Method of Test for Grindability of Coal by the Ball-Mill Method
D 409–97 Test Method for Grindability of Coal by the Hardgrove-Machine Method, **05.05**
D 410 Discontinued 1988; Method for Sieve Analysis of Coal
D 411–98 Test Methods for Shellac Used for Electrical Insulation, **10.01**
D 412–98a Test Methods for Vulcanized Rubber and Thermoplastic Rubbers and Thermoplastic Elastomers—Tension, **09.01**
D 413–98 Test Methods for Rubber Property—Adhesion to Flexible Substrate, **09.01**

D 1146–88(1994)$^{\epsilon 1}$ Test Method for Blocking Point of Potentially Adhesive Layers, **15.06**
D 1147 Redesignated F 36
D 1148–95 Test Method for Rubber Deterioration—Heat and Ultraviolet Light Discoloration of Light-Colored Surfaces, **09.01**
D 1149–91(1997) Test Method for Rubber Deterioration—Surface Ozone Cracking in a Chamber, **09.01**
D 1150 Discontinued 1992; Single and Multi-Panel Forms for Recording Results of Exposure Tests of Paints
D 1151–90(1995) Test Method for Effect of Moisture and Temperature on Adhesive Bonds, **15.06**
D 1152–97 Specification for Methanol (Methyl Alcohol), **06.04**
D 1153–94(1997) Specification for Methyl Isobutyl Ketone, **06.04**
D 1154 Discontinued 1957; Method of Test for Purity of Acetone and Methyl Ethyl Ketone
D 1155–89(1994)$^{\epsilon 1}$ Test Method for Roundness of Glass Spheres, **06.02**
D 1156 Discontinued 1984; Method of Test for Total Chlorine in Poly(Vinyl Chloride) Polymers and Copolymers Used for Surface Coatings
D 1157–91(1996) Test Method for Total Inhibitor Content (TBC) of Light Hydrocarbons, **05.01**
D 1158 Discontinued 1984; Method of Test for Bromine Number of Petroleum Distillates by Color-Indicator Titration; Replaced by D 1159
D 1159–98 Test Method for Bromine Number of Petroleum Distillates and Commercial Aliphatic Olefins by Electrometric Titration, **05.01**
D 1160–95 Test Method for Distillation of Petroleum Products at Reduced Pressure, **05.01**
D 1161 Discontinued 1981; Method of Test for Total Chloride Content of Paper and Paper Products
D 1162 Discontinued 1974; Method of Test for Water-Soluble Matter in Paper
D 1163 Discontinued 1986; Method of Test for Lint of Paper Towels
D 1164 Discontinued 1985; Test Method for Ring Crush of Paperboard; Replaced by TAPPI T 818
D 1165–80(1994)$^{\epsilon 1}$ Nomenclature of Domestic Hardwoods and Softwoods, **04.10**
D 1166–84(1995)$^{\epsilon 1}$ Test Method for Methoxyl Groups in Wood and Related Materials, **04.10**
D 1167 Discontinued 1972; Methods of Testing Asphalt-Base Emulsions for Use As Protective Coatings for Built-Up Roofs; Replaced by D 2939
D 1168–95 Test Methods for Hydrocarbon Waxes Used for Electrical Insulation, **10.01**
D 1169–95 Test Method for Specific Resistance (Resistivity) of Electrical Insulating Liquids, **10.03**
D 1170 Discontinued 1968; Specification for Nonmetallic Gasket Materials for General Automotive and Aeronautical Purposes; Combined with F 104
D 1171–94 Test Method for Rubber Deterioration—Surface Ozone Cracking Outdoors or Chamber (Triangular Specimens), **09.01**
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D 1175 Discontinued 1982; Method of Test for Abrasion Resistance of Textile Fabrics (Oscillatory Cylinder and Uniform Abrasion); Replaced by D 4157, D 4158
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D 1193–99 Specification for Reagent Water, **11.01**
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D 1195–93(1997) Test Method for Repetitive Static Plate Load Tests of Soils and Flexible Pavement Components, for Use in Evaluation and Design of Airport and Highway Pavements, **04.08**
D 1196–93(1997) Test Methods for Nonrepetitive Static Plate Load Tests of Soils and Flexible Pavement Components, for Use in Evaluation and Design of Airport and Highway Pavements, **04.08**
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D 1221 Discontinued 1975; Method of Test for Pinholes in Glassine and Other Greaseproof Papers
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D 1230–94 Test Method for Flammability of Apparel Textiles, **07.01**
D 1231 Discontinued 1962; Method of Test for Dimensional Change of Knit Cotton Fabrics
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D 1233–88(1993)$^{\epsilon 1}$ Specification for Twine Made for Bast and Leaf Fibers, **07.01**
D 1234–85(1995) Method for Sampling and Testing Staple Length of Grease Wool, **07.01**
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D 1240–96 Test Method for Rosin Acids Content of Naval Stores, Including Rosin, **06.03**
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D 1243–95 Test Method for Dilute Solution Viscosity of Vinyl Chloride Polymers, **08.01**
D 1244–98 Practice for Designation of Yarn Construction, **07.01**

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June 1992—58,000

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EXHIBIT 5

Form and Style for ASTM Standards

January 2015

FORM AND STYLE
FOR ASTM STANDARDS

ASTM INTERNATIONAL
100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959

CONTENTS

PREFACE

ASTM International (hereafter referred to as ASTM International or ASTM), founded in 1898, is a scientific and technical organization formed for "the development of standards on characteristics and performance of materials, products, systems, and services; and the promotion of related knowledge." It is the world's largest source of voluntary consensus standards.

The purpose of this manual is to promote uniformity of form and style in ASTM standards. Such uniformity is desirable because it helps the user to find what is needed more easily and to understand what is read more quickly. Such uniformity in a manuscript is necessary if it is to be published by ASTM International. Deviations from ASTM style may mean wasted time on the part of authors, reviewers, editors, and eventually the reader of the standard. This means costly time and resources are lost by everyone involved.

Section 10.7 of the *Regulations Governing ASTM Technical Committees* requires that the current edition of this manual be followed in the writing of standards. When conditions preclude compliance with this manual, a committee may request an exemption from the Committee on Standards (COS).

Responsibility for the *Form and Style for ASTM Standards* is vested in the Board of Directors. Revisions to this manual may be recommended by the Board of Directors, by the Committee on Standards, or by a technical committee or its Executive Subcommittee. The Committee on Standards acts upon recommendations for changes and reviews all requests from technical committees for exceptions to the *Form and Style for ASTM Standards*. Recommended changes to this manual in *technical* substance and format shall be referred to the Committee on Standards, which, at a regular meeting, shall rule on the merits of the recommendation. A circular letter ballot will be issued to the technical committees and the responses will be addressed by COS. The COS recommendation shall be sent to the Board of Directors. Changes adopted by the Board of Directors shall be announced to the members and shall become effective on the date determined by the Board of Directors.

Suggestions for *editorial* revision of this manual should be addressed to the Staff Coordinator—Form and Style Manual, ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959.

INTRODUCTION

This manual is the basic textbook for anyone writing an ASTM standard. A study of Parts A, B, C, or E will show the proper form for the principal types of standards including a detailed explanation of how to write each section, from the title to the appendixes. Within Parts A, B, C, and E, the first section lists the preferred sequence of headings and indicates whether these sections are mandatory. The headings identified as "mandatory" are required. Other headings shall be included when the subject matter is pertinent to the document under development, in which case, all instructions and guidance for that particular section shall be followed. For example, if the standard does not contain reference to any standard documents within the text, it is not required to include a section on Referenced Documents. If, however, specific hazards are cited throughout the text, then the section on Hazards shall be followed. Included at appropriate places are examples and standard wording. Also included are examples of correctly written complete manuscripts of various types of standards. Where standards are referenced throughout the text of this manual, visit the ASTM website, www.astm.org, and refer to the standard's Document Summary page.

For easy reference purposes, each paragraph in an ASTM standard shall be numbered. The modified decimal numbering system adopted is explained in Part D. Part E gives instructions for preparing standard definitions and a format for specialized terminology standards. Special instruction concerning patents, use of trademarks, open-end agreements, fire standards, and other legal issues are given in Part F.

Part G is a detailed Style Manual that includes among other things information on abbreviations, spellings, literature references, and preparation of illustrations.

ASTM policy is that SI units be included in all standards. Part H is included to aid the standards writer to incorporate these units correctly. It is the technical committee's decision whether SI or other units are the preferred unit of measurement used in the committee's document. When SI and non-SI units of measurement are contained in a document, the order in which they appear is determined by that committee.

For additional information about ASTM procedures, or available publications such as the *Regulations Governing ASTM Technical Committees* and Officer Handbook, contact ASTM Technical Committee Operations, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959 (Telephone: 610-832-9673).

DEFINITION

The following definitions apply to the use of the content of this manual and clarify which sections or formats, or both, are mandatory when presenting ASTM documents:

1. "Shall" is used to indicate that a provision is mandatory.
2. "Should" is used to indicate that a provision is not mandatory but is recommended as good practice.
3. "May" is used to indicate that a provision is optional.
4. "Will" is used to express futurity, but never to indicate any degree of requirement.

Definitions for *standard, classification, guide, practice, specification, terminology*, and *test method* are quoted below from the current *Regulations Governing ASTM Technical Committees:*

standard, *n— as used in ASTM International*, a document that has been developed and established within the consensus principles of the Society and that meets the approval requirements of ASTM procedures and regulations.

DISCUSSION—The term "standard" serves in ASTM International as a nominative adjective in the title of documents, such as test methods or specifications, to connote specified consensus and approval. The various types of standard documents are based on the needs and usages as prescribed by the technical committees of the Society.

classification, *n*— a systematic arrangement or division of materials, products, systems, or services into groups based on similar characteristics such as origin, composition, properties, or use.

guide, *n*— a compendium of information or series of options that does not recommend a specific course of action.

DISCUSSION—A guide increases the awareness of information and approaches in a given subject area.

practice, *n*— a definitive set of instructions for performing one or more specific operations that does not produce a test result.

DISCUSSION—Examples of practices include, but are not limited to: application, assessment, cleaning, collection, decontamination, inspection, installation, preparation, sampling, screening, and training.

specification, *n*— an explicit set of requirements to be satisfied by a material, product, system, or service.

DISCUSSION—Examples of specifications include, but are not limited to, requirements for; physical, mechanical, or chemical properties, and safety, quality, or performance criteria. A specification identifies the test methods for determining whether each of the requirements is satisfied.

terminology standard, *n*— a document comprising definitions of terms; explanations of symbols, abbreviations, or acronyms.

test method, *n*— a definitive procedure that produces a test result.

DISCUSSION—Examples of test methods include, but are not limited to: identification, measurement, and evaluation of one or more qualities, characteristics, or properties. A precision and bias statement shall be reported at the end of a test method. (Refer to Section A21 on Precision and Bias.)

approval date, *n*— the date assigned by ASTM International through the Committee on Standards, which indicates that a new standard, revision or reapproval has successfully completed the balloting and appeals process in accordance with the *Regulations Governing ASTM Technical Committees.*

publication date, *n*— the month/year that an approved standard is made publicly available in either electronic or hardcopy form.

PART A

FORM OF ASTM TEST METHODS

INTRODUCTION

An ASTM test method, as defined on p. vii, typically includes a concise description of an orderly procedure for determining a property or constituent of a material, an assembly of materials, or a product. The directions for performing the test should include all of the essential details as to apparatus, test specimen, procedure, and calculations needed to achieve satisfactory precision and bias.

An ASTM test method should represent a consensus as to the best currently available test procedure for the use intended. It should be supported by experience and adequate data obtained from cooperative tests.

In order to be the "best currently available," test methods need periodic review to determine whether revisions are desirable as the result of technological advances in manufacturing, testing, and use requirements.

ASTM test methods are frequently intended for use in the buying and selling of materials according to specifications and therefore should provide such precision that when the test is properly performed by a competent operator the results will be found satisfactory for judging the compliance of the material with the specification. These test methods cover the determination of fundamental properties of materials such as density, absolute viscosity, softening point, and flash point. They may include a variety of different laboratory procedures such as chemical and spectrochemical analyses, mechanical and electrical tests, weathering tests, visual examination, fire tests, performance characteristics, sampling, nondestructive tests, and radiation exposure tests. In some standards, optional test methods are included.

Statements addressing precision and bias are required in ASTM test methods. This gives the user of the test method an idea of the nature of the sample to be prepared and analyzed and information regarding the nature of the data obtained by using the method. The requirement of precision and bias statements does not mean that numerical statements are required. It means that the spread of resulting data and its relationship to an accepted reference material or source (if available) shall be addressed. Some test methods have no numerical expression of precision or bias (for example, pass/fail tests, spot tests.) In these cases, precision and bias shall be addressed and the reasons for not including relevant data explained. Test methods are sometimes prepared for use in research rather than in the buying and selling of materials. Other test methods cover process control, screening, and field tests. Although these latter test methods may not always be as precise as referee test methods, they are sufficiently precise for the intended use and usually require less time. Field tests allow testing at the site, thus eliminating transportation of specimens to and from the laboratory.

Special instructions with respect to the legal aspects are included in Part F and shall be followed in writing any standard. These include such matters as contractual items, caveat statements, patents, and fire standards. Assistance on the development of fire standards is available from Committee E05. The policies contained in Part F are approved by and are under the jurisdiction of the ASTM Board of Directors.

When a standard is being developed, the costs associated with its development and subsequent use generally should be considered. The prime objective should be the optimum use of resources to achieve satisfactory definition of the product or service. However, it should be noted that when the standard relates to the safety of persons, cost considerations are likely to become much less important than when attributes of materials or products are involved. Some standards, such as definitions, impose no cost on the user; others that include numerous and extensive requirements can entail significant expense to users of the standard. The requirements to be included should, therefore, be those that are technically relevant and yield benefits commensurate with the cost of their determination.

Cost effectiveness statements or rationale may be included within a standard if appropriate, usually in an appendix.

A1. Subject Headings of Text

A1.1 The following is the sequence for the text of ASTM test methods. Headings are those most generally used but may not be all-inclusive. It may be necessary to include other headings for specialized subjects. The headings identified as "mandatory" are required. Other headings shall be included when the subject matter is pertinent to the document under development, in which case, all instructions and guidance for that particular section shall be followed. For example, if the standard does not contain reference to any standard documents within the text, it is not required to include a section on Referenced Documents. If, however, specific hazards are cited throughout the text, then the section on Hazards shall be followed.

	Title (mandatory)
†	Designation (mandatory)
†	Introduction
	Scope (mandatory)
†	Referenced Documents
†	Terminology
	Summary of Test Method
	Significance and Use (mandatory)
	Interferences
	Apparatus
	Reagents and Materials
	Hazards (mandatory when applicable)
	Sampling, Test Specimens, and Test Units
	Preparation of Apparatus
	Calibration and Standardization
	Conditioning
	Procedure (mandatory)
	Calculation or Interpretation of Results
	Report
	Precision and Bias (mandatory)
	Measurement Uncertainty
†	Keywords (mandatory)
†	Annexes and Appendixes
†	References
	Summary of Changes

† The headings marked with a dagger (†) should appear only once in test methods that contain two or more test methods.

A1.2 Not all of these headings may be required for a particular standard. Additional headings that are included to cover specialized subjects should appear in the most appropriate place, depending on their relation to the sections listed in A1.1. When a standard includes several test methods, repetition of appropriate headings may be desirable.

A1.3 Subject headings in boldface type shall precede each section to orient the reader. Text divisions shall be subdivided in accordance with the Use of the Modified Decimal Numbering System guide in Part D of this publication.

A1.4 For convenience in application and when economy in printing may result, test methods may include a series of procedures for determining the same or different properties of a given material. In such test methods, include at the beginning of the standard individual sections describing those features that are common to all of the separate test methods. Identify different methods within the standard by capital letters, starting with A; i.e., Test Method A, Test Method B, etc.

A1.5 Examples of test methods for single determination:

B331 Test Method for Compressibility of Metal Powders in Uniaxial Compaction
C693 Test Method for Density of Glass by Buoyancy

A1.6 Examples of test methods covering a series of test methods:

D1179 Test Methods for Fluoride Ion in Water
D2137 Test Methods for Rubber Property—Brittleness Point of Flexible Polymers and Coated Fabrics
F38 Test Methods for Creep Relaxation of a Gasket Material

A1.7 In deciding whether to describe similar test methods as portions of a single standard or as separate test methods, the following criterion may be found useful: When the descriptions of the apparatus and procedure are similar and a significant economy in printing can be accomplished by combining, and if, because of clearly understood distinctions in applicability, no confusion can rise as to which test method should be used, then it is desirable to treat the test methods as parts of a single standard. If confusion could arise, the test methods should be published separately. If one test method is preferred as a referee method, it should be so designated, in which case

the other test methods should be designated as optional or nonreferee. When test methods are published separately, a worthwhile saving can be accomplished by making cross-references from one test method to another for the apparatus and detailed description of the procedure.

A2. Title (Mandatory)

A2.1 The title should be concise but complete enough to identify the nature of the test, the material to which is it applicable, and to distinguish it from other similar titles. Titles of analogous standards should be identical, except for the distinctive feature(s) of each standard. Titles are used frequently in lists, tables of contents, indexes, tabulating card systems, etc., and therefore should be brief but inclusive. Select words that easily lend themselves to indexing. The essential features of a title are the particular property or constituent being determined, the material to which the test method is applicable, and when pertinent, the technique or instrumentation. If the test method is designated to determine a number of constituents or properties, use a general title, omitting the names of specific constituents or properties. When a standard includes a number of individual test methods for different constituents or properties, the title need indicate only the general nature of the tests and the material to which it is applicable.

A3. Designation and Year Date

A3.1 *Designation (mandatory)*— The ASTM designation, assigned by Headquarters on submittal for approval, consists of the following sequential parts:

A3.1.1 A letter designation denoting in general the classification according to material, product, system or service.

A—Ferrous metals and products
B—Nonferrous metals and products
C—Cementitious, ceramic, concrete, and masonry materials
D—Miscellaneous materials and products
E—Miscellaneous subjects
F—End-use materials and products
G—Corrosion, deterioration, weathering, durability, and degradation of materials and products

A3.1.2 A sequential number following the letter designation (for example, Specification C150).

A3.2 *Year Date:* (for example, Specification C150-01).

A3.2.1 After the designation, a hyphen is followed by the last two numbers of the year of acceptance or of last revision. If the standard is revised again during the same year, this is indicated by adding an “a” for the second revision, “b” for the third revision, etc.

A3.2.2 The parenthetical phrase “(Reapproved 20___)” to designate the year of last preapproval of a standard, if applicable.

A3.2.3 For editorial changes that do not change the year designation, a note is inserted before the text to indicate the location and date of the change and a superscript epsilon ($^{\varepsilon}$) is added after the year designation. The epsilon designations and corresponding notes are numbered chronologically and are deleted upon occasion of the next revision or reapproval.

A3.3 The designation numbers of standards that have been discontinued are not reassigned.

A3.4 *SI Standards* (see Part H and Section G24.)

A4. Introduction

A4.1 A separate section covering general introductory or informational material is not generally used in ASTM test methods. Occasionally, a test method is of such a nature that it requires an explanatory statement for proper understanding by the user. In such instances an introduction should be included immediately after the title of the test method but without a section number.

A4.2 Examples of test methods that include introductions are as follows:

D143 Test Methods for Small Clear Specimens of Timber
D905 Test Method for Strength Properties of Adhesive Bonds in Shear by Compression Loading

A5. Scope (Mandatory)

A5.1 Include in this section information relating to the purpose of the test method. State if the method is quantitative or qualitative, and any known limitations. Concisely state the property or constituent that is being determined and the

materials that can be analyzed. State the range of concentrations/values determined.

A5.2 Include, where applicable, the analytical technique, for example, gas chromatography, and whether the test is performed in the laboratory, field, or on-line.

A5.3 Include in this section the system of units to be used in referee decisions.

A5.4 Include in this section any caveats required by ASTM policy such as the caveats on *safety hazards* (see F2.1) and *fire hazards* (see F2.2).

A5.5 For standards developed for reference in model (building) codes, include the following statement:

The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

A6. Referenced Documents

A6.1 List in alphanumeric sequence the designation and complete title of the following documents referenced within the standard; ASTM standards and adjuncts; and standards and codes of other organizations. For references to all other documents, including ASTM STPs, use the format indicated in Section G21.

A6.2 Provide footnotes to this section to indicate the sources of these documents. When ASTM standards are referenced later in the text, use only the type of standard (that is, specification, test method, practice, classification, guide, terminology, etc.) and the designation letter and number (for example, Test Method D1310).

A6.3 Do not include the year date when designating referenced documents unless there is a technical reason for requiring a particular revision.

A6.4 When listing referenced adjuncts, provide a brief description in this section, and a footnote of the availability. (For more specific information on adjuncts, refer to Section A28).

A7. Terminology

A7.1 Every standard should include a section on terminology.

A7.1.1 All significant terms that may have a meaning more specialized than the commonly used language should be defined within a standard or the terminology standard should be referenced. (See Part E on Terminology.)

A7.1.2 To avoid redundant definitions, check the committee terminology standard, terminology sections within committee technical standards, and the *ASTM Online Dictionary of Engineering Science and Technology*.

A7.2 *Terminology Within a Standard*— This section may include paragraphs on definitions, definitions of terms specific to a standard, symbols, abbreviations, acronyms, discussions, or a combination thereof.

A7.2.1 *Definitions*— Write a definition in the dictionary-definition form and assign a section number, term, part of speech, definition, and, when applicable, a delimiting phrase. Italicize the term, part of speech, and delimiting phrase. Do not capitalize the term or any other components of the definition except for proper nouns, acronyms, or any other words capitalized in normal usage (see Section E4). List the terms in alphabetical order. Example follows:

3. Terminology—(Always use as the main heading.)
3.1 *Definitions:*
3.1.1 *color blindness, n*—total or partial inability to differentiate certain hues.
3.1.2 *transmittance, n—of light,* that fraction of the incident light of a given wavelength which is not reflected or absorbed, but passes through a substance.

A7.2.2 *Discussions*— When more detail of the concept being defined is desirable, supplementary information should be added as a separate numbered paragraph labeled “Discussion” immediately following the definition. Use the term “Discussion” instead of “Note” (see E5.8). Example follows:

3.1.2.1 *Discussion*—Extraneous leakage is the sum of all leakage other than that intended to be measured by the test.

E283

A7.2.3 *Definition(s) of Term(s) Specific to This Standard*— This is a term that is specific to the standard in which it is used and that has no application out of that context. Write a definition of term specific to a standard in the dictionary-definition form and include a section number,

term, part of speech, definition, and, when applicable, a delimiting phrase. Italicize the term, part of speech, and delimiting phrase. Do not capitalize the term or any other components of the definition except for proper nouns, acronyms, or other words capitalized in normal usage (see Section E4). List the terms in alphabetical order. Example follows:

3.1 *Definition of Terms Specific to This Standard:*
3.1.1 *batch sampling, n*—sampling over some time period in such a way as to produce a single test sample for analysis.
D4175

A7.2.4 *Symbols*— In a standard with numerous equations containing identical quantity symbols, symbols may be listed alphabetically and unnumbered in this section instead of under each equation; also italicize the symbol and do not capitalize the definition. (See also Section E6.) Example follows:

3.1 *Symbols:*
A = cross-sectional area of specimen
B = normal induction

A7.2.5 *Referencing Terminology Standard*— If the terminology applicable to the standard is included in a terminology standard, cite the applicable terminology standard. Example follows:

3.1 *Definitions:*
3.1.1 For definitions of terms used in this test method, refer to Terminology D1129.

A8. Summary of Test Method

A8.1 Include here a brief outline of the test method, describing in the passive voice its essential features without the details that are a necessary part of the complete statement of procedure. If desired, a brief statement of the principle of the test method may be given; this is particularly desirable in the case of chemical methods and should appear as the first paragraph. In chemical methods state the type of procedure, such as colorimetric, electrometric, and volumetric, and describe the source of color, major chemical reaction including pertinent chemical equations, etc.

A9. Significance and Use (Mandatory)

A9.1 Include in this section information that explains the relevance and meaning of the test. State the practical uses for the test and how it is typically employed. Avoid repetition of information included in the Scope (see Section A5). Include statements to provide the user with comprehensive understanding of the following:

A9.1.1 The meaning of the test as related to the manufacture and end use of the material,

A9.1.2 The suitability of the test for specification acceptance, design purposes, service evaluation, regulatory statutes, manufacturing control, development and research, and

A9.1.3 The fundamental assumptions inherent in the test method that may affect the usefulness of the results.

A9.2 Include any discretion needed in the interpretation of the results of the test.

A9.3 Include, where applicable, comparisons of the test to other similar procedures.

A10. Interferences

A10.1 If the successful application of the test method requires the inclusion of explanatory statements on interference effects, include such information here; otherwise, omit this section. List briefly the constituents or properties that are likely to cause interference and the amounts that are known to interfere. In some cases this information is obtainable only by observation during the performance of the test. If the presence of an interfering factor affects the precision or bias of the test results and compensations are made in the calculations (Section A19), this should be explained in this section and noted in the appropriate section. In some cases, interferences may be a major factor in judging test results and explanations of their effects may become lengthy. Lengthy explanations may be placed in an annex to the standard.

A11. Apparatus

A11.1 In this section, include a brief description of the essential features of the apparatus and equipment required for the test, and, where they clarify or supplement the text, schematic drawings or photographs. Cover in separate

text divisions the important features and requirements for the apparatus. Do not list common laboratory apparatus, such as flasks and beakers, but include any especially modified forms or unusual sizes of common apparatus that are required or that may require special preparation.

A11.2 Trademarks shall not be used unless a specific manufacturer's product is required for a well-defined reason (see Section F3 for regulations regarding patents in ASTM standards). In such cases an explanatory footnote shall be included giving supplementary information regarding such apparatus or material. The footnote shall state that this apparatus or material "has been found satisfactory for this purpose." When special types of glassware are required, such as heat-resistant and chemical-resistant, state the significant characteristic desired rather than a trademark. For example, use "borosilicate glass" rather than "Pyrex" or "Kimax." Specify filter paper by describing the significant characteristic such as porosity, rate of filtering, and ash content, or by reference to ASTM Specification E832, for Laboratory Filter Papers

NOTE A1—Policies have been adopted by the Board of Directors that are applicable to standards involving patented apparatus, materials, and processes. These policies are described in the *Regulations Governing ASTM Technical Committees.* Before submitting to subcommittee or main committee ballot any draft test method that requires a specific manufacturer's product, consult the Staff Manager of your committee as to necessary conformance with the *Regulations Governing ASTM Technical Committees.*

A11.3 Detailed manufacturing requirements for apparatus, unless quite brief, should preferably be placed in an annex to the test method (see A24.3), retaining in the text only a brief outline with schematic drawings or illustrations where necessary. The purpose of this outline is to provide information regarding the essential features of the apparatus, to enable the user to assemble the equipment and understand its use in the test method.

A11.4 When essentially the same apparatus is used for more than one standard and the description of the apparatus requirements is lengthy, it is recommended that the complete specifications for the apparatus be included in an annex to one standard and merely a reference be made to them in the other standard, mentioning under "Apparatus" only such modifications as may apply in each particular case.

A11.5 When the same apparatus is used in several standards, the detailed specifications should be covered by a separate ASTM standard. Examples of such standards are:

E1 Specification for ASTM Thermometers
E133 Specification for Distillation Equipment

A11.6 It is the responsibility of the sponsoring committee to assure itself that suitable apparatus is available (see Section F4).

A11.6.1 If the apparatus is special or not readily available, detailed rules for referencing sources of supply shall be followed (see Section F4).

A11.6.2 If the apparatus has to be built, blueprints, plans, etc., should be cited in a footnote in this section as available through ASTM International Headquarters as adjunct material to the standard.

A12. Reagents and Materials

A12.1 When more than one procedure is included in one standard, list the reagents and materials required for each procedure as a separate section under each subdivision.

A12.2 It is recommended that, where applicable, the following be included as secondary sections ".1" and ".2" of this section:

6.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society where such specifications are available.[1] Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

6.2 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean reagent water as defined by Type ___ of Specification D1193.

NOTE A2—The identifying number (for example 6.1 and 6.2 as above) used in recommended texts are for illustrative purposes.

[1] *Reagent Chemicals, American Chemical Society Specifications*, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.

A12.2.1 If a different grade of water is required, add a second sentence as follows: "Water conforming to the following specifications is required" (list the specific properties, kinds of ion freedom, etc.)

A12.2.2 In standards covering two or more chemical methods these statements on purity should be made in a separate section entitled "Purity of Reagents."

A12.3 List the reagents alphabetically in separate divisions. Give the name of the reagent first, followed by any descriptive terms (see A12.7). State the desired concentration if significant; then follow with instructions for preparation and standardization (if required), using the imperative mood and concise descriptions. Spell out the full name of the reagent, and immediately after the first mention of the name include within parentheses the exact chemical formula of the reagent showing any water of crystallization, etc. Exception to this may be made in the case of organic, organometallic, or complex inorganic compounds by omitting the chemical formula. Subsequent references to compounds shall be by formula only where they can be clearly specified by this means, as in the case of most inorganic compounds. As exceptions, always spell out the word "water" and the names of substances in their elementary state; for example, use lead, not Pb; oxygen, not O_2. If the reagent is to be used as purchased, and not diluted, dissolved, or purified, state the chemical formula as given by the manufacturer.

A12.4 Do not use trademarks unless a specific manufacturer's product is required for a well-defined reason. (See Section F4.) In this case, use a superior reference number to refer to a footnote giving the required information, incorporating the phrase "has been found satisfactory for this purpose." Where particular reagents are required only for standardization or calibration, identify them by reference to an appropriate footnote such as "This reagent is used for standardization purposes only."

A12.5 Specify the reagent concentration in applicable terms, as follows:

Concentrated acids and bases ... density, unless mass percent is more generally used or required
Dilute acids and bases ... volume ratio, X + Y (X volumes of reagent added to Y volumes of water)
Nonstandardized solutions ... grams of reagent as weighed out per litre of solution
Standardized solutions ... normality, expressed decimally; or the equivalent of 1 mL of solution in terms of grams of a given element expressed as "1 mL + xxx g of ..."

A12.6 Wherever possible, use the same concentrations of reagents and methods of standardization as used in other similar ASTM test methods.

A12.7 Examples of reagent descriptions are as follows:

A12.7.1 *Ammonium Carbonate* $(NH_4)_2CO_3$).

A12.7.2 *Sodium Chloride Solution* (100 g/L)—Dissolve 100 g of sodium chloride (NaCl) in water and dilute to 1 L.

A12.7.3 *Potassium Hydroxide, Methanol Solution* (33 g/L)—Dissolve 33 g of potassium hydroxide (KOH) in methanol and dilute to 1 L with methanol.

A12.7.4 *Barium Chloride Solution* (100 g $BaCl_2$/L)—Dissolve 117.3 g of barium chloride dihydrate ($BaCl_2 \cdot 2H_2O$) in water and dilute to 1 L.

A13. Hazards

A13.1 *Safety Hazards*— Paragraph F2.1 specifies the generic safety hazards caveat and the types of standards in which it shall be used. Other statements on safety are subject to the following policies.

A13.1.1 *Warning Statement*— A warning statement identifies a specific hazard and provides information for avoiding or minimizing a particular hazard. When there are hazards to personnel, such as explosion, fire toxicity, or radiation, or technical hazards, such as damage to equipment, a warning statement shall be placed at the appropriate point in the text beginning with "Warning" in boldface type followed by a

description of the hazard, or a reference to a description of the hazard within the body of the standard (refer to A13.1.2).

A13.1.2 *Remedial Statements*— A remedial statement provides recommendations for treating a situation resulting from an unsuccessfully controlled hazard *associated with the use of a standard*. Such remedial statements shall not be included in standards, but reference may be made in a note to authoritative sources where reliable information about remedial measures can be obtained such as the appropriate Material Safety Data Sheet (MSDS) where applicable.

A14. Sampling, Test Specimens, and Test Units

A14.1 Under this heading give necessary special directions, in the imperative mood, for physically obtaining sample test units. If a test result is defined as a combination of the observations made on different test specimens, particularly describe how these specimens are to be selected. Give necessary special directions for storage of specimens, for preservation of specimens, and for special preparation of specimens for the test.

A14.2 Statistical aspects of sampling for a specific purpose, for example, in determining conformance of the mean properties of a lot to specifications, should be referenced or discussed in an appendix. These statistical aspects might include stratification, selection of primary and secondary sampling units, the number of such units to be selected, in the case of bulk material the number of increments combined to form a composite sample, the number of composites to be formed, the method of subsampling a composite, and the number of tests made on a subsample.

A14.3 If the method of sampling is described in an existing ASTM test method or ASTM specification, refer to that test method or specification by designation.

A14.4 If the method of sampling is detailed in a readily available publication other than an existing ASTM standard, refer to the publication in a footnote, arranging the information in accordance with the suggestions presented in the Standards Style Manual, Part G, of this publication.

A14.5 Where an existing sampling method (other than ASTM) is cited in a test method, guidelines should be given as to the use of the sampling scheme and precautions if needed. If explanatory documents regarding sampling are available, these should be cited in this section.

A14.6 A *test unit* is a unit or portion of a material that is sufficient to obtain a test result(s) for the property or properties to be measured. A *test specimen* is a test unit or portion of a test unit upon which a single or multiple observation is to be made. A *test result* refers to the value obtained for a given property from one test unit. A test unit may be a subunit of a primary (first stage) sampling unit or it may be a subunit of a composite of primary sampling units or of increments from these primary sampling units. A test result may be a single observation or a combination of a number of observations when two or more test specimens are measured for each test unit. (For additional information see Section G23.)

A14.7 The size of the test unit for chemical analysis usually is given in the “Procedure” section, but if significant in connection with pretreatment or preparation, it should be included here. When a test specimen is specified by mass, indicate the degree of precision desired.

A14.8 Include detailed requirements as to the size and number of test specimens to be used for both physical and chemical tests. Where a test specimen or test unit of a particular shape is required, the essential dimensions shall be specified, including tolerance. A drawing showing the details of the specimen or test unit may be included.

A15. Preparation of Apparatus

A15.1 Use this section only when detailed instructions are required for the initial assembly, conditioning, or preparation of the apparatus (see also A24.3.6).

A16. Calibration and Standardization

A16.1 *Apparatus*— Give detailed instructions, in the imperative mood, for calibration and adjustment of the apparatus necessary for the use of the test method.

A16.2 *Reference Standards and Blanks*— Give detailed instructions for the standardization and use of reference standards and blanks used in the test method. Describe any standard samples used to assure uniformity of the test technique, and standard specimens or photographic standards.

A16.3 *Calibration Curves and Tables*— Give detailed instructions for the preparation and use of calibration curves or tables, in accordance with the suggestions presented in the Standards Style Manual, Part G, of this publication. Include in the instructions for curve or table preparation items such as calibration, solutions, reference standards, blanks, color development, photometry, and construction.

A17. Conditioning

A17.1 Specify, in the imperative mood, the conditioning atmosphere to be used and the time of exposure to the atmosphere, as well as the atmosphere required during the test, where necessary. State whether the conditioning requirements apply to laboratory samples as well as individual specimens. Indicate any requirements for preconditioning. Where applicable, refer to ASTM Terminology E41, Terms Relating to Conditioning, and to ASTM Practice E171/E171M, for Conditioning and Testing Flexible Barrier Packaging.

A18. Procedure (Mandatory)

A18.1 Include in proper sequence detailed directions for performing the test. Describe the procedure in the imperative mood, present tense; for example: “Heat the test specimen ...” rather than “The test specimen shall be heated ...” State the number of samples to be taken, and also state the number of specimens to be tested from each sample. Describe in detail the successive steps of the procedure, grouping related operations into logical divisions. Subheadings may be used if they will help the organization of the material. Make the text of the procedure concise, to the point, and easily understandable. When alternative procedures are given, state their relative status; that is, which is the preferred or referee procedure.

A18.2 In chemical methods, specify the size of test specimen and indicate the degree of precision desired in the weighing. Consider the specimen size and its accuracy of weighing in connection with the ultimate use of the method. If the formula for a reagent has been given previously in accordance with the instructions given in A12.3, refer to the reagent by chemical formula only or name, whichever is less confusing. Otherwise, spell out the name of the reagent. The procedure shall provide for any operations necessary to obtain any correction data that may be needed.

A19. Calculation or Interpretation of Results

A19.1 *Calculation*— State the directions in the imperative mood for calculating the results of test including any equations and any required significant figures (see also Section G16 and ASTM Practice E29 for Using Significant Digits in Test Data to Determine Conformance with Specifications.) Spell out names in the text but use letter symbols in the equations to designate individual values. Use numerical values for any constants. Describe the letter symbol immediately under the equation (unless a section on symbols is included; see A7.2.4). Avoid the use of combined factors in chemical methods. Indicate the reference point on which the calculations are based, such as on the sample as received and dry basis, and the units in which the results are reported. If necessary for clarity, a typical calculation should be included in an explanatory note.

A19.1.1 An example of a typical equation is:

$$\text{Aluminum, \%} = \frac{(A \times B) \times 0.0587}{C} \times 100$$

where:

A = grams of aluminum oxyquinolate found in the aliquot used,

B = grams of aluminum oxyquinolate found in the blank, and

C = grams of sample represented in the aliquot used.

A19.2 *Interpretation of Results*— Use this heading in place of “Calculation” when the results of the test are expressed in descriptive form, relative terms, or abstract values. List and

define the descriptive terms or classifications used. The results of a test may be interpreted or expressed in terms of a rating scale. There is fairly wide agreement on five-step scales for many values or rankings of merit, with 5-good, 3-middle, 1-bad. In general, a higher score for more of a desirable property is the more satisfactory arrangement. This eliminates confusion arising from No. 1 in rank for the most of a quantity, without regard to the relative desirability.

A19.2.1 Examples of test methods that include rating systems are:

D130 Test Method for Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test
D3511/D3511M Test Method for Pilling Resistance and Other Related Surface Changes of Textile Fabrics: Brush Pilling Tester Method

A20. Report

A20.1 State in this section 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 was used. When the test method permits variation in operating or other conditions, incorporate in the report a statement as to the particular conditions used in the test. As an aid in the calculation and uniform recording of test results a standard report form or work sheet may be used, and if desirable a facsimile of the form may be included in the test method. Introduce the section as follows: "Report the following information:"

A21. Precision and Bias (Mandatory)

A21.1 *Definitions and Additional Information:*

A21.1.1 For precise definitions of statistical terms, refer to ASTM Terminology E456, Relating to Quality and Statistics.

A21.1.2 For more information on calculation methods relating to the use of statistical procedures, refer to ASTM Practices E177 and E691.

A21.2 *Statement of Precision (Mandatory)*:

A21.2.1 Precision is the closeness of agreement between test results obtained under prescribed conditions. A statement on precision allows potential users of the test method to assess in general terms its usefulness in proposed applications. A statement on precision is not intended to contain values that can be duplicated in every user's laboratory. Instead the statement 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.

A21.2.2 Precision shall be estimated in accordance with the interlaboratory test program prescribed in Practice E691, Conducting an Interlaboratory Study to Determine the Precision of a Test Method, or by an interlaboratory test program that yields equivalent information, for example, a standard practice developed by an ASTM technical committee. The data and details of the interlaboratory study to determine precision shall be filed as a research report at ASTM International Headquarters. The precision statement shall include reference to the research report in a Note.

A21.2.3 Every test method shall contain: (*1*) a statement regarding the precision of test results obtained in the same laboratory under specifically defined conditions of within-laboratory variability (repeatability conditions); and (*2*) a statement regarding the precision of test results obtained in different laboratories (reproducibility conditions).

A21.2.4 The repeatability conditions defined in Terminology E456 shall be used; namely, within-laboratory conditions under which test results are obtained with the same test method in the same laboratory by the same operator with the same equipment in the shortest practicable period of time using test specimens taken at random from a single quantity of homogenous material. If some other within-laboratory variability is also determined (such as for longer times or different operators within a laboratory), the particular conditions shall be reported in detail, and the precision designated "intermediate precision" (see Terminology E456). If the committee formerly called this repeatability, add "(formerly called repeatability)."

A21.2.5 The statement regarding between-laboratory variability shall pertain to test results obtained with the same method on random test

units from the same lot of homogeneous material in different laboratories with different operators using different equipment (reproducibility conditions).

A21.2.6 The precision statement shall include the repeatability standard deviation and reproducibility standard deviation; and shall include the 95 % repeatability limit and the 95 % reproducibility limit for the largest expected differences between two test results. The latter are numerically equal to 2.8 times the respective standard deviation for data that are known to be normally distributed, and approximately so for most other data encountered in ASTM committee work. Use a statement such as the following:

Precision [1]—The repeatability standard deviation has been determined to be (insert repeatability value) and the 95 % repeatability limit is (insert value). The reproducibility standard deviation has been determined to be (insert reproducibility value) and the 95 % reproducibility limit (insert value).

[1]Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: (insert report number). Contact ASTM Customer Service at service@astm.org.

A21.3 *Statement on Bias (Mandatory):*

A21.3.1 Bias is a systematic error that contributes to the difference between the mean of a large number of test results and an accepted reference value. A discussion on bias may be found in statistical documents, such as Practices E177 and C670.

A21.3.2 The bias statement shall describe the bias and methods employed to provide corrected test results. If the bias is not known but the direction or bounds on the bias, or both, can be estimated, these shall be reported in the bias statement.

A21.4 *General Considerations:*

A21.4.1 The precision and bias section of the test method shall include a brief descriptive summary of the interlaboratory study that will permit the user of the test method to judge the reliability of the data. This summary should include number of laboratories, number of property levels tested, range of the measured average property levels, and number of replicate tests. The summary may be included in a Note.

A21.4.2 If precision or bias, or both, varies with the test level, the variation shall be described in the statement.

A21.4.3 When revising or reapproving a test method, ensure that the information reported in the Precision and Bias section and the supporting data are still valid. If there has been a change to the test method that could affect precision, a new interlaboratory study should be conducted.

A21.5 *Exceptions:*

A21.5.1 If the responsible committee decides that an interlaboratory study for a new test method should be delayed, a temporary statement shall be included which addresses only repeatability based on the results from a single operator. A repeatability limit is not included. This temporary precision statement is permitted for five years, use a statement such as the following:

Precision [1]—The repeatability standard deviation from a single operator has been determined to be (insert repeatability value or values for different average property values).

[1]An interlaboratory study of this test method is being conducted and a complete precision statement is expected to be available on or before (insert year).

A21.5.2 If it is not feasible to determine the reproducibility, as directed in A21.2, within five years of the first approval of the standard, use a statement such as the following:

Precision [1]—The repeatability standard deviation from a single operator has been determined to be (insert the average test values and corresponding repeatability values).

[1]The reproducibility of this test method is not provided at this time because (insert here the reason or reasons). The reproducibility of this test method is being determined and is expected to be available on or before (insert year).

A21.5.3 When a test method specifies that the procedure in another ASTM test method is to be used without modification, no statements of precision and bias are necessary if those in the other test method are applicable. When a test method specifies that the procedure in another ASTM test method is to be used with only insignificant modification(s), use a statement

such as the following to assure the reader that precision and bias are not affected by the modification(s):

Precision and Bias—The precision and bias of this test method for measuring (insert here the name of the property) are essentially as specified in Test Method (insert here the designation of the other test method).

When a test method specifies that the procedure in another ASTM test method is to be used with significant revisions, provide statements on precision and bias as directed in A21.2 and A21.3.

A21.5.4 When a test method specifies that a test result is a nonnumerical report of success or failure or other categorization or classification based on criteria specified in the procedure, use a statement on precision and bias such as the following:

Precision and Bias—No information is presented about either the precision or bias of Test Method X0000 for measuring (insert here the name of the property) since the test result is nonquantitative.

A21.5.5 If it is not possible to provide a statement on precision (repeatability or reproducibility) as directed in A21.2, use a statement such as the following:

Precision—It is not possible to specify the precision of the procedure in Test Method X0000 for measuring (insert here the name of the property) because (insert here the reason or reasons).

Citing impracticability is not warranted if the reason is that an interlaboratory study has revealed that the precision is poor or that the standard was written before precision statements were required.

A21.5.6 If bias cannot be determined, a statement to this effect shall be included, such as the following:

Bias—No information can be presented on the bias of the procedure in Test Method X0000 for measuring (insert here the name of the property) because (insert here the reason; such as "no material having an accepted reference value is available").

A22. Measurement Uncertainty

A22.1 Measurement uncertainty is an estimate of the magnitude of systematic and random measurement errors that may be reported along with the measurement result. An uncertainty statement relates to a particular result obtained in a laboratory carrying out the test method, as opposed to precision and bias statements which are mandatory parts of the method itself and normally derived from an interlaboratory study conducted during development of the test method.

A22.2 It is neither appropriate for, nor the responsibility of, the test method to provide explicit values that a user would quote as their estimate of uncertainty. Uncertainty values must be based on data generated by a laboratory reporting results using the test method.

A22.3 In this section include guidance for developing estimates of uncertainty to be reported with test results. Suggestions should be considered for studies to perform, listings of the potential major contributing factors to uncertainty, descriptions of how the variation due to each factor might be evaluated, and examples of how they might be combined. Information of this type is particularly useful to users of the test method seeking laboratory accreditation. Information on measurement uncertainty may be placed in an appendix if it is for information only.

A22.4 For additional guidance refer to Guide E1488.

A23. Keywords (Mandatory)

A23.1 In this section, identify the words, terms, or phrases, that best represent the technical information presented in the standard. Select the keywords from the title and body of the document and include general, vernacular, and trade terms. These keywords will be used in the preparation of the ASTM Subject Index.

A23.2 Select three or more keywords that describe the names of tests, procedures, special materials, or the specific application(s) that will facilitate the identification and retrieval of the standard.

A23.3 All selected keywords shall be standalone terms; the type of standard, incomplete phrases, unattached adjectives, etc., shall not be used.

A24. Annexes and Appendixes

A24.1 Additional information may be included in one or more annexes and appendixes to the test method.

A24.2 The words "Mandatory Information" shall be included directly under the title of annexes and the words "Nonmandatory Information" shall be included directly under the title of appendixes.

A24.3 *Annexes*— Include in annexes any detailed information such as that on apparatus or materials that is a mandatory part of the test method but too lengthy for inclusion in the main text. Annexes shall precede appendixes. Examples of such information are as follows:

A24.3.1 Glossary of terms used in the method,

A24.3.2 List of symbols,

A24.3.3 Detailed description of apparatus,

A24.3.4 Instructions for calibrating and standardizing apparatus,

A24.3.5 Directions for cleaning apparatus, and

A24.3.6 Operating instructions and adjustments of specific makes of apparatus.

A24.4 *Appendixes*— An appendix to an ASTM standard is informative only and is not a mandatory part of the standard. Information on the following general subjects has been included in such appendixes:

A24.4.1 Notes on significance and interpretation of the test method, usually to amplify the statement in the text,

A24.4.2 Development of equations used in the calculations,

A24.4.3 Charts or supplementary information for computations,

A24.4.4 Suggested data forms for recording test results, and

A24.4.5 Commentary on rationale used in the development of the test method.

A25. References

A25.1 Include only references to publications supporting or providing needed supplementary information. Historical and acknowledgment references are not desirable. If there are five or more references, list them in an unnumbered section at the end of the standard in the order in which they appear in the text. If there are fewer than five literature references, use footnotes (see Section G21).

A26. Footnotes

A26.1 *General*— Footnotes referenced in the text are intended only for reference and shall never include any information or instructions necessary for the proper application of the method. Table footnotes are a part of the table. Use consecutive superior numerals for reference to footnotes except in connection with tables, in which case use italic capital letters.

A26.2 *Committee Jurisdiction and History*— Footnote 1 shall include in the first paragraph the committee having jurisdiction and, where the committee so requests, the subcommittee. The second paragraph shall include history information as follows: *(1)* approval date of latest revision, *(2)* month and year of publication, *(3)* designation and year of original issue, *(4)* designation and year of previous issue, and *(5)* information as to any other standards that may have been replaced by the standard, year of redesignation, etc.

A26.3 *Literature References*— Use footnotes for references if there are fewer than five. For five or more see Section A25, observing the limitations noted therein. Also see Section G21.

A26.4 *Sources of Apparatus*— Where apparatus may be special or not readily available from more than one source, the source may be referenced. (However, see Section F4 for detailed rules.)

A26.5 *Research Reports*— Reference in a footnote the availability of Research Reports (see Section A29).

A27. Notes

A27.1 Notes in the text shall not include mandatory requirements. Notes are intended to

set explanatory material apart from the text itself, either for emphasis or for offering informative suggestions, which are not properly part of the standard. Clarification of the description of required apparatus or procedure and modifications required or permitted in certain cases belong in the text itself. If inclusion of the contents yields a different result, then that information is considered mandatory for the performance of the standard and shall be located in the text. Notes may be preferable for detailed description of auxiliary procedures (for example, correction of barometric pressure in a test method not primarily concerned with pressure). Table notes are a part of the table and are mandatory provisions.

A27.2 Notes appearing in a given standard shall be numbered in sequence separately in the main text, separately in sequence in the annex, and separately in sequence in the appendix and should appear at the end of the paragraph to which they pertain. If it is desired to refer to a text note in connection with a specific word or phrase in the text, that word or phrase should be followed by a reference to the note, "(NOTE 1)," etc.

A27.3 Notes in the text are preferred for the following:

A27.3.1 To refer to editorial changes made in the text,

A27.3.2 To refer to similar or companion ASTM standards,

A27.3.3 Limitations of the application of the test when not covered in the text.

A27.3.4 Description, if included under "Scope," of experimental means for recognizing cases where the method is not applicable to the material under test.

A27.3.5 Description of additional (not alternative) apparatus, materials, procedures, or calculations that are not actually required; or description of merely recommended forms of construction of required apparatus.

A27.3.6 Explanation, if desired, of the reasons for a certain requirement or direction. If brief, include in the text rather than as a note.

A27.4 *Patent Disclaimer of Liability*— See Section 15 of the *Regulations Governing ASTM Technical Committees.* This note, quoted in F3.2 and not numbered, is generally placed at the end of the standard. Refer questions regarding the applicability of this section to the Staff Manager of your committee.

A27.5 *General Statement of ASTM Policy*— This note, quoted in F2.3 and not numbered, is generally placed at the end of the standards after the note on Patent Disclaimer of Liability.

A28. Adjuncts

A28.1 Occasionally, it is not practicable to publish as an integral part of the standard, because of its nature, material that may be required for use of the standard. Such material is published as an adjunct.

A28.2 Include a description of the adjunct in the text of the standard. If appropriate, include a figure (illustration) of the adjunct.

A28.3 When adjunct material is indicated, it shall be made available at the time of publication of the standard.

A28.4 Include all referenced adjuncts in the Referenced Documents section (see Section A6).

A28.5 Examples of adjuncts are as follows:

A28.5.1 Comparison standards such as the copper strip corrosion standards for Test Method D130 (lithograph aluminum strips),

A28.5.2 Charts such as the viscosity-temperature charts for liquid petroleum for D341,

A28.5.3 Reference radiographs such as E155 or reference photographs, such as E125,

A28.5.4 Technical data such as the twelve volumes of D1250, Petroleum Measurement Tables, and

A28.5.5 Drawings such as detailed drawings for the construction of the smoke chamber in Test Method D2843.

A29. Research Reports (Mandatory for Precision and Bias Statements Producing Numerical Results)

A29.1 Where numerical data have been generated to establish the precision and bias of a test method, a research report is required. The research report shall include a list of participating laboratories, description of samples, a copy of the laboratory instructions, the equipment/apparatus

used, the data, a statistical summary and a copy of the Precision and Bias Statement, where applicable. A guide for the research report is available at www.astm.org or from ASTM International Headquarters. The research report shall be placed on file at ASTM. A number is assigned by ASTM and a copy may be obtained upon request. A footnote shall be placed in the standard stating that a copy of the research report may be obtained from ASTM, giving the "RR" designation number.

A30. Rationale

A30.1 The inclusion of a rationale (commentary) section in ASTM standards is encouraged to ensure that brief and concise documentation is available to the user of the standard and to provide traceability and clarification of past actions. This documentation may include: *(1)* a brief history of the development of a new standard or revision to an existing standard including when and why the effort was initiated, *(2)* reasons and justification for requirements, *(3)* documentation of factors considered, and *(4)* listing of technical sources and literature.

A30.2 If included, this information shall appear in an appendix of the standard.

A30.3 Examples of standards that include section on rationale:

E84 Test Method for Surface Burning Characteristics of Building Materials

F746 Test Method for Pitting or Crevice Corrosion of Metallic Surgical Implant Materials

A31. Summary of Changes

A31.1 If the committee chooses to provide a Summary of Changes, place this unnumbered section at the end of the standard and begin with the following introductory paragraph:

Committee XXX has identified the location of selected changes to this standard since the last issue (insert designation and year date) that may impact the use of this standard.

A31.2 An asterisk will appear after the Scope (**Scope***) with the following wording at the bottom of the first page:

***A Summary of Changes section appears at the end of this standard.**

A31.3 Next list, by section or subsection, changes made since the last issue that may impact the use of the standard. For standards that have undergone multiple revisions in a short period of time, keep the Summary of Changes in the standard for 18 months. This will ensure that all changes from one publication of the Annual Book of ASTM Standards to the next are recorded. Brief descriptions of the changes and reasons for the changes may be included. If desired, a more extensive description of reasons for the changes should be placed in the appendix.

A31.4 An example of the list of changes is:

(1) Deleted Section 5 and renumbered subsequent sections.
(2) Updated precision statement in Section 10 to reflect the results of a recent interlaboratory study.
(3) Revised hardness requirements in Table 2.
(4) Revised Section 14 on Product Marking.

PART B

FORM OF ASTM SPECIFICATIONS

INTRODUCTION

The broad scope of ASTM International, which covers materials, products, systems, and services, and the need to provide for a variety of approaches to the writing of ASTM specifications, prevent the development of a single document or a series of documents that list all subjects to be covered in all ASTM specifications. This document, however, is intended to provide considerable guidance to the committees in their specification-writing activities.

Special instructions with respect to the legal aspects shall be followed in writing any standard. These include such matters as contractual items, caveat statements, patents, and fire standards. Assistance on development of fire standards is available from Committee E05. See Part F for details.

When a standard is being developed, the costs associated with its development and subsequent use generally should be considered. The prime objective should be the optimum use of resources to achieve satisfactory definition of the product or service. However, it should be noted that when the standard relates to the safety of persons, cost considerations are likely to become much less important than when attributes of materials or products are involved. Some standards, such as definitions, impose no cost on the user; others that include numerous and extensive requirements can entail significant expense to users of the standard. The requirements to be included should, therefore, be those that are technically relevant and yield benefits commensurate with the cost of their determination.

Cost effective statements or rationale may be included within a standard if appropriate, usually in an appendix.

Standards or sections of standards relating to the *safe use or performance* of consumer products (see NOTE B1) may be sent to Committee F15 on Consumer Products for review and comment at some appropriate stage prior to letter ballot of the originating main committee. This review is offered by Committee F15 to provide for the maximum of consumer input. Draft standards submitted to Committee F15 will receive rapid and constructive critique.

NOTE B1—Consumer products are those designed primarily for use by the consumer in and around the home, school, or recreational areas.

B1. Functions

B1.1 Specifications (see definition on p. vii) may have three functions and, although many specifications serve all three, it is well that those drafting specifications keep these functions in mind so that the primary purposes are not confused.

B1.1.1 *Purchasing*— Specifications facilitate dealings between the purchaser and the supplier. Sufficient requirements should be included to ensure that all batches, lots, or deliveries from any seller that conform to the specification will be satisfactory to the purchaser. Unnecessary requirements are likely to increase costs and should be avoided.

B1.1.2 *Standardization*— Standardization is an inevitable byproduct of most specifications. In some cases it may be the primary function. Standardization involves a deliberate and possibly arbitrary choice of a limited number from the multiplicity of qualities, sizes, compositions, etc., that may be available.

B1.1.3 *Providing Technical Data*— All specifications contain technical information, but in some cases the designer requires more information than that provided for purchase or standardization. Committees may add information of this type to specifications either as requirements or as appendixes.

B1.2 *Open-End Agreements*— There shall be no statements in specifications that allow

agreement between purchaser and supplier that do not meet the minimum requirements of the specification by such means as omitting tests that are a part of the specification, substituting or modifying a test method, or by changing the specification limits to be less restrictive.

B2. Subject Headings of Text

B2.1 The following is the sequence for the text of ASTM specifications. Headings are those most generally used, but may not be all-inclusive. It may be necessary to include other headings for specialized subjects. The headings identified as "mandatory" are required. Other headings shall be included when the subject matter is pertinent to the document under development, in which case, all instructions and guidance for that particular section shall be followed. For example, if the standard does not contain reference to any standard documents within the text, it is not required to include a section on Referenced Documents. If, however, specific hazards are cited throughout the text, then the section on Hazards shall be followed. Not all of these headings may be required for a particular standard. Additional headings, which are included to cover specialized subjects, should appear in the most appropriate place and sequence depending on their relation to the sections below.

Title (mandatory)
Designation (mandatory)
Scope (mandatory)
Referenced Documents
Terminology
Classification
Ordering Information
Materials and Manufacture
Chemical Composition
Physical Properties
Mechanical Properties
Performance Requirements
Other Requirements
Dimensions, Mass, and Permissible Variations
Workmanship, Finish, and Appearance
Sampling
Number of Tests and Retests
Specimen Preparation
† Test Methods
Inspection
Rejection and Rehearing
Certification
Product Marking
Packaging and Package Marking
Keywords (mandatory)
Supplementary Requirements
Quality Assurance
Annexes and Appendixes
References
Summary of Changes

† Test methods included shall contain the mandatory headings shown in Section A1, except for title and designation.

B2.2 Subject headings in boldface type shall precede each section to orient the reader. Substitute text divisions and number in accordance with the Use of the Modified Decimal Numbering System guide in Part D of this publication.

B3. Title (Mandatory)

B3.1 The title should be as concise as possible, but complete enough to identify the material, product, system, or service covered by the specification. Titles are used in lists, table of contents, and indexes, and it is most important that they be brief but inclusive. Use the singular form: "specification."

B4. Designation and Year Date

B4.1 Designation (mandatory)—The ASTM designation, assigned by Headquarters on submittal for approval, consists of the following sequential parts:

B4.1.1 A letter designation denoting in general the classification according to material, product, system, or service:

A—Ferrous metals and products
B—Nonferrous metals and products
C—Cementitious, ceramic, concrete, and masonry materials
D—Miscellaneous materials and products
E—Miscellaneous subjects
F—End-use materials and products
G—Corrosion, deterioration, weathering, durability, and degradation of materials and products

B4.1.2 A sequential number following the letter designation (for example, Specification C150).

B4.2 *Year Date:* (for example, Specification C150-01):

B4.2.1 After the designation, a hyphen is followed by the last two numbers of the year of acceptance or of last revision. If the standard is revised again during the same year, this is indicated by adding an "a" for the second revision, "b" for the third revision, etc.

B4.2.2 The parenthetical phrase ("Reapproved 20___") to designate the year of last reapproval of a standard, if applicable.

B4.2.3 For editorial changes that do not change the year designation, a note is inserted before the text to indicate the location and date of the change and a superscript epsilon ($^{\varepsilon}$) is added after the year designation. the epsilon designations and corresponding notes are numbered chronologically and are deleted upon occasion of the next revision or reapproval.

B4.3 Designation numbers of standards that have been discontinued are not reassigned.

B4.4 *SI Standards* (see Part H and Section G24).

B5. Scope (Mandatory)

B5.1 Include in this section information relating to the purpose of the specification. Concisely state the materials, products, systems, or services to which the specification applies and any known limitations. Include, where applicable, the intended use of the specification. Do not include references to trademarks.

B5.2 Include in this section the system of units to be used in referee decisions.

B5.3 Include in this section any caveats required by ASTM policy such as *safety hazards* (see F2.1) and *fire hazards* (see F2.2) if one or more test methods are detailed other than by reference.

B5.4 For standards developed for reference in model (building) codes, include the following statement:

> The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

B6. Referenced Documents

B6.1 List in alphanumeric sequence the designation and complete title all documents referenced within the standard. Refer to Section A6 for further information.

B6.2 Provide footnotes to this section to indicate the sources of these documents. When ASTM standards are referenced later in the text, use only the type of standard (that is, specification, test method, practice, classification, guide, terminology, etc.) and the designation letter and number (for example, Test Method D1310).

B6.3 Do not include the year date when designating referenced documents unless there is a technical reason for requiring a particular revision.

B6.4 When listing referenced adjuncts, provide a brief description in this section, and a footnote of the availability. (For more specific information on adjuncts, refer to Section B29).

B7. Terminology

B7.1 See Section A7.

B8. Classification

B8.1 When more than one material, product, or system is specified, they may be separated first by *types*, which are distinguished by Roman numerals. This first subdivision shall be based upon some major property, composition, or application of the item. Designate further subdivision by *grades* according to some pertinent property or properties and identify by Arabic numbers. If necessary, make additional division into *classes*, identified by capital letters.

B8.2 The precedence of type, grade, and class, as well as the method of designation, is the ASTM preferred style, and it shall be used in the absence of any established preference.

B8.3 When a type, grade, or class has been deleted, do not use this designation again, to avoid confusion with earlier specifications. If new designations are used, they shall be of different format and preferably followed (for a limited time) by the previous designation in parentheses.

B9. Ordering Information (See also Section B25)

B9.1 When the specification covers options for purchase, such as various types, grades, classes, alloys, sizes, and mass, the purchase order or inquiry should state which particular types, alloys, sizes are desired.

B9.2 A listing of each such optional feature, together with a reference to the applicable section of the specification, will be of assistance in the

wording of orders. After the attention of the purchaser is directed to all of the options in the specification, his attention might be directed to what would be furnished by the supplier if the purchaser fails to specify one or more of the options.

B9.3 It is recommended that this section be included in all specifications as a checklist of items to be included in a purchase order or contract. If this list contains any ASTM designation (including referenced documents), it is desirable to specify "year date(s)" to avoid misunderstandings between contractual parties.

B9.4 When citing a combined standard, indicate the system of units to be applied. For example:

X.X This material/product shall conform to the requirements stated in SI units of Specification A36/A36M.

B10. Materials and Manufacture

B10.1 General requirements regarding the materials and method of manufacture to be used may be included when deemed helpful to the user of the standard, such as the open-hearth, electric-furnace, or basic-oxygen bessemer processes generally specified for steel products. When the material, product, or system specified is made from two or more materials or products, this section should state briefly the general requirements of the materials or products to be used and the process to be followed in manufacture, including items such as the nature and character of any alloys, fillers, saturants, antioxidants, coatings, and plasticizers.

B11. Chemical Composition

B11.1 When necessary, detailed requirements shall be given as to chemical composition and other chemical characteristics for the material, product, or system. Frequently these are presented in tabular form. It is most important that the following information be clearly indicated: *(1)* name of each constituent specified, *(2)* whether the requirement is a maximum, minimum, or range, *(3)* whether an allowance for measurement error is incorporated in these limits, *(4)* the units applicable, *(5)* references to notes or footnotes when necessary for further clarification, and *(6)* appropriate analytical methodology.

B11.2 The sequence of items specified shall be consistent within a related group of specifications.

B11.3 The preferred introduction for this section is: "The material shall conform to the requirements prescribed in Table 1."

B11.4 *Limits on Nonspecified Elements*— It is suggested that the following statement be added to tables of chemical requirements as applicable to replace the requirements and statements presently being used regarding nonspecified elements: "By agreement between purchaser and supplier, analysis may be required and limits established for elements or compounds not specified in the table of chemical composition" (see also Section B24).

B12. Other Requirements

B12.1 When necessary, detailed requirements should be given as to characteristics to which the material, product, or system shall conform. Frequently these are presented in tabular form. It is most important that the following information be clearly indicated: *(1)* name of each property or requirements, *(2)* whether the requirement is a maximum, minimum, or range, *(3)* whether an allowance for measurement error is incorporated in these limits, *(4)* the units applicable, *(5)* references to notes or footnotes when necessary for further clarification, and *(6)* appropriate test methodology.

B12.2 *Physical Properties*— Present the requirements for electrical, thermal, optical, and similar properties in this section, usually in tabular form.

B12.3 *Mechanical Properties*— Present the requirements for tensile strength, yield strength, elongation, and similar properties in this section.

B12.4 *Performance Requirements*— Include functional, environmental, and similar requirements in this section when necessary.

B12.5 *Other Requirements*— Include additional requirements as needed.

B12.6 In preparing a specification it is essential to make sure that there is a test procedure for determining conformance for each requirement. These shall be listed in the specification (see Section B18).

B12.7 When it is not feasible to tabular the requirements, separate text division may be used to specify the various requirements. These shall be given appropriate headings consistent with the subject matter included.

B13. Dimensions, Mass, and Permissible Variations

B13.1 Details as to the standard shapes, mass, and size ranges usually are presented best in tabular form with brief reference in the text. Separate sections may be necessary with individual tables. The tables shall clearly indicate where the various size ranges are divided; for example, ranges from 0 to 250 mm, 250 to 500 mm, 500 to 750 mm shall be more properly stated as 250 mm and under, over 250 to 500 mm, inclusive; over 500 to 750 mm, inclusive, etc.

B13.2 The permissible variations in dimensions, mass, etc., may be included in the same tables with the nominal sizes. It shall be made clear whether the tolerances specified are both plus and minus or apply in only one direction.

B14. Workmanship, Finish, and Appearance

B14.1 Requirements covering the workmanship and finish include such general requirements as the type of finish and general appearance or color, uniform quality and tempers (for metals), and whether the item is clean, sound, free of scale and injurious defects. To avoid misunderstanding, these should be spelled out clearly. Provisions for removal or repair of minor surface imperfections that are not considered cause for rejection should be stated.

B14.2 For products such as pipe and tile it is usually customary to specify absence of defects such as fractures, large or deep cracks, checks, blisters, laminations, and surface roughness. The finish and shape of the ends also should be specified.

B15. Sampling

B15.1 If a specification applies to a unit of product or material such as a piece of cloth, a coil of wire, a section of plastic pipe, or a heat of steel, from which specimens are to be taken for testing, the procedure for obtaining these specimens shall be described.

B15.2 If a specification pertains to individual units of a lot and sampling inspection is likely to be the normal procedure, it is desirable for the specification to reference or include in a supplementary section a sampling procedure for determining acceptability of the lot (see Section B25).

NOTE B2—In a single sampling plan by attributes the acceptability of a lot will be determined by the number of units of product in the sample that do not conform to the specifications. The acceptable quality level (AQL) and limiting quality level (LQL) of an acceptance sampling plan, expressed as percentages of the units nonconforming, are characteristics of the sampling plan and are not to be viewed as product specifications.

B15.3 If a specification pertains to the mean of a lot, in particular to the mean of a lot of bulk material such as cement or pig iron, the procedure for sampling the lot or the formation of sample test units, or both, shall be described or referenced. The criterion for determining conformance of the lot shall be specifically stated.

B15.4 If a specification applies to a lot of bulk material, state the number of increments required to create a sample test unit and the number of test units to be taken to determine conformance of the lot.

B15.5 The minimum amount of material required to carry out conveniently all the tests in the specification should be indicated for the convenience of the user of the specification.

B16. Number of Tests and Retests

B16.1 State the number of test units and the number of test specimens or subunits that are required to determine conformance of the material or product to the specifications. In the sampling of a lot of bulk material, state the size of the sample in terms of the number of primary (first stage) sampling units that is required to determine conformance to the specifications.

NOTE B3—When a specification pertains to several different properties of a material to be determined by a variety of test methods, a test unit is defined as a unit or portion of the material that is sufficient to obtain a single, adequate set of test results for all properties to be measured.

B16.2 If a specification allows retesting in cases where the material or product fails to pass

the specification, state the rules for the retesting and the conditions under which the retesting would be permitted.

B17. Specimen Preparation

B17.1 Where special preparation is required, as for example in specifications for molding materials, this section shall be included.

B17.2 Refer to a standard test method if possible.

B17.3 If no standard test method exists, include sufficient detail in the specification to assure acceptable reproducibility of test results.

B17.4 State that specimens are to be prepared in accordance with the recommendations of the manufacturer only if neither B17.2 nor B17.3 is feasible.

B18. Test Methods

B18.1 List standard test methods for measurement of all requirements of a specification. Refer to the ASTM test methods used in testing the material to determine conformance with the specification. This includes sampling, chemical analysis, mechanical, electrical, thermal, optical, and other testing procedures. When alternative procedures are given in test methods, it is important to state which particular procedure shall be used as the basis for the specification requirement.

B18.2 When there is no ASTM test method specified for a particular quality or property of a specified material, describe the test procedure to be followed in detail in the specification, following the Form of ASTM Test Methods (Part A of this publication). Include all mandatory information listed in A1.1 (title, scope, significance and use, hazards, procedure, precision and bias).

B18.3 Where a method of some other organization is being used and the committee has not approved the test as an ASTM test method, then it is preferable to describe the test in detail in the specification and to include a footnote reference to the original source. Appropriate copyright releases shall be obtained.

B18.4 State all procedures in the imperative mood.

B19. Inspection

B19.1 The following statement has been adopted by the Board of Directors to be used when there is a substantial disagreement between producers and users within a particular committee, resulting in a blockage of progress in the acceptance of new specifications or revisions to specifications:

> Inspection of the material shall be agreed upon between the purchaser and the supplier as part of the purchase order or contract.

B19.2 Place any technical requirements on inspection such as sampling plan and physical or mechanical properties in other appropriate parts of the specification.

B20. Rejection and Rehearing

B20.1 The following statement serves as a guide to ASTM committees when there is need for a section on rejection and rehearing:

> Material that fails to conform to the requirements of this specification may be rejected. Rejection should be reported to the producer or supplier promptly and in writing. In case of dissatisfaction with the results of the test, the producer or supplier may make claim for a rehearing.

B21. Certification

B21.1 A certification section may be included in the standard when in the judgment of the committee, technical considerations make this advisable. If a certification section is included, the certification shall include reference to the standard designation and year date.

B21.2 The following are suggested statements:

> When specified in the purchase order or contract, the purchaser shall be furnished certification stating samples representing each lot have been tested and inspected as indicated in 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. Test reports may be transmitted to the purchaser by electronic services. The content of the electronically transmitted document shall conform to any existing agreement between the purchaser and the seller.

B21.3 Upon the request of the purchaser in the purchase order or contract, the certification of an independent third party indicating conformance to the requirements of this specification may be considered.

B22. Product Marking

B22.1 It is customary to specify the information to be marked on the material or included on the package, or on a label or tag attached thereto. Such information typically may include the name, brand, or trademark of the manufacturer, quantity, size, weight, ASTM designation, or any other information that may be desired for a specific material. If an ASTM standard is specified, indicate "ASTM" and the designation number (for example, ASTM F2063) on the marking, when possible.

B23. Packaging and Package Marking

B23.1 When it is customary and desirable to package, box, crate, wrap, or otherwise protect the item during shipment and storage in accordance with a standard practice, it is customary to state the requirements.

B24. Keywords (Mandatory)

B24.1 In this section, identify the words, terms, or phrases that best represent the technical information presented in the standard. Select the keywords from the title and body of the document and include general, vernacular, and trade terms. These keywords will be used in the preparation of the ASTM Subject Index.

B24.2 Select three or more keywords that describe the names of tests, procedures, special materials, or the specific application(s) that will facilitate the identification and retrieval of the standard.

B24.3 All selected keywords shall be standalone terms; the type of standard, incomplete phrases, unattached adjectives, etc., shall not be used.

B25. Supplementary Requirements

B25.1 For some standards supplementary requirements may be specified. These should not include statements that would allow the lowering of minimum requirements of the standard (see B1.2). Usually these apply only when specified by the purchaser in the purchase order or contract. A statement to this effect shall appear in the first paragraph of the Supplementary Requirements section. The following is a suggested statement relating to special requirements:

> The following supplementary requirements shall apply only when specified by the purchaser in the purchase order or contract.

B25.2 Supplementary requirements shall appear separately in a Supplementary Requirements section.

B25.3 *Quality Assurance*— This requirement, if included, shall be qualified by the statement: "When specified in the purchase order or contract." Reference to a suitable document, such as ASTM International, ANSI, MIL, etc., may be made by agreement between the supplier and the purchaser.

B25.4 *Qualification:*

B25.4.1 Qualification to nongovernment standards shall be based on the same justification and operated under the same rules as qualification to military or federal specifications. The justification and rules are covered in the DoD 4120.3-M manual, Chapter 4. Briefly, qualification is justified when one or more of the following apply: *(1)* The time to conduct one of the tests exceeds 30 days, *(2)* conformance inspection will require special equipment, *(3)* specification covers life survival or emergency life-saving equipment. The committee preparing the specification that calls for qualification will be asked to show that: *(1)* there is no other practical way of obtaining evidence of the availability of products to meet the specification in a reasonable time independent of that acquisition and *(2)* two or more sources are available and willing to submit their products for qualification.

B25.4.2 When qualification is determined to be feasible and necessary, it shall be included in the Supplementary Requirements section with wording similar to:

> Items furnished under this specification shall be products that are qualified for listing on the applicable qualified products list at the time set for opening of bids.

Qualification testing (as distinct from acceptance testing) shall be specifically identified with accept/reject criteria. A statement shall be made

concerning retention of qualification. This may either be a manufacturer's periodic self-certification, a periodic submission of test results, or a complete retest of the product. A statement similar to the following shall be included:

With respect to products requiring qualification, awards will be made only for products that are, at the time set for opening of bids, qualified for inclusion in Qualified Parts List (QPL No.) whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer tested for qualification in order that they may be eligible to be awarded contracts or purchase orders for the products covered by this specification. The activity responsible for the Qualified Parts List is (insert name and address of qualifying organization(s)) and information pertaining to qualifications of parts may be obtained from that activity.

B26. Annexes and Appendixes

B26.1 Additional information may be included in one or more annexes or appendixes to the specification.

B26.2 The words "Mandatory Information" shall be included directly under the title of annexes and the words "Nonmandatory Information" shall be included directly under the title of appendixes.

B26.3 *Annexes*— Include in annexes any detailed information such as that on apparatus or materials that is a mandatory part of the specification but too lengthy for inclusion in the main text. Annexes shall precede appendixes.

B26.4 *Appendixes*— There are times when it is desirable to include in a specification additional information for general use and guidance, but which does not constitute a mandatory part of the specification. It is appropriate to include such informational material in appendixes. Examples of material that has been included in such appendixes are tables showing approximate relationship between tensile strength and hardness, list of preferred thickness of plate, sheet, and strip reproduced from other documents, tables of standard mass and standard sizes, information on typical applications of the material covered, and information on typical physical properties whose definite values are not prescribed in the specification.

B27. References

B27.1 Include only references to publications supporting or providing needed supplementary information. Historical and acknowledgment references are not recommended. If there are five or more references, list them in an unnumbered section at the end of the specification in the order in which they appear in the text. If there are fewer than five literature references, use footnotes (see Section G21).

B28. Footnotes

B28.1 *General*— Footnotes referenced in the text are intended only for reference and shall never include any information or instructions necessary for the proper application of the specification. Table footnotes are a part of the table. Use consecutive superior numerals for reference to footnotes except in connection with tables, in which case use italic capital letters.

B28.2 *Committee Jurisdiction and History*— Footnote 1 shall include in the first paragraph the committee having jurisdiction and, where the committee so requests, the subcommittee. The second paragraph shall include history information as follows: *(1)* approval date of latest revision, *(2)* month and year of publication, *(3)* designation and year of original issue, *(4)* designation and year of previous issue, and *(5)* information as to the other standards that may have been replaced by the standard, year of redesignation, etc.

B28.3 *Literature References*— Use footnotes for references if there are fewer than five. For five or more see Section B27, observing the limitations noted therein. Also see Section G21.

B28.4 *Sources of Apparatus*— Where apparatus may be special or not readily available from more than one source, the source may be referenced. (However, see Section F4 for detailed rules.)

B28.5 *Research Reports*— Reference in a footnote the availability of research reports (see Section B31).

B29. Notes

B29.1 Notes in the text shall not include mandatory requirements. Notes are intended to

set explanatory material apart from the text itself, either for emphasis or for offering informative suggestions not properly part of the standard. Clarification of the description of required apparatus or procedure and modifications required or permitted in certain cases belong in the text itself. If inclusion of the contents yields a different result, then that information is considered mandatory for the performance of the standard and shall be located in the text. Notes may be preferable for detailed description of auxiliary procedures (for example, correction of barometric pressure in a test method not primarily concerned with pressure). Table notes are a part of the table and are mandatory provisions.

B29.2 Notes appearing in a given standard shall be numbered in sequence and should appear at the end of the paragraph to which they pertain. If it is necessary to refer to a text note in connection with a specific word or phrase in the text, that word or phrase should be followed by a reference to the note, "NOTE 1"), etc.

B29.3 Notes in the text are preferred for the following:

B29.3.1 To refer to editorial changes made in the text.

B29.3.2 To refer to similar or companion ASTM standards.

B29.3.3 Description, if included under "Scope," of experimental means for recognizing cases where the method is not applicable to the material under test.

B29.3.4 Description of additional (not alternative) apparatus, materials, procedures, or calculations that are not actually required; or description of merely recommended forms of construction of required apparatus.

B29.3.5 Explanation, if needed, of the reasons for a certain requirement or direction. If brief, include in the text rather than as a note.

B29.4 *Patent Disclaimer of Liability*— See Section 15 of the *Regulations Governing ASTM Technical Committees.* This note, quoted in F3.2 and not numbered, is generally placed at the end of the standard. Questions regarding the applicability of this section should be referred to the Staff Manager of your committee.

B29.5 *General Statement of ASTM Policy*— This note, quoted in F2.3 and not numbered, is generally placed at the end of the standard after the note on Patent Disclaimer of Liability.

B30. Adjuncts

B30.1 Occasionally it is not practicable to publish as an integral part of the standard, because of its nature, material that may be required for use of the standard. Such material is published as an adjunct.

B30.2 Include a description of the adjunct in the text of the standard. If appropriate, include a figure (illustration) of the adjunct.

B30.3 When adjunct material is indicated, it shall be made available at the time of publication of the standard.

B30.4 Include all referenced adjuncts in the Referenced Documents section (see Section A6).

B30.5 Examples of adjuncts are as follows:

B30.5.1 Comparison standards such as the copper strip corrosion standards for Test Method D130 (lithograph aluminum strips),

B30.5.2 Charts such as the viscosity-temperature charts for liquid petroleum for D341,

B30.5.3 Reference radiographs such as E155 or reference photographs, such as E125,

B30.5.4 Technical data such as the twelve volumes of D1250, Petroleum Measurement Tables, and

B30.5.5 Drawings such as detailed drawings for the construction of the smoke chamber in Test Method D2843.

B31. Research Reports

B31.1 Research reports, which include historical or round-robin information, or other data, shall be sent to Headquarters, where they are given a file number and may be obtained upon request. Such reports may be referenced in a footnote (see B28.5). If the specification contains a detailed test method, the requirements in Section A29 apply.

B32. Rationale (Commentary)

B32.1 The inclusion of a rationale (commentary) section in ASTM standards is encouraged to ensure that brief and concise documentation is available to the user of the standard and to

provide traceability and clarification of past actions. This documentation might include: *(1)* a brief history of the development of a new standard or revision to an existing standard including when and why the effort was initiated, *(2)* reasons and justification for requirements, *(3)* documentation of factors considered, and *(4)* listing of technical sources and literature.

B32.2 If included, this information shall appear in an appendix of the standard.

B32.3 Examples of standards that include sections on rationale:

E84, Test Method for Surface Burning Characteristics of Building Materials

F746, Test Method for Pitting or Crevice Corrosion of Metallic Surgical Implant Materials

F763, Practice for Short-Term Screening of Implant Materials

B33. Part Numbering

B33.1 *General*— Part-numbering systems may be included in an ASTM specification. The part-numbering system shall be placed in the appendix, shall be called out "when specified" as a supplementary requirement, and shall be referenced to appropriately under either "product marking," "packaging and package marking," or both places.

B33.2 *When Used for DOD Procurement:*

B33.2.1 The inclusion of a part-numbering system should be considered by technical committees when preparing specifications. Although it is a committee decision whether or not to include part numbering, ASTM International encourages such inclusion in specifications to make them more readily usable directly in procurement and supply applications.

B33.2.2 Part numbers shall be kept short and shall not exceed 15 characters. Part numbering shall be uniform for all parts covered by the same specifications; uniformity is also preferred for all part numbers within the same group of closely related items.

B33.3 *Criteria for Inclusion of Part Numbers:*

B33.3.1 In development of standards that embrace end products, every attempt should be made to define all product variables so as to enable one product to be positively distinguished from another (from both an engineering and stocking viewpoint). Each product so covered shall be assigned a part number that:

- Is uniquely identifying.
- Includes the document (standard) number.
- Does not exceed 15 characters including dashes, slashes, spaces, etc.
- Does not include the letters "I," "O," "Q," "S," "X," and "Z."
- Does not change when the document is changed in a manner that does not affect interchangeability.
- Does not change when the product is modified so as to not be interchangeable. (In such instances, appropriate usage guidance will be provided if appropriate.)

B33.3.2 All standards that include part numbers shall contain a five-digit numerical manufacturers' code as assigned by the U.S. Government under the Federal Cataloging Program. (See Fig. B1.)

B33.3.3 An example of a part-numbering system appears in ASTM Specification F1667, for Driven Fasteners: Nails, Spikes, and Staples.

B34. Summary of Changes

B34.1 If the committee chooses to provide a Summary of Changes, place this unnumbered section at the end of the standard and begin with the following introductory paragraph:

Committee XXX has identified the location of selected changes to this standard since the last issue (insert designation and year date) that may impact the use of this standard.

B34.2 An asterisk will appear after the Scope (**Scope***) with the following wording at the bottom of the first page:

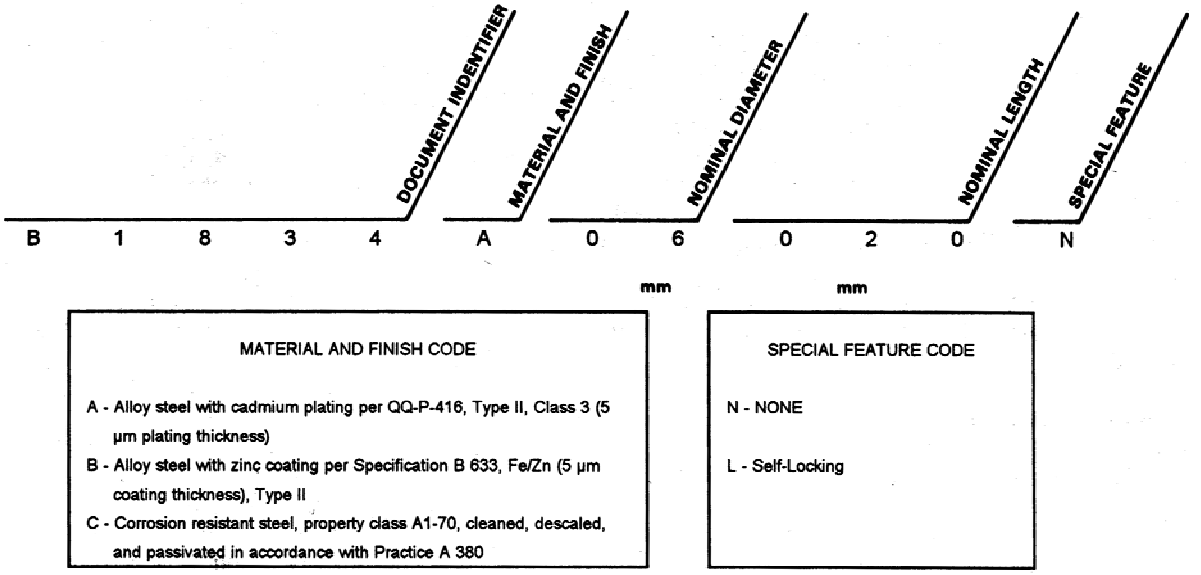
***A Summary of Changes section appears at the end of this standard.**

B34.3 Next list, by section or subsection, changes made since the last issue that may impact the use of the standard. For standards that have undergone multiple revisions in a short period of time, keep the Summary of Changes in the

standard for 18 months. This will ensure that all changes from one publication of the Annual Book of ASTM Standards to the next are recorded. Brief descriptions of the changes and reasons for the changes may be included. If desired, a more extensive description of reasons for the changes should be placed in the appendix.

B34.4 An example of the list of changes is:

(1) Deleted Section 5 and renumbered subsequent sections.
(2) Updated precision statement in Section 10 to reflect the results of a recent interlaboratory study.
(3) Revised hardness requirements in Table 2.
(4) Revised Section 14 on Product Marking.



Example: B1834A06020N indicates a Screw Cap, Hexagon Socket Button Head, SI, made of Cadmium Plated Alloy Steel, 6 mm in diameter, 20 mm in length, and no special feature

FIG. B1 Part Numbering System Covering Standard Items Used by U.S. Government

PART C

FORM OF OTHER TYPES OF ASTM STANDARDS

INTRODUCTION

In addition to test methods and specifications, ASTM standards take other forms, including the following:

Classifications
Practices
Guides
Terminology or Definitions (see Part E)
Reference Radiographs
Reference Photographs
Tables
Charts

As a committee attempts to develop a standard, the question of differentiation between a practice and a guide may arise. In general, a practice underscores a general usage principle whereas a guide suggests an approach. A standard practice connotes accepted procedures for the performance of a given task. Refer to definitions given on p. vii. A guide may propose a series of options or instructions that offer direction without recommending a definite course of action. The purpose of this type of standard is to offer guidance based on a consensus of viewpoints but not to establish a standard practice to follow in all cases. A guide is intended to increase the awareness of the user concerning available techniques in a given subject area, while providing information from which subsequent testing programs can be derived.

Regarding reference radiographs, reference photographs, tables, and charts, there are relatively few subject headings, and the form of the standard is left to the jurisdiction of the sponsoring committee. The first two types listed in the introduction to Part C, however, are most common and are given greater treatment below.

Special instructions with respect to the legal aspects are included in Part F and shall be followed in writing any standard. These include such matters as contractual items, caveat statements, patents, and fire standards. Assistance on development of fire standards is available from Committee E05. The policies contained in Part F are approved by and are under the jurisdiction of the ASTM Board of Directors.

When a standard is being developed, the costs associated with its development and subsequent use generally should be considered. The prime objective should be the optimum use of resources to achieve satisfactory definition of the product or service. However, it should be noted that when the standard relates to the safety of persons, cost considerations are likely to become much less important than when attributes of materials or products are involved. Some standards, such as a definition, impose no cost on the user; others that include numerous and extensive requirements can entail significant expense to users of the standard. The requirements to be included should, therefore, be those that are technically relevant and yield benefits commensurate with the cost of their determination.

Cost effectiveness statements or rationale may be included within a standard if appropriate, usually in an appendix.

CLASSIFICATIONS

C1. Description

C1.1 "A classification is a systematic arrangement or division of materials, products, systems, or services into groups based on similar characteristics such as origin, composition, properties, or use."[1]

[1]From *Regulations Governing ASTM Technical Committees.*

C1.2 Classifications provide a time- and space-saving shorthand for specifying the above description.

C1.3 Classifications may be defined by each committee differently because of the unique nature of that committee. A collection or grouping of definitions to one committee may be termed a classification while still another committee may group objects or properties in a classification.

C2. Subject Headings of Text

C2.1 The following is the sequence for the text of ASTM classifications. Headings are those most generally used but may not be all-inclusive. It may be necessary to include other headings for specialized subjects. The headings identified as "mandatory" are required. Other headings shall be included when the subject matter is pertinent to the document under development; in which case, all instructions and guidance for that particular section shall be followed. For example, if the standard does not contain reference to any standard documents within the text, it is not required to include a section on Referenced Documents. If, however, specific hazards are cited throughout the text, then the section on Hazards (see Section A13) shall be followed. Not all of these headings may be required for a particular standard. The use of footnotes and notes shall follow Sections A26 and A27 respectively. Additional headings that are included to cover specialized subjects should appear in the most appropriate place and sequence depending on their relation to the sections below.

Title (mandatory)
Designation (mandatory)
Scope (mandatory)
Referenced Documents
Terminology
Significance and Use (mandatory)
Basis of Classification (mandatory)
Test Methods and Retest
Keywords (mandatory)
Annexes and Appendixes
Summary of Changes

C3. Title (Mandatory)

C3.1 The title of a classification standard should be concise, but complete enough to identify the nature of the basis for classification, for specific materials, systems, services, and products.

C4. Designation (Mandatory)

C4.1 The ASTM designation is assigned by Headquarters on submittal for approval. Refer to Sections A3 or B4 for sequential parts of numbering.

C5. Scope (Mandatory)

C5.1 Include in this section information relating to the purpose of the classification. Concisely state what characteristics have been classified and the materials, products, systems, or services to which the classification applies. Where applicable state any limitations to the use of the classification.

C5.2 Include in this section the system of units to be used in referee decisions.

C5.3 Include, where applicable, comparisons of the classification to other similar classifications.

C6. Referenced Documents

C6.1 List here in alphanumeric sequence the designation number and complete title of all documents referenced within the classification. Refer to Section A6 for further information.

C7. Terminology

C7.1 See Section A7.

C8. Significance and Use (Mandatory)

C8.1 Include in this section information relating to the relevance of the classification. State how the classification is used and who would typically use it.

C9. Basis of Classification (Mandatory)

C9.1 The basis of classification is in fact the most important portion of the document. This heading sets up categories in which groupings are made. For example, ASTM Classification D388,

of Coals by Rank (Vol 05.06) defines classification of higher rank coals according to fixed carbon on a dry basis while lower rank coals are classed according to caloric value on the moist basis.

C10. Test Methods and Retest

C10.1 Properties enumerated in a classification may be determined in accordance with specific test methods. These methods should be referenced in this portion of the document.

C10.2 Because of variability resulting from sampling and a lack of satisfactory reproducibility, and in instances when the first test results do not conform to the requirements prescribed in this classification, then a retest option may be provided.

C11. Keywords (Mandatory)

C11.1 In this section, identify the words, terms, or phrases that best represent the technical information presented in the standard. Select the keywords from the title and body of the document and include general, vernacular, and trade terms. These keywords will be used in the preparation of the ASTM Subject Index.

C11.2 Select three or more keywords that describe the names of tests, procedures, special materials, or the specific application(s) that will facilitate the identification and retrieval of the standard.

C11.3 All selected keywords shall be standalone terms; the type of standard, incomplete phrases, unattached adjectives, etc., shall not be used.

C12. Annexes and Appendixes

C12.1 Supplementary information is provided herein to aid in understanding and using the standard.

C12.2 Annexes (see A24.3).

C12.3 Appendixes (see A24.4).

C13. Examples

C13.1 Examples of classifications are:

D388 Classification of Coals by Rank
D3475 Classification of Child-Resistant Packages

C14. Summary of Changes

C14.1 If the committee chooses to provide a Summary of Changes, place this unnumbered section at the end of the standard and begin with the following introductory paragraph:

Committee XXX has identified the location of selected changes to this standard since the last issue (insert designation and year date) that may impact the use of this standard.

C14.2 Next list, by section or subsection, changes made since the last issue that may impact the use of the standard. Brief descriptions of the changes and reasons for the changes may be included.

C14.3 An example of the list of changes is:

(1) Deleted Section 5 and renumbered subsequent sections.
(2) Updated precision statement in Section 10 to reflect the results of a recent interlaboratory study.
(3) Revised hardness requirements in Table 2.
(4) Revised Section 14 on Product Marking.

PRACTICES AND GUIDES

C15. Description

C15.1 A standard practice is an accepted procedure for the performance of one or more operations or functions. In certain cases practices may include one or more test methods necessary for full use of the practice. Examples of practices include selection, preparation, application, inspection, necessary precautions for use or disposal, installation, maintenance, and operation of testing apparatus.

C15.2 A standard guide is a compendium of information or series of options that does not recommend a specific course of action. Guides are intended to increase the awareness of information and approaches in a given subject area. Guides may propose a series of options or

instructions that offer direction without recommending a definite course of action. The purpose of this type of standard is to offer guidance based on a consensus of viewpoints but not to establish a standard practice to follow in all cases.

C16. Subject Headings of Text

C16.1 The following is the sequence for the text of ASTM practices and guides. Headings are those most generally used but may not be all-inclusive. It may be necessary to include other headings for specialized subjects. The headings identified as "mandatory" are required. Other headings shall be included when the subject matter is pertinent to the document under development; in which case, all instructions and guidance for that particular section shall be followed. For example, if the standard does not contain reference to any standard documents within the text, it is not required to include a section on Referenced Documents. If, however, specific hazards are cited throughout the text, then the section on Hazards (see Section A13) shall be followed. The use of footnotes and notes shall follow Sections A26 and A27 respectively.

Title (mandatory)
Designation (mandatory)
Scope (mandatory)
Referenced Documents
Terminology
Summary of Practice
Significance and Use (mandatory)
Reagents
Procedure
† Test Methods
Report
Keywords (mandatory)
Annexes and Appendixes
Summary of Changes

†Test Methods included shall contain the mandatory headings included in Section A1, except for title and designation.

C16.2 Not all of these headings may be required for a particular standard. Additional headings that are included to cover specialized subjects should appear in the most appropriate place and sequence depending on their relation to the sections listed in C16.1.

C17. Title (Mandatory)

C17.1 The title should be concise but complete enough to identify the nature of the practice. It should identify the subject of application and should be distinguishable from similar titles (see A2.1 as it applies to titles of test methods).

C18. Designation (Mandatory)

C18.1 The ASTM designation is assigned by Headquarters on submittal for approval. Refer to Sections A3 and B4 for sequential parts of numbering.

C19. Scope (Mandatory)

C19.1 Include in this section information relating to the purpose of the practice or guide and to what it applies. Clearly state any limitations of the practice or guide.

C19.2 Include in this section the system of units to be used in referee decisions.

C19.3 Include in this section any caveats required by ASTM policy such as *safety hazards* (see F2.1) and *fire hazards* (see F2.2).

C19.4 For standards developed for reference in model (building) codes, include the following statement:

The text of this standard references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

C20. Referenced Documents

C20.1 List here in alphanumeric sequence the designation number and complete title of all documents referenced within the practice (or guide). Refer to Section A6 for further information.

C21. Terminology

C21.1 See Section A7 and Part E.

C22. Summary of Practice

C22.1 Include here a brief outline of the practice, describing its essential features without the details that are a necessary part of the complete statement of procedure and sequence. If desired, a brief statement of the principle of the practice may be given.

C23. Significance and Use (Mandatory)

C23.1 Include in this section information that explains the relevance and meaning of the practice (or guide). State the practical uses for the practice and how it is typically employed. Avoid repetition of information included in the Scope (see Section C19).

C23.2 Include separately any appropriate comments on limitations of the practice. Indicate any means of recognizing cases where the practice may not be applicable.

C23.3 Include, where applicable, comparisons of the practice (or guide) to other similar procedures.

C24. Reagents

C24.1 See Section A12.

C25. Procedure

C25.1 Include in the procedure detailed directions for performing the task outlined in the practice.

C25.2 In some cases, to aid in clarity, a diagrammatic, photographic, or schematic may be of value to the user of the practice. These shall be supplied to the ASTM editorial staff as originals. An excellent example of this type of approach is illustrated in ASTM Practice D2855, for Making Solvent-Cemented Joints with Poly-(Vinyl Chloride) (PVC) Pipe and Fittings.

C26. Test Methods

C26.1 List standard test methods for measurement of all requirements of practices or guides. Refer to the ASTM test methods used in testing the material to determine conformance with the practice or guide. This includes sampling, chemical analysis, mechanical, electrical, thermal, optical, and other testing procedures. When alternative procedures are given in test methods, it is important to state which particular procedure shall be used as the basis for the practice or guide requirement.

C26.1.1 Examples of standard practices that include multiple test methods:

D4169 Practice for Performance Testing of Shipping Containers
E679 Practice for Determination of Odor and Taste Thresholds by a Forced-Choice Ascending Concentration Series Method of Limits
E795 Practices for Mounting Test Specimens During Sound Absorption Tests

C26.2 When there is no ASTM test method specified for a particular quality or property of a specified material, describe the test procedure to be followed in detail in the practice (or guide), following the Form of ASTM Test Methods (Part A of this publication). Include all mandatory information listed in A1.1 (title, scope, significance and use, hazards, procedure, precision and bias).

C26.3 Where a method of some other organization is being used and the committee has not approved the test as an ASTM test method, then it is preferable to describe the test in detail in the practice or guide and to include a footnote reference to the original source. Obtain appropriate copyright releases.

C26.4 State all procedures in the imperative mood.

C27. Report

C27.1 Include detailed information as to calculating, interpreting, and reporting results in this section.

C27.2 Depending upon the nature of the practice, an entire section may, by necessity, be devoted to calculation or interpretation of results, or both.

C27.3 When a practice permits variance in conditions under which the standard practice has been performed, these conditions should become part of the report.

C28. Keywords (Mandatory)

C28.1 In this section, identify the words, terms, or phrases that best represent the technical information presented in the standard. Select the keywords from the title and body of the document and include general, vernacular, and trade terms. These keywords will be used in the preparation of the ASTM Subject Index.

C28.2 Select three or more keywords that describe the names of tests, procedures, special

materials, or the specific application(s) that will facilitate the identification and retrieval of the standard.

C28.3 All selected keywords shall be stand-alone terms; the type of standard, incomplete phrases, unattached adjectives, etc., shall not be used.

C29. Annexes and Appendixes

C29.1 Supplementary information is provided herein to aid in understanding and utilizing the standard.

C29.2 Annexes (see A24.3).

C29.3 Appendixes (see A24.4).

C30. Rationale

C30.1 The inclusion of a rationale (commentary) section in ASTM standards is encouraged to ensure that brief and concise documentation is available to the user of the standard and to provide traceability and clarification of past actions. This documentation might include: *(1)* a brief history of the development of a new standard or revision to an existing standard including when and why the effort was initiated, *(2)* reasons and justification for requirements, *(3)* documentation of factors considered, and *(4)* listing of technical sources and literature.

C30.2 If included, this information shall appear in an appendix of the standard.

C30.3 Examples of standards that include sections on rationale:

E84 Test Method for Surface Burning Characteristics of Building Materials

F746 Test Method for Pitting or Crevice Corrosion of Metallic Surgical Implant Materials

F763 Practice for Short-Term Screening of Implant Materials

C31. Summary of Changes

C31.1 If the committee chooses to provide a Summary of Changes, place this unnumbered section at the end of the standard and begin with the following introductory paragraph:

Committee XXX has identified the location of selected changes to this standard since the last issue (insert designation and year date) that may impact the use of this standard.

C31.2 An asterisk will appear after the Scope (Scope*) with the following wording at the bottom of the first page:

***A Summary of Changes section appears at the end of this standard.**

C31.3 Next list, by section or subsection, changes made since the last issue that may impact the use of the standard. For standards that have undergone multiple revisions in a short period of time, keep the Summary of Changes in the standard for 18 months. This will ensure that all changes from one publication of the Annual Book of ASTM Standards to the next are recorded. Brief descriptions of the changes and reasons for the changes may be included. If desired, a more extensive description of reasons for the changes should be placed in the appendix.

C31.4 An example of the list of changes is:

(1) Deleted Section 5 and renumbered subsequent sections.
(2) Updated precision statement in Section 10 to reflect the results of a recent interlaboratory study.
(3) Revised hardness requirements in Table 2.
(4) Revised Section 14 on Product Marking.

PART D

USE OF THE MODIFIED DECIMAL NUMBERING SYSTEM

INTRODUCTION

In recent years, "point" systems for numbering sections of a document have come into extensive use. Many national organizations, associations, societies, industrial concerns, and government agencies are using a Modified Decimal Numbering (MDN) System. MDN is also used by standardization organizations.

In 1963, ASTM International adopted the MDN System for ASTM standards. This guide has been prepared for the use of members who are drafting or revising standards. The object of the MDN System is to assign to each division in a text a unique number that shows the relationship of the specific section to all previous sections and gives a complete designation which does not require reference to previous sections or pages.

D1. Scope

D1.1 The Modified Decimal Numbering (MDN) System is designed primarily for numbering the text division in standards.

D1.2 The MDN System is also referred to as the "Point" System.

D2. Parts of a Standard

D2.1 All documents are considered to consist of several primary divisions called primary sections. A primary section may include one or more secondary sections. A secondary section may include one or more ternary sections which in turn may include one or more quaternary sections.

D2.2 The terms "primary section," "secondary section," "ternary section," and "quaternary section" shall not be used in headings or references.

D2.3 References shall be made by referring to only the number when referring to secondary, ternary, and quaternary sections. Refer to primary sections as "Section 4" or "Sections 5 to 9."

D2.4 Either of the generic words "section" or "division" may be used in correspondence or other communication, but shall not be used in references, other than primary, as directed in D2.2 and D2.3.

D3. Assignment of Numbers

D3.1 Number the primary sections of a standard serially, beginning with 1 or "Scope," using as many numbers as required by the number of sections.

D3.2 Assign to the successive secondary sections of any primary section a two-part number consisting of the number used for the primary section followed by a decimal point and a consecutive number, beginning with 1, using as many numbers as required by the number of secondary sections. For example, if there are eleven secondary sections in the fifth section of a standard, designate these secondary sections 5.1, 5.2, 5.3 ... 5.9, 5.10, and 5.11.

D3.3 Assign to the successive ternary sections in a secondary section a three-part number consisting of the two-part number assigned to the secondary section followed by a decimal point and a consecutive number, beginning with 1, using as many numbers as required by the number of ternary sections. For example, if there are four ternary sections in secondary section 8.4, designate the ternary sections, 8.4.1, 8.4.2, 8.4.3, and 8.4.4.

D3.4 Assign to each of the successive quaternary sections in a ternary section a four-part number consisting of the three-part number assigned to the ternary section followed by a decimal point and a consecutive number, beginning with 1, using as many numbers as required by the number of quaternary sections. For

example, if there are three quaternary sections in the second ternary section of secondary section 8.4, designate them 8.4.2.1, 8.4.2.2, and 8.4.2.3.

D3.5 There shall be no further subdivision beyond that allowed by the four-part number. The judicious use of unnumbered center headings may help in the adherence to this rule.

D4. Supplementary Requirements

D4.1 Designate each supplementary requirement by the letter "S" followed by a consecutive number, beginning with 1 for the first supplementary requirement.

D4.1.1 There shall be no decimal point between the "S" and the number.

D4.1.2 Do not renumber supplementary requirement designations once deleted.

D4.2 Designate primary, secondary, and ternary sections of each supplementary requirement as shown in D3.2, D3.3, and D3.4, respectively.

NOTE D1—Primary sections of a supplementary requirement, an annex, or an appendix are numbered the same as a secondary section of the main standard (with two-part numbers); secondary and ternary sections of a supplementary requirement, an annex, or an appendix are, therefore, numbered the same as ternary and quaternary sections (with three and four-part numbers), respectively, of the standard.

D4.3 No individual supplementary requirement shall be subdivided into more than three levels in accordance with D3.5.

D5. Literature References

D5.1 Where a document includes five or more literature references, list them in a separate unnumbered section at the end of the document, preceding annexes and appendixes. Assign a one-part number of each individual reference. See Section G21 of this publication.

D6. Annexes and Appendixes

D6.1 Separate annexes and appendixes from the main text with the centered headings ANNEX(ES) and APPENDIX(ES).

D6.2 Precede the title of each annex by the letter "A" followed by a number in consecutive order, beginning with 1 for the first annex (A1, A2, A3, etc.) Precede the title of each appendix by the letter "X" followed by a number in consecutive order, beginning with 1 for the first appendix (X1, X2, X3, etc.)

D6.2.1 There shall be no decimal point between the "A" or "X" and the number.

D6.3 Designate primary, secondary, and ternary sections of each annex or appendix as shown in D3.2, D3.3, and D3.4, respectively (NOTE D1) (for example, A1.1, A1.1.1, and A1.1.1.1).

D6.4 No individual annex or appendix shall be subdivided into more than three levels in accordance with D3.5.

D7. Equations

D7.1 Equations should be numbered when two or more are included in the main text of the standard (see G16.6). Designate equations with consecutive arabic numbers beginning with 1. Number each equation in the order that it appears in the standard, regardless of the section number in which it is referenced.

D7.2 Designate equations in annexes and appendixes by the designation of the annex or appendix followed by consecutive numbers beginning with 1 (for example, Eq A1.1, A2.4, X3.2).

D8. Tables

D8.1 Assign consecutive arabic numbers to successive tables throughout the main text of the standard without regard to the number assigned to the section in which the table is referenced.

D8.2 Designate tables in annexes and appendixes by the designation of the annex or appendix followed by consecutive numbers beginning with 1 (for example, Table A1.1, A2.4, X3.2). Tables shall follow directly the appropriate annex or appendix.

D9. Figures

D9.1 Assign consecutive arabic numbers to successive figures throughout the main text of the standard without regard to the number assigned to the section in which the figure is referenced.

D9.2 Designate figures in annexes and appendixes by the designation of the annex or appendix followed by consecutive numbers

beginning with 1 (for example, Fig. A1.1, A2.4, X3.2). Figures shall follow directly any tables of the appropriate annex or appendix.

D10. Text Notes

D10.1 Assign consecutive numbers to successive notes throughout the main text of the standard without regard to the number assigned to the section to which the note may refer. Notes shall be indicated by the word "NOTE" followed by the number.

D10.2 Designate notes in annexes by the letter "A" and in appendixes by the letter "X," followed by consecutive numbers, beginning with 1.

D10.3 Designate notes pertaining to figures by consecutive numbers, beginning with 1 for the first note to each individual figure.

D11. Footnotes

D11.1 Assign consecutive numbers to successive footnotes throughout the standard, including supplementary requirements, annexes, and appendixes, without regard to the number assigned to the section in which the footnotes appears.

NOTE D2—Since Footnote 1 is required for sponsoring committee and year date of a standard, the first footnote referenced in the body of the text is Footnote 2.

D11.2 Designate footnotes to tables by consecutive letters, beginning with "A" for the first footnote to each individual table.

D11.3 Footnotes shall be referenced by superscript numbers, or, in the case of tables, by superscript italic capital letters.

D12. Combination of Systems

D12.1 Do not use a combination of the MDN System and other systems for designating secondary, ternary, and quaternary sections. For example, do not divide 8.4 into 8.4 (a), 8.4 (b), and 8.4 (c), rather than the 8.4.1, 8.4.2, and 8.4.3 as directed in D3.3.

D13. Omission of Numbers

D13.1 Do not assign MDN numbers to examples that are numbered serially throughout a document.

D13.2 Do not assign numbers to centered headings when used.

D14. Introductory Sections

D14.1 Where a standard has a preliminary section with a heading such as "Introduction" or "Foreword," do not assign this section a number so that "Scope" shall always be designated with the one-part number "1" in accordance with D3.1.

D15. General Application

D15.1 Exercise care to distinguish between successive, parallel, and alternative sections and supplementary sections such as secondary, ternary, and quaternary sections. Only the latter three require the addition of another decimal point and number. Note also the manner of handling alternative clauses within a section. For example:

10. Procedure
10.1 Dry the specimen by either (1) heating at 105EC (221EF) for 2 h, or (2) holding the specimen in a conditioned atmosphere until dry to the touch.

Note that the above example is a single sentence and no further numbering breakdown is required.

10. Procedure
10.1 Make all tests on conditioned specimens using the procedure given in 10.3 and 10.4.
10.2 Calibrate the tension testing machine and see that the oven is at the specified temperature.
10.3 *Variable Frequency Procedure:*
10.3.1 Adjust the ...
10.3.2 Insert the ...
10.4 *Variable Tension Procedure:*
10.4.1 Start the ...
10.4.2 Clamp the ...

Note that in the above example, 10.3 and 10.4 are successive subdivisions of 10, not subdivisions of 10.1 or 10.2.

D16. Problems

D16.1 Any problems in the implementation of the MDN System in ASTM standards should be referred to the ASTM Director of Standards Publications for resolution.

PART E

TERMINOLOGY IN ASTM STANDARDS

INTRODUCTION

ASTM standard terminology is written to promote three objectives: *(1)* precise understanding and interpretation of ASTM standards, *(2)* standardization of terminology in standards, reports, and other technical writings, and *(3)* explanation of the meanings of technical terms for the benefit of those not conversant with them.

For terminology to be effective, it should be used consistently. It is, therefore, the responsibility of each technical committee to manage terminology usage in all standards for which it has jurisdiction to ensure that usage is consistent both within the committee and the Society. Part E provides guidance to technical committees and to those who review the work of technical committees regarding the principles of terminology.

E1. Terminology Management

E1.1 In ASTM International, technical committees are responsible for defining terminology within technical standards and for developing terminology as a type of standard. Terminology ensures precise interpretation of ASTM standards and explains technical terms for the benefit of users who are not conversant with the language of the standard. Use terminology that is clear, explicit, and not liable to misinterpretation when referred to in technical operations, commercial contracts, or legal proceedings.

E1.2 Terminology in a technical standard may include *definitions of terms* and *definitions of terms specific to a standard* and explanations of *symbols*, *abbreviations*, and *acronyms* that are necessary for the reader to understand that particular standard.

E1.3 All technical standards should contain a *Terminology* section that includes *definitions of terms* or *definitions of terms specific to a standard*, or both. Reference to a related terminology standard(s) can be sufficient for this section.

E1.4 All technical committees should develop and maintain a general terminology standard. Terminology, as a type of standard, is comprised of *definitions of terms* and explanations of *symbols*, *abbreviations*, and *acronyms* pertaining to the scope of a technical committee or a specialized field within the committee.

E2. Definitions of Terms and Definitions of Terms Specific to a Standard

E2.1 The distinction between *definitions of terms* and *definitions of terms specific to a standard* is related to the degree of application. If a term has a meaning more specialized than its commonly used language, is used by two or more subcommittees within a committee, or appears in several standards, it is labeled as a *definition of a term*. When the term is limited in application to the standard in which it needs to be defined, it is labeled as a *definition of a term specific to a standard*. *Definitions of Terms* and *Definitions of Terms Specific to a Standard* appear in separate subsections within the *Terminology* section of a technical standard. Since *definitions of terms specific to a standard* have limited application, they do not generally appear in a technical committee's general terminology standard.

E2.1.1 An example of a *definition* is:

X.x **dolly**, *n*—a low platform or structure mounted on wheels or casters, designed primarily for moving bulky loads for short distances. (Compare **pallet**)

D996

E2.1.2 An example of a *definition specific to a standard* is:

X.x **standard**, *n*—as used in ASTM International, a document that has been developed and established within the consensus principles of the Society and that meets the approval requirements of ASTM procedures and regulations.

Form and Style for ASTM Standards

E3. Guidelines for Writing Definitions of Terms and Definitions of Terms Specific to a Standard

E3.1 Use these guidelines when writing both *definition of terms* and *definitions of terms specific to a standard*.

E3.2 Prepare a definition when:

E3.2.1 Any term used in a standard is essential to the interpretation and application of the standard;

E3.2.2 A term used in a standard is not adequately defined in common language;

E3.2.3 Using qualitative adjectives and nouns that *could* be taken to denote or connote an *absolute, unqualified*, or *unconditional* property or capability; for example: *waterproof, stainless, unbreakable, vapor barrier, gas-free, flat, safe, rigid, pure*. Such qualitative adjectives and nouns shall not be used unless *actually used and defined* in their absolute sense;

E3.2.4 Describing a *quantitative determinable* property or capability that might cause misinterpretation or confusion; for example: *strong, high, accurate, clean*.

E3.3 Do not develop a definition when:

E3.3.1 A term is adequately defined in reference source material (print or electronic version), unless a definition is required for clarity;

E3.3.2 A term has a well-recognized authoritative meaning such as terms defined in the International System of Units (SI);

E3.3.3 A term is defined acceptably for the committee's purposes in the *ASTM Online Dictionary of Engineering Science and Technology* or the committee's terminology standard;

E3.3.4 A term that meets the committee's needs has been defined in a technical standard of another committee or subcommittee.

E4. Form of a Definition

E4.1 Write *definitions of terms* and *definitions specific to a standard* in the dictionary-definition form. Include term, part of speech, definition, and, when applicable, a delimiting phrase (see E5.5).

E4.2 Describe the essential characteristics of the term. Keep it simple. Do not include irrelevant details such as how things are made, used, or measured.

E4.3 State the definition without repeating the term defined. Use language that is understandable to non-experts.

E4.4 Complete the definition in one sentence. If two or more phrases are needed to state the meaning, connect them with semicolons. Include any necessary supplementary information as a Discussion.

E4.5 The term and its elements should appear in the following order: term; abbreviation; symbol; dimensions of quantities, measurement units; part of speech; delimiting phrase; statement of meaning, including specification limits where applicable; cross-references to synonyms or related terms; attribution.

E5. Elements of a Term

E5.1 *Abbreviations*— For terms usually represented by an abbreviation, place a comma and the preferred abbreviation following the term, and then the part of speech, for example:

average, *avg*, *n*—

E5.2 *Symbols*— For terms usually represented by a letter symbol, place a comma and the preferred symbol following the term, and then the part of speech, for example:

ampere, *A*, *n*—

E5.3 *Dimensions of Physical Quantities*— If the term represents a physical quantity, state its analytical dimension in italics in square brackets immediately following the letter symbol, or if there is none, following the term itself, for example:

critical height, H_c[*L*],*n*—*in earth grading*, the maximum height at which a vertical or sloped bank of soil will stand unsupported under a specific set of conditions.

D653

E5.4 *Parts of Speech*— Including the part of speech enables the user to distinguish between closely allied terms; for example:

flame resistance, *n*—the ability to withstand flame impingement or give protection from it.

E176

flame resistant, *adj*—having flame resistance

E176

E5.5 *Delimiting Phrases*— If a term has different meanings in other technical fields or contexts, include an italicized phrase that delimits the definition to its field of application. This phrase should follow the dash and be separated from the basic statement of meaning by a comma, for example:

beam, *n*—*in a balance*, the horizontal pan support.
beam, *n*—*in a building*, a horizontal load-carrying structural member of the building frame.
beam, *n*—*in optics*, a concentrated unidirectional flow of radiant energy.

E284

E5.6 *Specification Limits*— If a definition involves specification limits applicable only to a specific standard (for example, in defining plate by specifying a thickness range), make the term specific to that standard. If, however, it is intended that this definition be broadly accepted within a specific technical committee or within ASTM International, delimit its scope, for example:

plate, *n*—*aluminum products*, a rolled flat product of thickness 6.4 mm (0.25 in.) or greater.

E5.7 *Cross-references*— Cross-references bring together related terms and narrower terms of a given genus. A cross-reference may take the place of a definition, or it may be appended to a definition to draw attention to related definition, for example:

flat-bed—see **truck**.

E5.8 *Discussions*— To fill in more detail of the concept being defined, supplementary information may be added as a separate discussion immediately following the definition, for example:

3.1 ***builder's model***, *n*—a reference standard of quality for specific building components, denoting, by example, the level of quality adopted by a builder.

3.1.1 *Discussion*—The examples or samples of construction material, permit examination of quality level.

E631

E5.9 *Attributions*— If an existing definition is adopted from another reference source material (for example, technical standard, manual, or dictionary), copy it exactly and identify the original source in a boldface notation at the right margin following the definition.

E5.9.1 Notify Headquarters that permission to publish shall be obtained from the organization holding copyright. The definition shall not be published without permission.

E6. Use of Symbols, Acronyms, and Abbreviations as Terminology

E6.1 In standards containing numerous symbols, acronyms, or abbreviations, these items may be listed under the appropriate subheading as a convenience to the user of the standard.

E6.1.1 *Symbols*— Alphabetically list the symbols. Do not assign a number or capitalize the explanation, for example:

X.x *Symbols*:
A = cross-sectional area of specimen
B = normal induction

E6.1.2 *Acronym*— An acronym is a shortened form of a compound term that uses the initial letters of the term to make a pronounceable word. Alphabetically list, and capitalize the acronyms. In a few cases acronyms are written in lower case, such as laser and sonar. Do not capitalize the explanation unless it is a proper noun, for example:

X.x *Acronyms*:
X.x.1 *PERT*, n—*program evaluation and review technique*
X.x.2 *radar*,*n*—radio detecting and ranging

E6.1.3 *Abbreviations*— An abbreviation is a shortened form of a compound word or phrase. List the abbreviations alphabetically. Do not include abbreviations appearing in Section G3. Do not capitalize the explanation unless it is a proper noun, for example:

X.x *Abbreviations*:
X.x.1 *assn*—association
X.x.2 *avg*—average

FORM OF A TERMINOLOGY STANDARD

E7. Subject Headings of Text

E7.1 The following list shows in sequence the subjects usually covered in a terminology standard:

Title (mandatory)
Designation (mandatory)
Scope (mandatory)
Significance and Use
Terminology: Terms and Definitions (mandatory)
Symbols, Abbreviations, Acronyms
Keywords (mandatory)
Annexes and Appendixes
Bibliography or References
Summary of Changes

E8. Title (Mandatory)

E8.1 The title should be as concise as possible but complete enough to identify the subject covered by the terminology. The title of a terminology standard preferably is *Terminology of ...*, although *Terminology Relating to ...* is acceptable.

E9. Designation (Mandatory)

E9.1 The designation will be assigned by ASTM International Headquarters upon submittal of the standard for Society approval.

E10. Scope (Mandatory)

E10.1 Provide information about the field of application of the terminology. Include information on how, when, and by whom the terminology will be used. Indicate here whether the terminology standard is general or relates to a specialized field. Where the content of a terminology standard is limited or restricted, as in a specialized terminology standard, the scope statement should so indicate.

E11. Referenced Documents

E11.1 Include in this section only ASTM standards, adjuncts, and standards or codes of other organizations. All referenced documents shall be cited.

E11.1.1 Provide footnotes to this section to indicate the sources of these documents.

E11.1.2 Do not include the year date when designating referenced documents unless there is a technical reason for specifying a particular year date.

E11.1.3 When listing reference adjuncts, provide a brief description, in this section, and a footnote of their availability.

E12. Significance and Use

E12.1 When use restrictions exist, include a significance and use statement. Give a warning of them such as: “This terminology is not intended to …”

E13. Terminology (Mandatory)

E13.1 *Terms and Their Definitions (Mandatory)*— Compose a definition in the dictionary-definition form (see E4.5) and include the term, part of speech, definition, and when applicable, a delimiting phrase. Boldface the term and italicize the part of speech and delimiting phrase. Do not capitalize the term or any other components of the definition except for proper nouns, acronyms, or any other words capitalized in normal usage. List the terms unnumbered and in alphabetical sequence.

E13.1.1 Although the preferred style of listing terms and their definitions is in alphabetical sequence, in some cases it may be desirable to show the relationships in a logical family of concepts by grouping definitions according to a classification system. Place narrower or subordinate terms and their definitions in alphabetical order under the definition of the broader term, as the main entry, for example:

soil structure, *n*—an arrangement and state of aggregation of soil particles in a soil mass.

flocculent structure, n—an arrangement composed of flocs of soil particles instead of individual soil particles.

honeycomb structure, n—an arrangement of soil particles having a comparatively loose, stable structure resembling a honeycomb.

single-grained structure, n—an arrangement composed of individual soil particles, characteristic structure of coarse-grained soils.

D653

E13.1.2 *Cross-references*— See E5.7 for rules governing cross-references.

E13.1.3 *Discussions*— See E5.8 for rules governing discussions.

E13.1.4 *Attributions*— See E5.9 for rules governing attributions.

E14. Symbols, Acronyms, and Abbreviations

E14.1 Any of these subsections can be used for the convenience of the user of the standard. Follow the guidelines detailed in Section E6.

E15. Keywords

E15.1 In this section, identify the words, terms, or phrases that best represent the technical information presented in the standard. Select the keywords from the title and body of the document and include general, vernacular, and trade terms. These keywords will be used in the preparation of the ASTM Subject Index.

E15.2 Select three or more keywords that describe the names of tests, procedures, special materials, or the specific application(s) that will facilitate the identification and retrieval of the standard. Keywords for terminology standards should include the words *definitions* and *terminology*.

E15.3 All keywords shall be stand-alone terms; incomplete phrases and unattached adjectives shall not be used.

E16. Annexes and Appendixes

E16.1 To aid in understanding and using the terminology, supplementary information such as illustrations, commentaries, or rationale may be included in annexes (mandatory information), or appendixes (nonmandatory information).

E17. Bibliography or References

E17.1 Supplementary publications, useful for consultation by users who wish to have more detailed information on the particular terminology, may be provided. If the publications are cited in the text, they should be listed in a References section at the end of the standard (see Section A25); otherwise, the section should be titled Bibliography.

E18. Summary of Changes

E18.1 This unnumbered section shall be placed at the end of the standard and begin with the following introductory paragraph:

Committee XXX has identified the location of selected changes to this standard since the last issue (insert designation and year date) that may impact the use of this standard.

E18.2 Next list, by section or subsection, changes since the last issue that may impact the use of the standard. Brief descriptions of the changes and reasons for the changes may be included.

E18.3 An example of the list of changes is:

(1) Added the term bioconcentration.
(2) Revised scope.
(3) Modified the definition for sediment.

PART F

CAVEATS AND OTHER LEGAL ASPECTS IN STANDARDS—SPECIAL INSTRUCTIONS

INTRODUCTION

This section contains special instructions for the use of commercial-contractual statements, caveats, patents, trademarks, specific sources of supply, references to other organization, etc., in standards. When a standard contains any one of these statements or references, the committee shall obtain the necessary guidance from ASTM International Headquarters for the inclusion in the standard.

F1. Commercial-Contractual Items in Standards

F1.1 Certain requirements, such as those listed below, shall not be included in ASTM standards. If a committee feels it is important that this type of information be given, the committee may request an exemption from the Committee on Standards for the inclusion of such requirements in an ASTM standard.

- Adjustment, settlement, and investigation of claims
- Costs of testing, retesting statements
- Effective Dates
- Open-end agreements (see B1.2)
- Prices
- Purchasing

F1.2 The matter of who shall pay for services should be stated in the agreement or purchase order and not in the standard. Statements covering inspection (follow Section B19), rejection and rehearing (follow Section B20), testing and retesting (follow B16.2), marking (follow Section B22), and certification (follow Section B21) are suitable when they do not contain mandatory requirements covering the costs involved.

F2. Caveat Statements and Policies in Standards

F2.1 The generic caveat on *safety hazards* specified below shall appear in the Scope section of *(1)* test methods; *(2)* specifications where test methods are detailed other than by reference; and *(3)* practices and guides that involve the use of material, operations, or equipment.

This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

F2.1.1 When the standard does not involve the use of hazardous materials, operations, or equipment, a request for an exception to the inclusion of the generic caveat shall be presented to the ASTM Standing Committee on Standards.

F2.1.2 Specific *warning* statements shall be included in the standard (see Section A13 for the use of warning statements). These statements shall not prescribe specific remedial measures and actions. However, reference may be made to authoritative sources where reliable information concerning remedial measures can be obtained.

F2.1.3 Where there exists in a standard a specific warning statement(s), reference to the appropriate section(s) shall be made following the generic safety hazards caveat in the scope.

F2.2 *Fire Standards:*

F2.2.1 Every fire standard shall state its purpose, specify the known limitations of the standard, and specify the significance of the data that are generated (including relevance to human life and property, where appropriate). Use precise terminology (see Part E, Terminology in ASTM Standards), and include the appropriate caveat as listed below. Standards should include, when practical, sufficient background or explanatory material to guide users in properly applying ASTM fire standards.

F2.2.2 ASTM fire standards include fire-test-response standards, fire hazard assessment standards, and fire risk assessment standards.

Other types of fire standards shall also be permitted, including terminologies, guides, specifications, and practices. The following criteria shall be followed by fire standards:

F2.2.2.1 Fire-test-response standards provide a means for measuring the response of materials, products, or assemblies to heat and flame under controlled conditions of test. ASTM fire-test-response standards shall contain the following caveat:

This standard is used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled conditions, but does not by itself incorporate all factors required for fire hazard or fire risk assessment of the materials, products, or assemblies under actual fire conditions.

F2.2.2.2 Fire-hazard assessment standards provide a method for assessing the potential for harm for materials, products, or assemblies that could be anticipated under specified fire conditions. ASTM fire-hazard assessment standards shall contain the following statement:

This standard is used to predict or provide a quantitative measure of the fire hazard from a specified set of fire conditions involving specific materials, products, or assemblies. This assessment does not necessarily predict the hazard of actual fires which involve conditions other than those assumed in the analysis.

F2.2.2.3 Fire-risk assessment standards provide a method for assessing the probability of loss resulting from a given fire situation involving interaction between the material, product, or assembly with its environment. ASTM fire-risk assessment standards shall contain the following statement:

This standard is used to establish a means of combining the potential for harm in fire scenarios with the probabilities of occurrence of those scenarios. Assessment of fire risk using this standard depends upon many factors, including the manner in which the user selects scenarios and uses them to represent all scenarios relevant to the application. This standard cannot be used to assess fire risk if any specifications are different from those contained in the standard.

F2.2.2.4 ASTM develops fire standards other than fire-test-response standards, fire-hazard assessment standards, or fire-risk assessment standards, which provide information on fire issues that is not associated with a quantitative output (where quantitative outputs include a binary pass/fail option or a classification into categories). Such ASTM fire standards shall contain the following statement:

This fire standard cannot be used to provide quantitative measures.

F2.2.2.5 The following generic caveat is appropriate for fire standards that do not describe a fire test but do produce quantitative results that are calculated measures of fire-test-response characteristics and not by themselves measures of fire hazard or fire risk.

This standard is used to determine certain fire-test responses of materials, products, or assemblies to heat and flame under controlled conditions by using results obtained from fire-test-response standards. The results obtained from using this standard do not by themselves constitute measures of fire hazard or fire risk.

F2.2.2.6 The following caveat is required for fire test methods:

Fire testing is inherently hazardous. Adequate safeguards for personnel and property shall be employed in conducting these tests.

F2.2.3 *Titles and Criteria for Fire-Hazard and Fire-Risk Assessment Standards*— All standards developed, approved, or reapproved for the analysis and control of fire hazard or fire risk shall contain the words "FIRE-HAZARD ASSESSMENT" or "FIRE-RISK ASSESSMENT" in the title. The results of all such assessments shall be expressed in terms that relate the item in question to the anticipated fire environment. When appropriate, the standard may also contain acceptance or classification criteria and a statistical sampling plan as a guide to its use.

F2.2.4 ASTM Committee E05 on Fire Standards is available to provide review of fire standards developed by other ASTM committees.

F2.3 *General Policy Caveat*— The Board of Directors approved the inclusion of a General Statement of ASTM Policy in all standards:

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 International 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, 100 Barr Harbor Drive, West Conshohocken, PA 19428.

This statement shall appear in a note at the end of the standard, following the note on ASTM Disclaimer of Liability as to Patented Inventions (see Section F3 on Patents in ASTM Standards).

F2.4 *Working Document Caveat*— The Board of Directors approved the use of the "Working Document" statement to be stated on the front page of every draft document or manuscript from a committee. The following statement shall be typed or stamped on the document:

This document is not an ASTM standard; it is under consideration within an ASTM technical committee but has not received all approvals required to become an ASTM standard. You agree not to reproduce or circulate or quote, in whole or in part, this document outside of ASTM Committee/Society activities, or submit it to any other organization or standards bodies (whether national, international, or other) except with the approval of the Chairman of the Committee having jurisdiction and the written authorization of the President of the Society. If you do not agree with these conditions, please immediately destroy all copies of the document. *Copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. All Rights Reserved.*

Anyone requesting an ASTM committee draft document is entitled to receive a copy. However, after receipt of this document, they shall adhere to the caveat.

F2.5 *Professional Judgment Caveat*— When a Technical Committee is developing a Standard Guide or Practice that may involve professional judgment, the following caveats may be used:

Standard Guide—This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

Standard Practice—This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title means only that the document has been approved through the ASTM consensus process.

F2.6 *Mercury Caveat*— When a standard includes reference to the element of mercury or products containing mercury, the following caveat shall appear in the Scope section.

Warning—Mercury has been designated by many regulatory agencies as a hazardous substance that can cause serious medical issues. Mercury, or its vapor, has been demonstrated to be hazardous to health and corrosive to materials. Caution should be taken when handling mercury and mercury containing products. See the applicable product Safety Data Sheet (SDS) for additional information. Users should be aware that selling mercury and/or mercury containing products into your state or country may be prohibited by law.

F3. Patents in ASTM Standards

F3.1 When a committee has determined an item covered by a patent or a pending patent may be necessary in a proposed standard, the committee shall include a statement in the balloting process and a footnote in the draft standard, indicating a willingness to consider alternative(s). ASTM standards submitted to ANSI for approval as American National Standards shall conform to the ANSI patent policy. The ANSI patent policy may be obtained on the ANSI website (www.ansi.org).

F3.1.1 *Statement in Balloting Process*— The statement with the ballot shall include a request for an alternative(s) as follows:

The (name of material, product, process, apparatus) is covered by a patent. If you are aware of an alternative(s) to the patented item, please attach to your ballot return a description of the alternatives. All suggestions will be considered by the committee. If alternatives are identified, the committee shall reconsider whether the patented item is necessary. The committee, in making its decision, shall follow Regulation 15.

F3.1.2 *Statement in Footnote of Standard*— A footnote shall be included in the standard as follows:

The (name of material, product, process, apparatus and may include the patent number for reference) is covered by a patent. Interested parties are invited to submit information regarding the identification of an alternative(s) to this patented item to the ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.

The footnote shall be cited in the specific section of the standard where the patented item is first mentioned. Information describing the patented item will be set forth once in the standard, in this footnote.

F3.2 *Disclaimer of Liability as to Patented Inventions*— Neither ASTM International nor an ASTM committee shall be responsible for identifying all patents under which a license is required in using an ASTM document or for conducting inquiries into the legal validity of those patents which are brought to the Society's attention. Where applicable, an ASTM document shall include a note worded as follows:

"ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility."

F4. Use of Trademarks and Specific Sources of Supply for Apparatus, Reagents, and Materials in ASTM Standards

F4.1 ASTM International is authorized to certify products, equipment or services.

F4.1.1 ASTM International has a registered certification mark, along with other registered marks.

F4.1.2 ASTM International does not permit its trademarks to be used in a manner that suggests it has approved any product, equipment or services other than in relation to an ASTM Certification Program.

F4.1.3 ASTM International does not permit the use of third-party trade- or service marks in ASTM standards in a manner that could suggest ASTM International's endorsement, approval, sponsorship, or certification of the trademarked item or service.

F4.1.4 Requiring participation in or that a product meet an ASTM Certification Program to comply with an ASTM standard is prohibited.

F4.2 *Trademarks:*

F4.2.1 Trademarks shall not be used in ASTM standards, unless the trademark is used to refer to a specific source of supply and such use conforms to the requirements of F4.3.

F4.2.2 Trademarks in ASTM standards shall not be used in a manner that: is false or misleading; violates the rights of the Mark's owner; violates any law, regulation or other public policy; or mischaracterizes the relationship between the Society and the material, product, system or service represented by the Mark, including but not limited to any use of a Mark that might reasonably be construed as an endorsement, approval, sponsorship, or certification by the Society of the material, product, system or service, or that might be reasonably construed as support or encouragement to purchase or utilize the material, product, system or service represented by the Mark. Judgment is at the sole discretion of the Committee on Standards.

F4.2.3 If ASTM International staff decides permission should be obtained to use a trademark, such permission shall be obtained by ASTM International Headquarters from the holder of the Mark.

F4.2.4 The first reference to the trademark in the standard shall include a footnote containing the name of the trademark holder. Trademark symbols shall not be included. "Trademark" shall be used as an adjective.

F4.3 *Sources of Supply:*

F4.3.1 To allow the widest possible use of ASTM standards, it is the responsibility of the sponsoring committee to ensure that sources of supply exist for unique or difficult-to-obtain apparatus, reagents, and materials.

F4.3.2 Reference to specific commercial sources of supply are permitted only when there is a sole source of supply.

F4.3.2.1 Information on the sole source of supply shall be included in a footnote. Include wording such as:

The sole source of supply of the apparatus known to the committee at this time is (name and address of the supplier). If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.

F4.3.3 If the apparatus is not widely available, but more than one source of supply is known, or if apparatus that is widely available needs to be checked for suitability in the application specified, the committee can reference criteria for evaluating the apparatus. This reference can be to a section of the standard, to a separate existing standard or other published document, or can be in the form of an annex or appendix to the standard, or filed as an ASTM research report or adjunct.

F4.3.3.1 Text referencing the availability of such criteria, and any requirement on the use of such criteria, should be included in the appropriate section of the standard. Include wording such as:

All available apparatus may not be suitable for this application. Apparatus considered for use in this application shall be checked for suitability in accordance with the requirements of (insert reference to appropriate evaluation document).

F5. Reference to Standards of Other Organizations

F5.1 When referencing standards of other organizations, include the designation and title for the document in the *Referenced Documents* sections.

F5.1.1 In all cases, information on the title, designation, and source availability of the reference standards shall be included. Do not include the year date of reference documents unless there is a technical reason for requiring a particular revision.

F5.2 When it is necessary to quote portions of a non-ASTM standard, permission to republish shall be obtained from the organization holding copyright by ASTM International Headquarters.

F5.3 Joint logos shall not be printed on ASTM standards, except with the authorization of the Board of Directors. When a standard has been developed in cooperation with another organization(s), a note may appear in the standard, crediting the other organization's participation.

F5.3.1 In cases of disagreement on implementation of this policy, the matter shall be referred to the Committee on Standards for decision.

PART G

STANDARDS STYLE MANUAL

G1. Styling

G1.1 Check the draft standard against the rules given in this style manual. Many technical committees have editorial subcommittees that review draft standards before submittal to Headquarters. The ASTM editorial staff does the final styling and is available to assist members. There are a number of forms of assistance available to the ASTM standards-writer, such as the following: on-line templates to write standards and access to the latest *Form and Style for ASTM Standards*, the *ASTM Online Dictionary of Engineering Science and Technology* (see www.astm.org), *Committee White Papers* (supplements to this manual), and editorial workshops. Also, see the Introduction to this manual.

G1.2 Of the instructions that follow, some are included because they are deviations from the standard references, some because they are used frequently and are therefore listed here for convenience. Sections on various points of ASTM style appear in the following alphabetical order:

G2. Electronic Standard Preparation

G2.1 *Rationale for Ballot*— A rationale explaining the reason for the ballot is mandatory for all ballots.

G2.2 *New Standard*— For help in writing new standards, go to www.astm.org and use the online draft standard templates.

G2.3 *Extensive Revision*— When doing an extensive revision, process in manuscript form. Submit entire document for ballot and do not use track changes as shown in G2.4 if the revisions would make the ballot too cumbersome to follow. In this case, the ballot rationale shall be used to state the extent of the changes and that the document should be reviewed in its entirety.

G2.4 *Minimum to Moderate Revisions*

G2.4.1 Clearly indicate what has changed by using the "track changes" tool. Follow these instructions to properly use the track changes tool:

G2.4.1.1 Only submit for ballot those sections that are being revised.

G2.4.1.2 Open the document and excerpt into a separate file only those sections to be revised.

G2.4.1.3 Select "Tools" from the pull-down menu.

G2.4.1.4 Select "Track Changes." This will automatically default to underlining added text and striking through deleted text.

G2.4.1.5 Ensure that all changes (insertions, deletions, etc.) have been properly marked with the revision bar in the margins.

G3. Abbreviations and Unit Symbols

G3.1 In the text, use unit symbols after numbers denoting a definite quantity. Example: "The length is 25 mm [1.0 in]."

G3.2 Use unit symbols in tables and figures, and in lists defining symbols used in equations.

G3.3 Use unit symbols and abbreviations in the singular only. Thus "fifty kilograms" shall be designated "50 kg," not "50 kgs." Exceptions: Figs., Nos., Eqs., Refs, Vols.

G3.4 When a long word or phrase for which there is no standard abbreviations is used frequently, it may be replaced by an abbreviation that is explained when it first occurs. Examples: below top dead center (btdc), relative centrifugal force (rcf).

G3.5 Commonly accepted abbreviations for names of societies, associations, government agencies, etc., may be used, provided the name is spelled out the first time it is used. Use no periods and run together. Examples: ASTM International, TAPPI, NASA, ARPA.

G3.6 The standard unit symbols and abbreviations for use in Society publications in the list below are so common that they may be used without explanation. For proper form and style for SI units follow IEEE/ASTM SI-10 American National Standard for Metric Practice, the SI Quick Reference Guide (Annex A) and Part G and Part H. If a discrepancy exists between these documents, follow Part G and Part H of the Form and Style Manual.

absolute	abs
academic degrees	use periods and run together (M.S., Ph.D., etc.)
alternating current	ac
American	Am. [A]
American wire gauge	AWG
ampere	A
ampere hour	Ah
angstrom	A
ante meridian	a.m.
Association	Assn. [B]
atmosphere	atm
average	avg
barrel	bbl
becquerel	Bq
billion electronvolts	(use GeV, gigaelectronvolts)
Birmingham wire gauge	BWG
brake horsepower	bhp
brake-horsepower hour	bhp•h
Brinell hardness number	HB (see ASTM E10)
British thermal unit	Btu
Brown and Sharpe (gauge)	B&S
bushel	Bu
calorie	cal
candela	cd
centimetre	cm
centipoise	cP
centistokes	cSt
circular mil	cmil
coefficient	*spell out*
Company	Co. [B]
Corporation	Corp. [B]
coulomb	C
cubic	use exponential form [C]
cubic centimetre	cm^3
cubic decimetre	dm^3
curie	Ci
cycles per minute	cpm
cycles per second	(use Hz, hertz)
day	*spell out*
decibel	dB
degree (angle)	°
degree Celsius	°C
degree Fahrenheit	°F
degree Rankine	°R
degrees of freedom	df
Department	Dept. [B]
diameter	dia (in figures and tables)
differential	d
direct current	dc
Division	Div. [B]
dollar	$
effective horsepower	ehp
electromotive force	emf
electronvolt	eV
Engineers	Engrs. [A]
equation(s)	Eq(s)
farad	F
figure(s)	Fig(s). [D]
foot	ft
footcandle	fc
foot pound-force	ft•lbf (use for work, energy) (see lbf•ft)
gallon	gal
gauss	G
gilbert	Gb
grain	*spell out*
gram	g
gravity (acceleration)	g
gray	Gy
half hard	SH
henry	H
hertz	Hz
horsepower	hp
horsepower hour	hp•h
hour	h
Hurter and Driffield scale (film density)	H&D
hydrogen ion concentration, negative logarithm of	pH
inch	in.
inch of mercury	in.Hg
inch of water	in.H_2O
inch pound-force	in.•lbf (use for work, energy) (see lbf•in.)
inclusive	incl (in figures and tables only)
Incorporated	Inc. [B]
indicated horsepower	ihp
inside diameter	ID (in figures and tables only)
Institute	Inst. [B]
integrated neutron flux	nvt, n/cm^2
Iron pipe size	IPS
joule	J
K alpha radiation	Ka
kelvin	K
kilocalorie	kcal
kilocycle per second	(see note on cycles per second)
kilogram	kg
kilogram-calorie	kg•cal
kilogram-force	kgf
kilogram metre	kg•m
kilometre	km

kilovolt	kV
kilovolt ampere	kVA
kiloelectronvolt	keV
kilovoltpeak	kVp
kilowatt	kW
kilowatthour	kWh
kip (1000 lbf)	*spell out*
kip (1000 lbf) per square inch	ksi
Knoop hardness number	HK (see ASTM E384)
lambert	L
linear	*spell out*
litre	L
logarithm (common)	log
logarithm (natural)	ln
lumen	lm
lux	lx
magnetomotive force	mmf
mass-to-charge ratio	*m/e*
maximum	max (in figures and tables only)
maxwell	Mx
median effective concentration	EC_{50}
median effective dose	ED_{50}
median lethal concentration	LC_{50}
median lethal dose	LD_{50}
megacycles per second	(see note on cycles per second)
megagram	Mg
megawatt	MW
meta	*m*
metre	m
microampere	µA
microcurie	µCi
microfarad	µF
microgram	µg
microhenry	µH
microinch	µin.
microlitre	µL
micro-micro (prefix, use pico)	p
micrometre (formerly micron)	µm
microroentgen	µR
microsecond	µs
microvolt	µV
microwatt	µW
mil	*spell out*
mile	*spell out*
miles per hour	mph
milliampere	mA
milli-angstrom	mA
millicurie	mCi
milliequivalent	meq
milligram	mg
millihenry	mH
millilitre	mL
millimetre	mm
millimetre of mercury	mmHg
million electronvolts	MeV
milliroentgen	mR
millisecond	ms
millivolt	mV
milliwatt	mW
minimum	min (in figures and tables only)
minute	min (spell out when used with minimum)
molal	*spellout*
molar	*M*
mole	mol
month (When followed by a date use Jan., Feb., March, April, May, June, July, Aug., Sept., Oct., Nov., Dec. When there is no date, spell out. Examples: Jan. 15, 1995; January 1995)	*spell out*
nanometre (formerly millimicron)	nm
National	Nat. [A]
newton	N
normal	*N*
number(s) (This abbreviation can often be omitted entirely. It is usually understood (as in *STP 325*, Specimen 8, Test 14, etc.))	No(s). [D]
oersted	Oe
ohm	O
ortho	*o*
ounce	oz
outside diameter	OD (in figures and tables only)
page	p.
pages	pp.
para	*p*
parts per billion	ppb
parts per million	ppm
pascal	Pa
per	use the diagonal line in expressions with unit symbols[E]
percent	%
pico (prefix)	p
picofarad	pF
pint	Pt
poise	P
Poisson's ratio	µ (v is preferred in applied mechanics)
post meridian	p.m.
pound	lb
pound-force	lbf
pound-force foot	lbf•ft (use for torque) (see ft•lbf)
pound-force inch	lbf•in. (use for torque) (see in•lbf)
pound-force per square foot	lbf/ft^2
pound-force per square inch	psi or $lbf/in.^2$
pound-force per square inch absolute	psia
pound-force per square inch gauge	psig
quart	qt
rad (dose unit)	rd
radian	rad
radio frequency,*n*	rf
radio frequency,*adj*	r-f
radius	R (in figures and tables only)
Railway	Ry. [B]
Railroad	R.R. [B]
reference(s)	Ref(s)
relative humidity	RH (in figures and tables only)
revolution per minute	r/min
revolution per second	r/s
Rockwell hardness, C scale	HRC (see ASTM E18)
roentgen	R
root mean square	rms
Saybolt Furol seconds	SFS
Saybold Universal seconds	SUS
second	s

secondary	*sec*
siemens	S
Society	Soc. [B]
socket joint (tables and drawings only)	Sj
specific gravity	sp gr
square	use exponential form (exception: psi, ksi) [C]
standard taper (tables and drawings only)	TS
steradian	sr
stokes	St
tensile strength	*spell out*
tertiary	*tert*
tesla	T
thousand electronvolts	KeV
thousand pounds	kip
thousand pounds-force per square inch	ksi
ton	*spell out*
torr	*spell out*
United States, *n*	*spell out*
United States, *adj*	U.S.
United States Pharmacopeia	USP
versus	*spell out*
Vickers hardness number	HV (see ASTM E384)
volt	V
volume (of a publication)	Vol [D]
watt	W
watt hour	W•h
weber	Wb
week	*spell out*
yard	yd
year	*spell out*
Young's modulus	E

[A] In footnotes and references only.
[B] At end of name only.
[C] With unit symbols only.
[D] Only when followed by a number.
[E] Exceptions: cpm, mph, psi.

G4. Alloy Designations

G4.1 Use the following for alloy designations:

3135 steel
2024-T4 aluminum
Ti-4Al–3V-Mo
Ti-6Al–4V
0.5Ti molybdenum alloy or molybdenum with 0.5 % titanium or
0.5Ti alloy (where molybdenum is understood)

G4.2 ASTM and SAE have jointly developed a unified numbering system (UNS) for alloy identification (Practice E527).

G5. And/Or

G5.1 Do not use this expression. For example, when "A and/or B" is truly the case, write "A or B, or both." For example, when "A, B, and/or C" is truly the case, write "A, B, or C, or combinations thereof."

G6. Capitalization

G6.1 Use capitals sparingly.

G6.2 In headings and titles, capitalize all nouns, pronouns, verbs, adjectives, adverbs, and all other words of five or more letters. Do not use initial caps on abbreviations (except see G6.6), or the phrase "et al." or in the word "to" in the infinitive form of a verb.

G6.3 Use initial cap for "committee" where used in a title, as "Committee A01," "Committee on Publications." Everywhere else use lowercase, as "The committee recommends ..." This rule also applies to use of "symposium," etc.

G6.4 Use initial cap on Society, Staff, and Headquarters when referring to ASTM International, its Staff, and its Headquarters.

G6.5 Capitalize trademarks. The initial cap becomes lowercase after the word is accepted into the language as generic. When in doubt, capitalize. The following are now lowercase: babbitt, bunsen, cellophane, diesel, kraft, neoprene, nylon, portland cement, saran.

G6.6 Use initial cap in referring to volumes, figures, tables, etc., as Vol 2, Fig. 2, Table 2. Use lowercase in less direct references such as: "This volume contains ...," "In the same figure is shown ..."

G6.7 Use initial caps in such expressions as: Test 1, Specimen A, Cement B, Type 1, Class C, Grade B, etc.

G6.8 It is permissible to use all caps in directions such as: "Turn the machine to OFF position" or "Turn the dial to TITRATE."

G7. Chemical Formulas

G7.1 Chemical formulas should be used freely in tables and figures. In text in which chemical formulas are mentioned infrequently, spell out the names. Where they are mentioned frequently, spell out the name in the first reference to it, followed by the formula in parentheses. The formula alone may be used subsequently. Do not use chemical formulas for organic or complex inorganic compounds. Always spell out the word

"water" and the name of the elements (use lead, not Pb). Isotopes may be written as carbon-14 or as ^{14}C.

G8. Contractual Parties

G8.1 Terms describing contractual parties shall be limited to the following:

G8.1.1 *Party of First Part*, producer, supplier, seller, or manufacturer.

G8.1.2 *Party of Second Part*, purchaser or user.

G9. Crystal Planes and Directions

G9.1 Use the following symbols for crystallographic planes and directions:
plane (111)
family of planes {111}
direction [111]
family of directions <111>

G10. Dictionaries and Other Reference Publications on Style

G10.1 For spelling, punctuation, capitalization, and foreign words, use a reference source material, such as *Merriam-Webster's Collegiate Dictionary* or *Webster's Third New International Dictionary* (print or electronic versions). For other information on style use *Manual of Style*, The University of Chicago Press (print or electronic version).

G11. Dilution Ratio

G11.1 Use the form "9+1" rather than "9:1" for dilution ratios. This means that the 1 part solute is to be mixed with the 9 parts solvent. Specify whether volumes or weights are being used, for example, volume/volume, weight/volume, etc.

G12. Creating and Submitting Figures for Ballot

G12.1 *Definition*— A figure can be a technical drawing (vector line art), information visual (chart/graph/schematic), or a photograph, or a combination of these.

G12.2 Please include figure(s) with your ballot submission to ensure timely publication of your standards.

G12.2.1 Size each figure up to 30 picas in width (approximately 125 mm or 5 in.) This is the maximum.

G12.3 *How do I create and save non-photographic images (for example, graphs, drawings, schematics) or digital photographs from a hard copy original or from computer-generated artwork?*

G12.3.1 Keep in mind that the larger the original, the greater potential for a better reproduction.

G12.3.2 Size each figure to 30 picas in width (approximately 5 in.). For full-page/landscape figures, size to 42 picas in width (approximately 7 in.). These are the maximum allowable widths.

G12.3.3 When taking digital photographs, use the highest resolution possible on the camera. Absolute minimum resolution is 1200 × 960 pixels. 1936 × 1296 pixels is better, and 2896 × 1944 pixels is even better.

G12.3.4 Check the image quality and the brightness and contrast levels.

G12.3.5 Submit artwork in its original file source/extension. ASTM graphic designers can work with most file formats, including CAD. (SVG, EPS, or AI files are preferred for technical drawings. TIFF or JPG preferred for photographs or halftones. GIF is discouraged as a generally low-resolution file type.)

G12.3.6 If you need to scan hard copy, adjust the resolution on your scanner as follows:

G12.3.6.1 Technical drawing or other information visual FTP—Please scan the line art at 1200 dpi (dots per inch).

G12.3.6.2 Photograph FTP—Please scan at 600 DPI. If the image is to be enlarged, increase the percentage of the scanned image.

G12.3.6.3 ASTM can also scan for you (see G12.5).

G12.3.7 Furnish short titles or captions for each figure.

G12.4 *How do I submit the file?*

G12.4.1 **E-mail** your staff manager or editor.

G12.4.2 **FTP**—Please contact the ASTM Help Desk for assistance at 1-800-262-1373.

G12.4.3 **DVD/CD-ROM**

G12.4.4 *Hard copy can be mailed to ASTM Headquarters, in case ASTM cannot use the electronic file. See the following instructions.*

G12.5 *How do I submit hard copy?*

G12.5.1 Provide camera-ready figures of professional quality, because the printer will scan what is submitted, and it will appear in the standard exactly as you have supplied it. To this end:

G12.5.1.1 Use a laser or other high-quality printer.

G12.5.1.2 Do not handwrite on the figure.

G12.5.1.3 Do not use a faxed or photocopied figure.

G12.5.1.4 Furnish short titles or captions for each figure.

G13. Footnotes

G13.1 For footnotes in tables, use superior italic capital letters, beginning anew for each table. Type the footnotes below the table.

G13.2 For all other footnotes, use superior numbers.

G13.3 Do not use footnotes in figure captions. Either cite a previous footnote or reference (for example, "see Footnote 3," or "taken from Ref (**4**)"), or write out the reference in the caption. For style of publication footnotes, see Sections G21 and G22.

G14. Hyphens

G14.1 In ASTM standards, hyphenate compound adjectives, such as: "low-alloy steel," "cold-drawn wire." Compound adjectives involving SI units should use a space, such as: "50 mm gauge." Write expressions such as the following *with* the hyphen after the first word: "high- and low-temperature tests." For the sake of appearance, omit hyphens in such expressions as "3 % nickel alloy" or "3EC rise in temperature." Also do not hyphenate chemical compounds and the words "stainless steel" and "cast iron."

G14.2 Do not hyphenate an adverb-adjective combination when the adverb ends with "ly."

G14.3 Spelled-out fractions used as nouns are not hyphenated (one third of the load); used as adjectives, they *are* hyphenated (a one-third share).

G15. Italics

G15.1 *Italicize:*

G15.1.1 All symbols for physical quantities that can have a numerical value (quantity symbols).

G15.1.2 Letters in parentheses used to identify listings in text or subdivisions of illustrations, "Fig. 1(*a*)."

G15.1.3 *Chemistry*— *N* (normal), *M* (molar), c (concentration). Do not italicize symbols for the elements (Fe, N, Na, etc.) Exception: italicize *N* for nitrogen when it is used to denote position, as in *N*-methylaniline. Italicize *o, m,* and *p* as ortho, meta, and para; for example, *p*-cresol. Italicize and abbreviate secondary and tertiary as *sec* and *tert*; for example, *tert*-butyl alcohol. Italicize *iso* when used in *iso*octane.

G15.1.4 *Titles*— of books, including ASTM books, such as *Annual Book of ASTM Standards* and *ASTM STP 379*.

G15.1.5 *Foreign Words*— Use a reference source material, such as *Merriam-Webster's Collegiate Dictionary* or *Webster's Third New International Dictionary* (print or electronic version) as a guide to foreign words.

G15.1.6 *Transistor Type*— Use *n-p-n*, *p-n-p*, *n*-type, etc.

G15.2 *Do not italicize:*

G15.2.1 Letters used to subdivide a categorical classification, such as Method A, Cement B, Class C, Grade D, Type E, Sample F.

G15.2.2 *Metallurgy*— A_1 point, A_{r1}, etc.

G15.2.3 *Abbreviations*— pH, sin, cos, tan, log, d (for derivative).

G16. Mathematical Material

G16.1 Mathematical material can appear in the standard text or as equations. In all cases, submit clear copy, without ambiguities arising from carelessly placed subscripts or superscripts, confusion between Greek and Roman letters, incomplete fraction lines, and so on. When there

is a possibility of confusion (for example capital letter O and zero), include an editorial note nearby to clarify with more description. For example:

$$1 = 1 \times 10\text{^}3\ \mu m$$

Editorial Note: Lowercase “L” equals number one times 10 superscript 3 Greek mu

G16.2 *Greek Symbols*— If unclear, type out the name of the Greek symbol in an editorial note.

G16.3 Superscripts (superior symbols) should be marked with a caret or type “superscript” in an editorial note. Subscripts (inferior symbols) should be marked with an inverted caret or type “subscript” in an editorial note.

G16.4 Indicate what symbol is preferred to show multiplication (for example, times symbol, middle dot, or asterisk).

G16.5 *Equations*— Type on a separate line in a larger font. Equations are numbered throughout the text. The format for a numbered equation is:

$$S = \frac{Mc}{I}$$

where:
S= stress, psi or Pa,
M= bending moment, lbf•in. or N•m,
c= distance from neutral axis to outermost fiber, in., or m, and
I= second moment of area, $in.^4$ or m^4.

G16.6 *Exp versus e*— If the exponent is relatively short and on one line, without superscripts or subscripts, use e:

$$e^{(a-b)cx}$$

If it is relatively long or has superscripts or subscripts, use exp:

$$\exp[x^2 /2- 1n(x/a)]$$

G16.7 *Fractions*— Use the solidus (diagonal line) in the text:

1/4

Use the built-up fraction (with a horizontal line) in an equation. If you use a built-up fraction on one side of an equation, use it on the other side:

$$\frac{a}{b} = \frac{c-d}{e-f_2} \times 12$$

Use parentheses liberally to clearly show the complete numerator or denominator. For example, does log *a/b* mean log (*a/b*) or (log *a*)/b? Use the parentheses to clarify. If you write *a/b* + c but mean *a*/(b + c), use parentheses.

G16.8 *Statistical Data*— For data that are treated statistically, follow the recommendations in the *ASTM Manual on Presentation of Data and Control Chart Analysis (MNL7).* Committee E11 on Quality and Statistics, which is responsible for MNL7, is prepared to cooperate with other technical committees in helping them present data most effectively. In particular:

G16.8.1 To present the essential information contained in a set of observations from one population, give the average, the standard deviation or coefficient of variation, and the number of observations.

G16.8.2 Whenever you give an average, give also the number of observations on which the average is based.

G16.8.3 Use the following symbols, where needed:

x = average (arithmetic mean)
s = root-mean square deviation
n= number of observations
s= standard deviation
v= coefficient of variation

G17. Numbering

G17.1 See Part D.

G18. Numerals

G18.1 Use arabic numerals in designating figures and tables, thus: “Fig. 3,” “Table 6.”

G18.2 Spell out all numbers from one through twelve, with the following exceptions:

G18.2.1 Use numerals when the quantity is partly fractional, as: 1.15, 1½.

G18.2.2 Use numerals when followed by an expression having a standard unit symbol, as: 25 mm, 45 kg, 9 %.

G18.2.3 If for any reason the standard abbreviation or unit symbol of the expression following the number is not used, or if the expression does not admit of abbreviation (as *year*, *ton*, etc.), the use of numerals is optional, unless covered in the following paragraphs:

G18.2.4 In statements containing two or more numbers, one of which is greater than twelve, express all numbers as numerals, such as "2 tests and 16 weighings."

G18.2.5 In a series of connected numerical statements implying precision, use numerals, as "5 months, 3 days."

G18.2.6 Use numerals after abbreviations, as: Vol 26, Fig. 2.

G18.3 Use numerals for all numbers exceeding twelve, with the following exceptions:

G18.3.1 Do not begin a sentence with a numeral. When the numeral is spelled out, also spell out the unit following, as "One gram is usually sufficient."

G18.3.2 Spell out round numbers used in an indefinite sense, such as, "a *hundred* metres or so."

G18.3.3 Spell out numbers when used in the following manner: "*fifteen* 25 mm rods" (or 15 twenty-five millimetre rods).

G18.3.4 In decimal numbers having no units, place a zero before the decimal point, as: "0.65 mm," not ".65 mm."

G18.4 In pointing off numbers of more than four figures, use spaces instead of commas in the text, illustrations, and tabular matter (1 234 567). Do not point off numbers of four figures (1234) except in tables when they occur in a column containing numbers of more than four figures.

G18.5 In expressing ratios (except dilution ratios) use 1 to 10 or 1:10, not 1-10.

G18.6 In expressing grades of, for example, emery paper, use 3/0, not 000.

G19. Percent versus Percentage Points

G19.1 When a quantity is reduced from 40 to 30, it is reduced by 25 %. When a quantity decreases from 40 % to 30 %, it decreases by 10 *percentage points*. Use the forms "mass percent," "volume percent," "atom percent," etc.

G20. Polymers

G20.1 Where the name of the monomer is one word, the prefix "poly" is simply run in, as: polystyrene, polyisobutylene, etc. Where the name of the monomer is two words, they are enclosed in parentheses and the prefix "poly" added, as in the following words: poly(vinyl chloride), poly(methyl methacrylate).

G21. References, Other Documents

G21.1 If there are fewer than five references cited in the standard, use footnotes. If five or more references are cited, type them in a separate list of references at the end of the manuscript, following annexes and appendixes, if any. Assign a consecutive arabic number to each reference. Indicate the reference in the text by enclosing the number in parentheses and using boldface. Show a footnote reference after the first boldface reference number, stating in the footnote: "The boldface numbers in parentheses refer to the list of references at the end of this standard." If it is necessary to use the word "reference," use the style: "According to Ref (**3**) ..." It is preferable, however, to use the author's name, as "According to Jones (**3**) ..." If there are two authors, use both names, as: "According to Jones and Smith (**3**)..." If there are three or more authors, use "et al," as: According to Jones et al (**3**) ..."

G21.2 Do not list ASTM standards as references; list them in the section on Referenced Documents (see also Section A6). Do not list as references documents that are not readily accessible to the reader, such as unpublished theses and private correspondence.

G21.3 Type references (and publication footnotes) as follows:

G21.3.1 *Books*— Type author's name or names (initials last), complete title of book (italic, no quotation marks), name of publisher (no abbreviations), address of publisher (city and state), year of publication, and page number, if reference is to a page number. Example:

Jones, J. J., *Plasticity and Creep*, John Wiley & Sons, Inc., New York, NY, 1958, p. 250.

G21.3.2 *Magazines, Journals* (including *Standardization News*)— Type author's name or names (initials last), title of paper (in quotation marks), complete title of journal (italic, no quotation marks), volume number, issue number (this may be omitted if the journal page numbers are continuous throughout the volume), date of publication, and page numbers. Example:

Jones, J. J., and Smith, R. R., "Correlation of Brinell Hardness and Tensile Strength," *Materials in Design Engineering*, Vol 10, No. 2, February 1958, pp. 52-67.

G21.3.3 *Proceedings, Transactions, Reports, Bulletins, etc.*— Type author's name or names (initials last), complete title of paper (in quotation marks), name of publication (italic, no quotation marks), name of publisher, volume number, if any, date of publication, and page numbers. Examples:

Jones, J. J., "Lubrication Problems in Space Vehicles," *Transactions*, American Society of Mechanical Engineers., Vol 52, 1948, pp. 135-140.

Jones, J. J., "Classification of Bitumens," *Journal of the Institute of Petroleum*, Vol 38, 1952, p. 121.

Jones, J. J., "Fatigue of Aircraft Structures," *NASA TR-108*, National Aeronautics and Space Administration, 1959.

Jones, J. J., "Effect of Carbon Content on Notch Properties of Aircraft Steels," *Bulletin 642*, Engineering Experiment Station, University of Illinois, 1957.

G21.3.4 *Symposium Volumes or Other Books Comprising Collections of Papers*— Follow style for books in G21.3.1 and add title of paper, in quotes, after author's name.

G21.3.5 *Patents*— Type patent number and date. Example: U.S. Patent No. 2 232 185, Feb. 18, 1941.

G21.3.6 *Annual Book of ASTM Standards*— Cite referenced ASTM standards in section on Referenced Documents, not in references (see Section G22).

G21.3.7 *ASTM Proceedings*— McVetty, P.G., "The Interpretation of Creep Tests," *Proceedings*, ASTM International, Vol 34, Part II, 1934, p. 105. (Volume 38 was the last to be issued in two parts.)

G21.3.8 *ASTM Special Technical Publication:*

G21.3.8.1 *Whole Book:*

Symposium on Synthetic Bioabsorbable Polymers for Implants. ASTM STP 1396, ASTM International, 2000.

G21.3.8.2 *Single Paper:*

Gorna, K., and Gogolewski, S., "Novel Biodegradable Polyurethanes for Medical Applications,"*Symposium on Synthetic Bioabsorbable Polymers for Implants, ASTM STP 1396*,ASTM International, 2000, p. 39.

G21.3.8.3 *Journal Reference to Website:*

Name of Author(s), "Name of Paper," *Title of Journal*, Volume, Number, Issue Number, Paper Identification Number, Online, Available: URL, Access Date.

Example:

Aydilek, A. H. and Edil, T. B., "Evaluation of Woven Geotextile Pore Structure Parameters Using Image Analysis," *Geotechnical Testing Journal*, Vol. 27, No.1, ID GTJ111070, Online, Available: www.astm.org, 12 January 2004.

G22. References, Standards

G22.1 Refer to ASTM standards first in the section on Referenced Documents. Follow the designation (without year) with the full title, and use a footnote to refer to the appropriate publication. The footnote should read: For referenced ASTM standards, visit the ASTM website, www.astm.org or contact ASTM Customer Service at Service@astm.org. For the *Annual Book of ASTM standards* volume information, refer the standard's Document Summary page on the ASTM website. Thereafter use simply the abbreviated designation (Test Method D1708, Practice E691, Specification A250/A250M, etc.) Do not include the word "Standard." Do not use quotes on titles of standards, whether those of ASTM International or other organizations.

G22.2 Any reference to a combined standard shall include the entire designation, for example, Specification A36/A36M. When only one system of units is applicable, this may be indicated where the reference is cited; for example:

This material shall conform to the general requirements stated in SI units of Specification A36/A36M.

G22.3 Do not refer to a specific paragraph, section, table, or figure of another standard unless necessary to avoid confusion. For example, say, "the section on Impregnation Time of Methods D202."

G23. Sample versus Specimen

G23.1 In general, the word "sample" should be used only to describe a piece or quantity of bulk material that has been selected by some sampling process. Pieces or quantities taken from the sample for testing are called "specimens." Quantities of liquid or bulk aggregate are usually called "samples," because a sampling procedure is usually used to obtain them.

G23.2 To describe the piece on which a test is made, use "specimen" or "test specimen," not "piece" or "sample."

G24. SI Units

G24.1 SI units shall be included in all ASTM standards in accordance with IEEE/ASTM SI-10, the SI Quick Reference Guide (Annex A) and Part G and Part H. If a discrepancy exists between these documents, follow Part G and Part H of the Form and Style Manual.

G24.2 Combined Standards—Both units of measure are included, and either system is to be regarded separately as the standard. The combined designation format: A36/A36M. (See also A3.4.)

G25. Spelling

G25.1 Included in the following list are those spellings of words commonly found in ASTM standards. For words that do not appear in this list, use a reference source material. *See Section G10 on Dictionaries and Other Reference Publications on Style*. Use international spelling for SI units; that is, litre and metre.

A

airborne
alignment
appendixes (pl)

B

babbitt metal (lc)
Brinell (cap)

C

catalog (not catalogue)
CODEN

D

Disk
disc (CD)
Diskette (Floppy)
drier (comp. of dry)
dryer (apparatus)

E

ensure (meaning be sure)
et al.
eutectic (noun)
eutectoid (adj.)

F

fireclay (adj.)

G

gastight
gauge (measurement, instrument)
Geiger-Muehller tube
gray (not grey)

H

heat treat (verb)
heat-treated (adj.)
Hooke's law (lc "l")

I

indexes (pl)
in situ (roman)
insofar
*iso*octane (all other "iso's" roman)

K

kerosine/kerosene

L

litre (not liter)

M

magnetic particle inspection (not Magnaflux)
metre (not meter)
microscopic (meaning very small)
microscopical (meaning pertaining to use of a microscope)

N

neoprene (lc)
nital (lc)
nitrile rubber (butadiene) (lc)
Normal Law integral (cap N and L)

P

pipet (not pipette)
plaster of paris (not plaster of Paris)

R

Rockwell (cap)

S

sigma phase (spell out sigma)
siliceous
SR-4 strain gage
Stokes' law (lc "l")

U

Usage

V

V-Notch (noun and adj.)

X

X ray (noun)
X-ray (adj and verb)

G26. Symbols

G26.1 In general, avoid the use of symbols in text except in accordance with Sections G3 and G7. When stating dimensions, use "by" not ×, for example, "10 by 5 in. (254 by 127 mm)." Show tolerances, for example, as 10 by 5 ± 2 in. (254 by 127 ± 6 mm)." Do not use a hyphen or a dash for the word "to" except in tables where needed to conserve space. Do not use (') or (") for feet and inches in text, tables, or figures.

G26.2 In combination with words not having symbols, spell out entirely, for example, "bubbles per minute."

G27. Tables

G27.1 Number each table with an arabic numeral and give it a title that is complete and descriptive.

G27.2 In column headings, first include the quantity being tabulated, then a comma, then the units, for example:

"Tensile Strength, min, psi."

G27.3 *Powers of 10*— Do not use powers of 10 in the column heading, since it is not clear whether the numbers in the table have been or are to be multiplied by the power of ten. Instead, indicate the multiplication (for example, 1.45×10^6) in the first entry in the table; or use an expression such as "Young's Modulus, millions of psi" in the column heading.

G27.4 *Footnotes*— See G13.1.

G27.5 Use horizontal rules under column headings. Use vertical rules only when the complexity of the table demands them for clarity. Use leaders (three periods) in any space that represents a blank entry.

G27.6 *Notes*— Additional information can be included in a note that appears below the title.

G27.7 When two (or more) separate systems of units are both listed in one table (for example, SI and inch-pound units), separate the units by using separate columns, or parentheses, or brackets.

G27.7.1 When the size of a table and limitations of space (on the printed page) make it impractical to expand the table to include SI unit equivalents, duplicate the table.

G27.7.2 When following the instructions given in G27.7 or G27.7.1 is impractical, because of the size and the number of tables, include the pertinent conversion factors as footnotes under each table instead of attempting to include the actual converted numbers themselves.

G28. Tension/Compression/Flexure Tests

G28.1 The words "tension," "compression," and "flexure" are used adjectivally to modify "specimen," "test," or "testing." Examples: tension test, compression testing, flexure specimen. To modify other nouns, the adjectives "tensile,"

"compressive," and "flexural" are used. Examples: tensile strength, compressive force, flexural data.

G28.2 In some areas (notably the textile industry) there is a difference between a "tension test" and a "tensile test," and in these cases the appropriate terminology shall be used.

G29. Thermal Conductivity

G29.1 The form to be used for the unit for thermal conductivity *k* is: Btu•in./h•ft^2• F[SI units: W/(m•K)].

G30. Thermometers

G30.1 Whenever possible, refer to thermometers described in ASTM Specification E1 or E2251, for ASTM Thermometers. Reference to an ASTM thermometer of the desired range should be as follows:

Thermometer—ASTM (name) Thermometer having a range from ___ to ___ (°C or °F, whichever applies) and conforming to the requirements for Thermometer (give thermometer number; for example, 16F) as prescribed in Specification (E1 or E2251, whichever applies).

G30.2 Do not specify both temperature scales unless there is a definite need for them.

G31. Trademarks

G31.1 Avoid the use of trademarks whenever possible. For example, use aluminum oxide instead of Aloxite, petroleum jelly instead of Vaseline. When trademarks are used, they should, of course, be initial cap and the owner of the trademark indicated by footnote.

Aloxite (trademark, use aluminum oxide)
Alundum (trademark)
Bakelite (trademark)
Carborundum (trademark)
Celite (trademark)
Chromel-Alumel (trademark)
Haydite (trademark)
Inconel (trademark)
Invar (trademark)
Kel-F (trademark, use polychlorotrifluoroethylene)
Lucite (trademark, use poly(methyl methacrylate) (PMMA))
Magne-Gage (trademark)
Masonite (trademark)
Monel metal (trademark)
Muntz metal (trademark)
Mylar (trademark, use polyester film)
Nichrome (trademark)
Nujol (trademark, use light mineral oil)
Plexiglas (trademark, use poly(methyl methacrylate) (PMMA))
Pyrex (trademark, use borosilicate)
Scotch tape (trademark, use pressure-sensitive tape)
Teflon (trademark, use TFE-fluorocarbon or polytetrafluoroethylene (PTFE))
Thiokol (trademark, use as an adjective, as "Thiokol polysulfide rubber")
Transite (trademark)
Tygon (trademark, use vinyl)
Vaseline (trademark, use petroleum jelly)
Vycor (trademark, use high-silica)

PART H

USE OF SI UNITS IN ASTM STANDARDS

H1. Scope

H1.1 This part is intended to guide technical committees in the use of the standard formats for denoting the use of the International System of Units (SI), non-SI units (usually inch-pound), or both in ASTM standards.

H1.2 SI units of measurement shall be included in all ASTM standards.

H1.2.1 Each technical committee shall have the option of using rationalized SI units, or rationalized inch-pound units, or both, as the standard units of measure.

DISCUSSION—Given ASTM's mission to be the foremost developer and provider of voluntary consensus standards with global recognition and use, ASTM technical committees are urged to give diligent consideration to the use of rationalized SI (metric) units in their standards

H1.2.2 Follow the procedures given in IEEE/ASTM SI-10, the SI Quick Reference Guide and Part G and Part H. If a discrepancy exists between these documents, follow Part G and Part H. IEEE/ASTM SI-10 appears in the *Annual Book of ASTM Standards*, and is also available as a separate publication.

H1.2.2.1 For committees that have special considerations with the use of SI units in ASTM Standards, it is permissible to develop committee specific technical guidance for clarification. Examples of such documents are as follows:

ASTM Committee B05 on Copper and Copper Alloys Outline of Form of Specifications
(www.astm.org/COMMIT/B05_outline.pdf)
A994 Guide for Editorial Procedures and Form of Product Specifications for Steel, Stainless Steel, and Related Alloys

H2. Terminology

H2.1 *SI unit, n, in ASTM standards*— unit of the International System of Units (SI) and other units specifically approved in IEEE/ASTM SI-10 as a unit for use with SI.

H2.2 *inch-pound unit, n, in ASTM standards*— unit based on the inch and the pound, commonly used in the United States of America and defined by the National Institute of Standards and Technology, including certain other units accepted for use with these units.

DISCUSSION—Inch-pound, also known as U.S. Customary Units, are one type of non-SI units. Another example of non-SI units is the centimetre gram second (cgs) system.

H2.3 *rationalization, n, in ASTM standards*— (formerly *hard conversion*) the planned simplification of a converted value achieved by modifying the value to reflect dimensions or physical characteristics of existing real measurements or configurations; as a result of this change the object or quantity may not be interchangeable with the original.

H2.4 *SI standard, n, in ASTM standards*— a standard that contains rationalized SI units of measurement.

DISCUSSION—There are two formats of SI standards: solely SI, combined standard.

H2.4.1 *Solely SI standard, n*— an ASTM standard in which only rationalized SI units are cited; inch-pound units are not provided in the standard.

H2.4.2 *combined standard, n*— an ASTM standard in which rationalized SI units and inch-pound units are included in the same standard, with each system of units to be regarded separately as standard. (For example, Specification A36/A36M).

H3. Format Requirements for Standards in SI Units

H3.1 For a standard citing SI units of measurement as the standard units of measurement, select the type of SI standard to be written and follow the appropriate format requirement listed below:

H3.1.1 *Solely SI Standards:*

H3.1.1.1 *Scope*— Include the following in the scope as a numbered paragraph:

1.X Units—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

H3.1.1.2 *Units*— Within the text, show only rationalized SI units.

H3.1.2 *Combined Standards:*

H3.1.2.1 *Scope*— Include the following in the scope as a numbered paragraph:

1.X Units—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

H3.1.2.2 *Units*— Within the text, it is recommended that SI units appear first followed by the inch-pound units in brackets. However, a technical committee can opt to reverse the order in which the units appear (i.e., inch-pound units shown first, followed by SI units in brackets) if the following additional conditions are met: all units appear in a consistent order throughout the text of the standard; all combined standards under the technical committee's jurisdiction apply the same convention.

H3.1.2.3 *Specifying Selected Units in Combined Standard*— When citing a combined standard and applying only one system of units, indicate the system of units to be applied (see B9.4).

H4. Format Requirements for Standards in Inch-Pound Units

H4.1 For a standard citing inch-pound units of measurement as the standard units of measurement, follow the format requirement below:

H4.1.1 *Scope*— Include the following in the scope as a numbered paragraph:

1.X Units—The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

H4.2 *Units*— Within the text, inch-pound units shall appear first followed by non-rationalized SI units in parentheses.

H5. Special Format Considerations

H5.1 *Repetitive Equivalents*— For standards in which inch-pound units are regarded as standard, insert a specific repetitive SI equivalent only the first time in occurs in each paragraph of a standard.

H5.2 *Expressing General Units*— When a standard specifies units for reporting results, the preferred unit in each system should be stated, especially in the case of compound units. For example, "Report twist of yarn in twists per inch (twists per metre)"; not "... in twists per inch (25.4 mm)."

H5.3 *Using Percentages for Tolerance Limits*— When appropriate, eliminate the need for equivalents in the case of tolerances by expressing the limits in percentages.

H5.4 *Sieve Sizing*— When a standard cites sieve sizes, use the standard sieve sizes given in Table 1 of ASTM Specification E11, Wire Cloth and Sieves for Testing Purposes.

H5.5 Where it has been long-standing practice to use SI units alone (such as stating temperatures only in degrees Celsius), equivalents may be omitted.

H6. Tables

H6.1 For instructions on including SI units in tables, see Section G27.

ANNEX A

SI QUICK REFERENCE GUIDE

SI QUICK REFERENCE GUIDE:
International System of Units (SI)
*The Modern Metric System**

UNITS

The International System of Units (SI) is based on seven base units:

Base Units

Quantity	*Name*	*Symbol*
length	metre	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

and a number of derived units which are combinations of base units and which may have special names and symbols:

Examples of Derived Units

Quantity	*Expression*	*Name*	*Symbol*
acceleration			
angular	rad/s^2		
linear	m/s^2		
angle			
plane	dimensionless	radian	rad
solid	dimensionless	steradian	sr
area	m^2		
Celsius temperature	K	degree Celsius	°C
density			
heat flux	W/m^2		
mass	kg/m^3		
current	A/m^2		
energy, enthalpy			
work, heat	N·m	joule	J
specific	J/kg		
entropy			
heat capacity	J/K		
specific	J/(kg·K)		
flow, mass	kg/s		
flow, volume	m^3/s		
force	$kg·m/s^2$	newton	N
frequency			
periodic	1/s	hertz	Hz
rotating	rev/s		
inductance	Wb/A	henry	H
magnetic flux	V·s	weber	Wb
mass flow	kg/s		
moment of a force	N·m		
potential, electric	W/A	volt	V
power, radiant flux	J/s	watt	W
pressure, stress	N/m^2	pascal	Pa
resistance, electric	V/A	ohm	Ω
thermal conductivity	W/(m·K)		
velocity			
angular	rad/s		
linear	m/s		
viscosity			
dynamic (absolute) (μ)	Pa·s		
kinematic (ν)	m^2/s		
volume	m^3		
volume, specific	m^3/kg		

** For compete information see IEEE/ASTM SI-10.*

SYMBOLS

Symbol	*Name*	*Quantity*	*Formula*
A	ampere	electric current	base unit
Bq	becquerel	activity (of a radio nuclide)	1/s
C	coulomb	electric charge	A·s
°C	degree Celsius	temperature interval	°C = K
cd	candela	luminous intensity	base unit
F	farad	electric capacitance	C/V
Gy	gray	absorbed dose	J/kg
g	gram	mass	kg/1000
H	henry	inductance	Wb/A
Hz	hertz	frequency	1/s
ha	hectare*	area	10 000 m^2
J	joule	energy, work, heat	N·m
K	kelvin	temperature	base unit
kg	kilogram	mass	base unit
L	litre	volume	m^3/1000
lm	lumen	luminous flux	cd·sr
lx	lux	illuminance	lm/m^2
m	metre	length	base unit
mol	mole	amount of substance	base unit
N	newton	force	kg·m/s^2
Ω	ohm	electric resistance	V/A
Pa	pascal	pressure, stress	N/m^2
rad	radian	plane angle	m/m (dimensionless)
S	siemens	electric conductance	A/V
Sv	sievert	dose equivalent	J/kg
s	second	time	base unit
sr	steradian	solid angle	m^2/m^2 (dimensionless)
T	tesla	magnetic flux density	Wb/m^2
t	tonne, metric ton	mass	1000 kg; Mg
V	volt	electric potential	W/A
W	watt	power, radiant flux	J/s
Wb	weber	magnetic flux	V·s

* allowed with SI

Use of Symbols

The correct use of symbols is important because an incorrect symbol may change the meaning of a quantity. Some SI symbols are listed in the Symbol table.

SI has no abbreviations—only symbols. Therefore, no periods follow a symbol except at the end of a sentence.

Examples: A, *not* amp; s *not* sec; SI, *not* S.I.

Symbols appear in lower case unless the unit name has been taken from a proper name. In this case the first letter of the symbol is capitalized.

Examples: m, metre; Pa, pascal; W, watt

Exception: L, litre

Symbols and prefixes are printed in upright (roman) type regardless of the type style in surrounding text.

Example: . . . a distance of 73 km *between . . .*

Unit symbols are the same whether singular or plural.

Examples: 1 mm, 100 mm; 1 kg, 65 kg

Leave a space between the value and the symbol.

Examples: 115 W, *not* 115W; 0.75 L, *not* 0.75L
88 °C, *not* 88°C or 88° C

Exception: No space is left between the numerical value and symbol for degree of plane angle.

Examples: 73°, *not* 73 °

Note: Symbol for coulomb is C; for degree Celsius it is °C

Do not mix symbols and names in the same expression.

Examples: radians per second or rad/s,
not radians/second; *not* radians/s
m/s or metres per second,
not metres/second; *not* metres/s
J/kg or joules per kilogram,
not joules/kilogram; *not* joules/kg

Symbol for product—use the raised dot (·)

Examples: N·m; mPa·s; W/(m^2·K)

Symbol for quotient—use one of the following forms:

Examples: m/s or $^m/_s$ or use the negative exponent

Note: Use only one solidus (/) per expression and parentheses to avoid any ambiguity.

PREFIXES

Most prefixes indicate orders of magnitude in steps of 1000 and provide a convenient way to express large and small numbers and to eliminate nonsignificant digits and leading zeroes in decimal fractions.

Examples: 64 000 watts is the same as 64 kilowatts*
0.057 metre is the same as 57 millimetres
16 000 metres is the same as 16 kilometres*
*except for intended accuracy

Prefix	*Symbol*	*Represents*
yotta	Y	10^{24}
zetta	Z	10^{21}
exa	E	10^{18}
peta	P	10^{15}
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
hecto	h*	10^{2}
deka	da*	10^{1}
deci	d*	10^{-1}
centi	c*	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}
atto	a	10^{-18}
zepto	z	10^{-21}
yocto	y	10^{-24}
	* allowed with SI	

To realize the full benefit of the prefixes when expressing a quantity by numerical value, choose a prefix so that the number lies between 0.1 and 1000. For simplicity, give preference to prefixes representing 1000 raised to an integral power (i.e., mm, μm, km).

**Exceptions:* In expressing area and volume, the prefixes hecto, deka, deci, and centi may be required; for example, cubic decimetre (L), square hectometre (hectare), cubic centimetre.

Tables of values of the same quantity.

Comparison of values.

For certain quantities in particular applications. For example, the millimetre is used for linear dimensions in architectural and engineering drawings even when the values lie far outside the range of 0.1 mm to 1000 mm; the centimetre is usually used for anatomical measurements and clothing sizes.

Compound Units. A compound unit is a derived unit expressed with two or more units. The prefix is attached to a unit in the numerator.

Examples: V/m *not* mV/mm
MJ/kg *not* kJ/g

Compound prefixes formed by a combination of two or more prefixes are not used. Use only one prefix.

Examples: 2 nm *not* 2 mμm;
6 m^3 *not* 6 kL;
6 mPa *not* 6 kkPA

Exponential Powers. An exponent attached to a symbol containing a prefix indicates that the multiple (of the unit with its prefix) is raised to the power of 10 expressed by the exponent.

Examples: 1 $mm^3 = (10^{-3}\ m)^3 = 10^{-9}\ m^3$
1 $ns^{-1} = (10^{-9}\ s)^{-1} = 10^{9}\ s^{-1}$
1 $mm^2/s = (10^{-3}\ m)^2/s = 10^{-6}\ m^2/s$

NUMBERS

International practice separates the digits of large numbers into groups of three, counting from the decimal to the left and to the right, and inserts a space to separate the groups. In numbers of four digits, the space is not necessary except for the uniformity in tables.

Examples: 6.358 568; 85 365; 51 845 953; 88 000;
0.246 113 562; 7 258

Small Numbers. When writing a number between one and minus one, put a zero before the decimal marker.

Note: This applies to large numbers which have an exponent: as -0.1 × 10^6. This rule is given colloquially as "never use a naked decimal point."

Decimal Marker. The recommended decimal marker is a dot on the line (period). (In some countries, a comma is used as the decimal marker.)

Because **billion** means a million million in most countries but a thousand million in the United States, avoid using billion in technical writing.

DO'S AND DON'TS

The units in the international system of units are called SI units—*not* Metric Units and *not* SI Metric Units.

Non-SI units include inch-pound units, old metric units and many other units. Inch=pound units (IP) refers to sets of units which contain inches and pounds. These include so-called customary units, US customary units, conventional units, imperial units, and English units.

Treat all spelled out names as nouns. Therefore, do not capitalize the first letter of a unit except at the beginning of a sentence or in capitalized material such as a title.

Examples: watt; pascal; ampere; volt; newton; kelvin
Exception: Always capitalize the first letter of Celsius.

Do not begin a sentence with a unit symbol—either rearrange the unit names or write the unit name in full.

Use plurals for spelled out unit names when required by the rules of grammar.

Examples: metre—metres; henry—henries;
kilogram—kilograms; kelvin—kelvins
Irregular: hertz—hertz; lux—lux; siemens—siemens

Do not put a space or hyphen between the prefix and unit name.

Examples: kilometre *not* kilo metre or kilo-metre;
milliwatt *not* milli watt or milli-watt

When a prefix ends with a vowel and the unit name begins with a vowel, retain and pronounce both vowels.

Example: kiloampere
Exceptions: hectare; kilohm; megohm

When a derived unit name is formed by multiplication, leave a space between units that are multiplied.

Examples: newton metre, *not* newton-metre;
volt ampere, *not* volt-ampere

Use the modifier squared or cubed after the unit name.

Example: metre per second squared
Exception: For area or volume the modifier may be placed before the units.
Example: square millimetre; cubic metre

When derived units are formed by division, use the word *per*, not a solidus (/).

Examples: metre per second, *not* metre/second; watt per square metre, *not* watt/square meter

SELECTED CONVERSION FACTORS

CAUTION: These conversion values are rounded to three or four significant figures, which is sufficiently accurate for most applications. When making conversions, remember that a converted value is no more precise than the original value. Round off the final value to the same number of significant figures as those in the original value. See ANSI SI 10 for additional conversions with more significant figures.

Multiply	*By*	*To Obtain*
acre	0.4047	ha
atmosphere, standard	*101.325	kPa
bar	*100	kPa
barrel (42 US gal, petroleum)	159	L
Btu, (International Table)	1.055	kJ
Btu/lb·°F (specific heat, C^p)	4.184	kJ/(kg·K)
bushel	0.03524	m^3
calorie, kilogram (kilocalorie)	4.187	kJ
candle, candlepower	*1.0	cd
centipoise, dynamic viscosity, μ	*1.00	mPa·s
centistokes, kinematic viscosity, ν	*1.00	mm^2/s
ft	*0.3048	m
ft	*304.8	mm
ft/min, fpm	*0.00508	m/s
ft/s, fps	*0.3048	m/s
ft of water	2.99	kPa
ft^2	0.09290	m^2
ft^2/s, kinematic viscosity, ν	92 900	mm^2/s
ft^3	28.32	L
ft^3	0.02832	m^3
ft^3/h, cfh	7.866	mL/s
ft^3/min, cfm	0.4719	L/s
ft^3/s, cfs	28.32	L/s
footcandle	10.76	lx
$ft{\cdot}lb_f$ (torque or moment)	1.36	N·m
$ft{\cdot}lb_f$ (work)	1.36	J
$ft{\cdot}lb_f/lb$ (specific energy)	2.99	J/kg
$ft{\cdot}lb_f/min$ (power)	0.0226	W
gallon, US (*231 in^3)	3.785	L
gph	1.05	mL/s
gpm	0.0631	L/s
gpm/ft^2	0.6791	$L/(s{\cdot}m^2)$
gr/gal	17.1	g/m^3
horsepower (550 $ft{\cdot}lb_f/s$)	0.746	kW
inch	*25.4	mm
in of mercury (60°F)	3.377	kPa

Multiply	*By*	*To Obtain*
in of water (60°F)	248.8	Pa
in·lb_f (torque or moment)	113	mN·m
in^2	645	mm^2
in^3 (volume)	16.4	mL
in^3 (section modulus)	16 400	mm^3
in^4 (section moment)	416 200	mm^4
km/h	0.278	m/s
kWh	*3.60	MJ
kip/in^2 (ksi)	6.895	MPa
litre	*0.001	m^3
micron (μm) of mercury (60°F)	133	mPa
mil (0.001 in.)	*25.4	mm
mile	1.61	km
mile, nautical	1.85	km
mph	1.61	km/h
mph	0.447	m/s
millibar	*0.100	kPa
mm of mercury (60°F)	0.133	kPa
mm of water (60°F)	9.80	Pa
ounce (mass, avoirdupois)	28.35	g
ounce (force of thrust)	0.278	N
ounce (liquid, US)	29.6	mL
ounce (avoirdupois) per gallon	7.49	kg/m^3
pint (liquid, US)	473	mL
pound		
lb_m (mass)	0.4536	kg
lb_m (mass)	453.6	g
lb_f (force or thrust)	4.45	N
lb_m/ft (uniform load)	1.49	kg/m
lb_m/(ft·h) (dynamic viscosity, μ)	0.413	mPa·s
lb_m/(ft·s) (dynamic viscosity, μ)	1490	mPa·s
lb_f·s/ft^2 (dynamic viscosity, μ)	47 880	mPa·s
lb_m/min	0.00756	kg/s
lb_m/h	0.126	g/s
lb_f/ft^2	47.9	Pa
lb_m/ft^2	4.88	kg/m^2
lb_m/ft^3 (density, ρ)	16.0	kg/m^3
lb_m/gallon	120	kg/m^3
ppm (by mass)	*1.00	mg/kg
psi	6.895	kPa
quad (10^{15} Btu)	1.06	EJ
quart (liquid, US)	0.946	L
rpm	0.105	rad/s
tablespoon (approx.)	15	mL
teaspoon (approx.)	5	mL
therm (100,000 Btu)	105.5	MJ
ton, short (2000 lb)	0.907	Mg; t (tonne)
yd	*0.9144	m
yd^2	0.836	m^2
yd^3	0.7646	m^3

* Conversion factor is exact.

Note: In this list the kelvin (K) expresses temperature intervals. The degree Celsius symbol (C) may be used for this purpose as well

Summary of Changes

The following changes were made since the March 2014 edition and published in this edition.

(1) Revised Sections G3.6, G24.1, and H1.2.2 to reference IEEE SI 10, the SI Quick Reference Guide, and Part G and Part H. The ASTM Form and Style is the default document for formatting so that the spelling of litre and metre can be maintained.
(2) Revised G14.1 and G18.3.3 to reflect using space rather than hyphen for compound adjectives using SI units.
(3) Added the SI Quick Reference Guide to the Form and Style Manual as Annex A.
(4) General revisions were made to reflect current practices.

The following changes were made since the October 2013 edition and published in this edition.

(1) Added F2.6, Mercury Caveat.

The following changes were made since the March 2013 edition and published in this edition.

(1) Revised Section F1 on Commercial-Contractual Items in Standards.
(2) Editorially revised Section G12 on Creating and Submitting Figures for Ballot

The following changes were made since the October 2012 edition and published in this edition.

(1) Editorially revised B22.1 on Product Marking.

The following changes were made since the March 2012 edition and published in this edition.

(1) Revised Section A21 on Precision and Bias.

The following changes were made since the October 2011 edition and published in this edition.

(1) Clarified use of the term “dictionary” to mean print or electronic reference materials in A7.1.1, E2.1, E3.3.1, E5.9, G10.1, G15.1.5, and G25.1.
(2) Editorially updated ASTM standards references in A17.1, A19.2, and the table in G3.6 (Vickers Hardness number)

The following changes were made since the October 2010 edition and published in this edition.

(1) Clarified language in Section F1.
(2) Revised Ordering Information, B9.3, to focus on the importance of referenced documents within a specification, and to encourage the use of year dates.
(3) Editorially changed A27.4 and A29.4 to correct a reference in the *Regulations Governing ASTM Technical Committees.*
(4) Editorially updated the title of IEEE/ASTM SI-10 in G3.6.

The following changes were made since the March 2010 edition and published in this edition.

(1) Editorially removed reference to ANSI Y10.3M in A19.1 since it was withdrawn without replacement.
(2) Revised D4 with the addition of D4.1.2 to modify language on the current editorial practice for Supplementary Requirements.
(3) Editorially changed E3.3.3 to update the referenced title to *ASTM Online Dictionary of Engineering Science and Technology*.
(4) Revised F4.1 to include ASTM Certification Programs.

The following changes were made since the September 2009 edition and published in this edition.

(1) Added “kerosene” as an acceptable spelling in G25.1.

The following changes were made since the March 2009 edition and published in this edition.

(1) Revisions of A27.1 and B29.1 for better clarity.
(2) Replaced G12 with a new procedure for creating and submitting figures for ballot.
(3) Editorial changes were made to C2, C16, A26.4, and B28.4.

The following changes were made since the March 2008 edition and published in this edition.

(1) Insertion of new sections F2.2.2.5 and F2.2.2.6 dealing with Fire Standards Safety Caveats.

The following changes were made since the October 2007 edition and published in this edition.

(1) Revisions were made to Part G dealing with Styling, Electronic Manuscript Preparation, Abbreviations, Figures, Mathematical Material, and Thermometers.

The following changes were made since the October 2006 edition and published in this edition.

(1) Removal of the 'separated by a space' requirement in standard designation numbers found in A3.1.2 and B4.1.2.
(2) Insertion of new section G16.6.1 and an example for clarifying how to place a multiplication symbol in an equation.
(3) Revision of G27.7 for better clarity.
(4) Revision of H1.2.1 for better clarity, as well as to include a*Discussion*on the use of SI units in standards.
(5) Reversal of the order of appearance of Sections H3 and H4.

The following changes were made since the March 2006 edition and published in this edition.

(1) Insertion of a new section F4.1 to clarify ASTM's policy on certification and accreditation.
(2) Reversal of the order of appearance of the*Trademarks*section with the*Sources of Supply*section for a more logical flow.
(3) Removal of the word*reference*where used as an adjective in the term*reference materials*to expand this section to cover all materials – not just*reference materials*.
(4) Insertion of new language as F4.2.2 to make trademark language consistent with *Regulations Governing ASTM Technical Committees* and Board Policy.

The following changes were made since the October 2005 edition and published in this edition.

(1) Revisions were made to A21.4.1, A21.4.2, and A21.5.4 to clarify the intent of the language.
(2) Sections A29 and B31 on Research Reports were revised to make clearer the instructions on how the research report is to be referenced in a standard.
(3) Revision to F2.4, Working Document Caveat, in order to remain consistent with ASTM policy.
(4) Revisions were made to Sections F4 and F4.2 dealing with Use of Trademarks.

The following changes were made since the March 2005 edition and published in this edition.

(1) Revision to Working Draft Caveat, F2.4, in order to remain consistent with ASTM policy.
(2) Section G25.1, added (measurement, instrument) to "gauge" and deleted spelling "gage."

The following changes were made since the September 2004 edition and published in this edition.

(1) Section A18.3 was deleted. Including this section was redundant and could lead to confusion.
(2) New Section H1.2.2.1 was added pertaining to rounding of SI Units.

The following changes were made since the April 2004 edition and published in this edition.

(1) New Section A21.4.5 pertaining to precision and bias was added.
(2) A revision was made in B1.2 for clarification.

The following changes were made since the September 2003 edition and published in this edition.

(1) Revisions to A1.4 clarify how to identify different test methods within a standard.
(2) New Section A22 on Measurement Uncertainty was added.
(3) Revision to F1 was made and new Section F1.4 was added concerning effective dates.
(4) Revisions were made to F3.1, F3.1.1, and F3.1.2 dealing with patents.

The following changes were made since the March 2003 edition and published in this edition.

(1) The following sentence was added in B25.1. "These should not include statements that would allow the lowering of minimum requirements of the standard (seeB1.2)."
(2) Megagram (Mg) was added to G3.6.

The following changes were made since the September 2002 edition and published in this March 2003 edition.
(1) New definitions for "publication date" and "approval date" were added to p. viii on Definitions
(2) Sections A31.3, B34.3, and C31.3 on Summary of Change Sections were revised to permit standards that have undergone multiple revisions in a short period of time to retain changes for 18 months.
(3) The statement in A21.5.3 was revised to correct ambiguity in the requirement for precision and bias.

The following changes were made editorially since the March 2002 edition and are published in the September 2002 edition.
(1) Replaced the verbiage "year of issue" and "date of issue" with "year date" throughout.
(2) Standardized the terms "purchase order or contract" in Part B.
(3) An additional sentence was included in F3.1 regarding the ANSI patent policy.

The sections shown below have been editorially changed since the October 2001 edition and are published in the March 2002 edition.
(1) Section G2 on Electronic Manuscript Preparations was replaced.
(2) Additional sentences were included in the suggested statement in B21.2.

The following changes were made since the March 2001 edition and published in the October 2001 edition.
(1) Deletion of A3.1.3 and A5.4 regarding companion standards. The same changes were made to B4.1.3 and B4.4.1
(2) Mandatory for Standards Producing Numerical Results was added to the heading of Section A29 on Research Reports.
(3) New section F2.2.2.4 dealing with a fire risk assessment statement.
(4) Deletion of G24.2 dealing with companion standards.

The following changes were made since the February 2000 edition and are published in the March 2001 edition.
(1) Revisions to Section B21 on Certification.

The following changes were made since the December 1998 edition and are published in the February 2000 edition.
(1) Revision to Section A13 to revised A13.1.1 on Warning Statement, delete A13.1.2 on Precautionary Statement, and delete A13.2 on Technical Hazards. Revise F2.1.2 and F2.1.3 to eliminate wording dealing with precautionary statements.

The following changes were made since the January 1996 edition and published in the December 1998 edition.
(1) Revision to Part H dealing with the use of SI units in ASTM standards. Revision to G38. These were the results from Circular Letter #713.
(2) Added new F2.5 Professional Judgment Caveat.

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EXHIBIT 6

Designation: D 86 – 07

An American National Standard

Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure[1]

This standard is issued under the fixed designation D 86; 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.

1. Scope*

1.1 This test method covers the atmospheric distillation of petroleum products using a laboratory batch distillation unit to determine quantitatively the boiling range characteristics of such products as light and middle distillates, automotive spark-ignition engine fuels, aviation gasolines, aviation turbine fuels, 1-D and 2-D regular and low sulfur diesel fuels, special petroleum spirits, naphthas, white spirits, kerosines, and Grades 1 and 2 burner fuels.

1.2 The test method is designed for the analysis of distillate fuels; it is not applicable to products containing appreciable quantities of residual material.

1.3 This test method covers both manual and automated instruments.

1.4 Unless otherwise noted, the values stated in SI units are to be regarded as the standard. The values given in parentheses are provided for information only.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 All standards are subject to revision, and parties to agreement on this test method are to apply the most recent edition of the standards indicated below, unless otherwise specified, such as in contractual agreements or regulatory rules where earlier versions of the method(s) identified may be required.

2.2 *ASTM Standards:* [2]

D 97 Test Method for Pour Point of Petroleum Products
D 323 Test Method for Vapor Pressure of Petroleum Products (Reid Method)
D 2892 Test Method for Distillation of Crude Petroleum (15-Theoretical Plate Column)
D 4057 Practice for Manual Sampling of Petroleum and Petroleum Products
D 4177 Practice for Automatic Sampling of Petroleum and Petroleum Products
D 4953 Test Method for Vapor Pressure of Gasoline and Gasoline-Oxygenate Blends (Dry Method)
D 5190 Test Method for Vapor Pressure of Petroleum Products (Automatic Method)
D 5191 Test Method for Vapor Pressure of Petroleum Products (Mini Method)
D 5842 Practice for Sampling and Handling of Fuels for Volatility Measurement
D 5949 Test Method for Pour Point of Petroleum Products (Automatic Pressure Pulsing Method)
D 5950 Test Method for Pour Point of Petroleum Products (Automatic Tilt Method)
D 5985 Test Method for Pour Point of Petroleum Products (Rotational Method)
E 1 Specification for ASTM Liquid-in-Glass Thermometers
E 77 Test Method for Inspection and Verification of Thermometers
E 1272 Specification for Laboratory Glass Graduated Cylinders
E 1405 Specification for Laboratory Glass Distillation Flasks

2.3 *Energy Institute Standards:*[3]

IP 69 Determination of Vapour Pressure—Reid Method
IP 123 Petroleum Products—Determination of Distillation Characteristics
IP 394 Determination of Air Saturated Vapour Pressure
IP Standard Methods for Analysis and Testing of Petroleum and Related Products 1996—Appendix A

[1] This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.08.0A on Distillation.

In the IP, the equivalent test method is published under the designation IP 123. It is under the jurisdiction of the Standardization Committee.

Current edition approved Jan. 15, 2007. Published February 2007. Originally approved in 1921. Last previous edition approved in 2005 as D 86–05.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Energy Institute, 61 New Cavendish St., London, WIG 7AR, U.K., http://www.energyinst.org.uk.

***A Summary of Changes section appears at the end of this standard.**

TABLE 1 Preparation of Apparatus

	Group 1	Group 2	Group 3	Group 4
Flask, mL	125	125	125	125
ASTM distillation thermometer	7C (7F)	7C (7F)	7C (7F)	8C (8F)
IP distillation thermometer range	low	low	low	high
Flask support board	B	B	C	C
diameter of hole, mm	38	38	50	50
Temperature at start of test				
Flask °C	13–18	13–18	13–18	not above
°F	55–65	55–65	55–65	ambient
Flask support and shield	not above ambient	not above ambient	not above ambient	
Receiving cylinder and 100 mL charge				
°C	13–18	13–18	13–18[A]	13–ambient[A]
°F	55–65	55–65	55–65[A]	55–ambient[A]

[A] See 10.3.1.1 for exceptions.

3. Terminology

3.1 *Definitions:*

3.1.1 *charge volume*, *n*—the volume of the specimen, 100 mL, charged to the distillation flask at the temperature specified in Table 1.

3.1.2 *decomposition*, *n*—*of a hydrocarbon*, the pyrolysis or cracking of a molecule yielding smaller molecules with lower boiling points than the original molecule.

3.1.2.1 *Discussion*—Characteristic indications of thermal decomposition are evolution of fumes and erratic temperature readings that usually decrease after any attempt is made to adjust the heat.

3.1.3 *decomposition point*, *n*—the corrected thermometer reading that coincides with the first indications of thermal decomposition of the liquid in the flask.

3.1.3.1 *Discussion*—The decomposition point, as determined under the conditions of this test method, does not necessarily correspond to the decomposition temperature in other applications.

3.1.4 *dry point*, *n*—the corrected thermometer reading that is observed at the instant the last drop of liquid (exclusive of any drops or film of liquid on the side of the flask or on the temperature sensor), evaporates from the lowest point in the distillation flask.

3.1.4.1 *Discussion*—The end point (final boiling point), rather than the dry point, is intended for general use. The dry point can be reported in connection with special purpose naphthas, such as those used in the paint industry. Also, it is substituted for the end point (final boiling point) whenever the sample is of such a nature that the precision of the end point (final boiling point) cannot consistently meet the requirements given in the precision section.

3.1.5 *dynamic holdup*, *n*—the amount of material present in the neck of the flask, in the sidearm of the flask, and in the condenser tube during the distillation.

3.1.6 *emergent stem effect*, *n*—the offset in temperature reading caused by the use of total immersion mercury-in-glass thermometers in the partial immersion mode.

3.1.6.1 *Discussion*—In the partial immersion mode, a portion of the mercury thread, that is, the emergent portion, is at a lower temperature than the immersed portion, resulting in a shrinkage of the mercury thread and a lower temperature reading.

3.1.7 *end point (EP) or final boiling point (FBP)*, *n*—the maximum corrected thermometer reading obtained during the test.

3.1.7.1 *Discussion*—This usually occurs after the evaporation of all liquid from the bottom of the flask. The term maximum temperature is a frequently used synonym.

3.1.8 *front end loss*, *n*—loss due to evaporation during transfer from receiving cylinder to distillation flask, vapor loss during the distillation, and uncondensed vapor in the flask at the end of the distillation.

3.1.9 *initial boiling point (IBP)*, *n*—the corrected thermometer reading that is observed at the instant the first drop of condensate falls from the lower end of the condenser tube.

3.1.10 *percent evaporated*, *n*—the sum of the percent recovered and the percent loss.

3.1.11 *percent loss (or observed loss)*, *n*—one hundred minus the percent total recovery.

3.1.11.1 *corrected loss*, *n*—percent loss corrected for barometric pressure.

3.1.12 *percent recovered*, *n*—the volume of condensate observed in the receiving cylinder, expressed as a percentage of the charge volume, associated with a simultaneous temperature reading.

3.1.13 *percent recovery*, *n*—the maximum percent recovered, as observed in accordance with 10.18.

3.1.13.1 *corrected percent recovery*, *n*—the percent recovery, adjusted for the difference between the observed loss and the corrected loss, as described in Eq 8.

3.1.13.2 *percent total recovery*, *n*—the combined percent recovery and residue in the flask, as determined in accordance with 11.1.

3.1.14 *percent residue*, *n*—the volume of residue in the flask, measured in accordance with 10.19, and expressed as a percentage of the charge volume.

3.1.15 *rate of change (or slope)*, *n*—the change in temperature reading per percent evaporated or recovered, as described in 13.2.

3.1.16 *temperature lag*, *n*—the offset between the temperature reading obtained by a temperature sensing device and the true temperature at that time.

3.1.17 *temperature measurement device*, *n*—a thermometer, as described in 6.3.1, or a temperature sensor, as described in 6.3.2.

3.1.18 *temperature reading, n*—the temperature obtained by a temperature measuring device or system that is equal to the thermometer reading described in 3.1.19.

3.1.18.1 *corrected temperature reading, n*—the temperature reading, as described in 3.1.18, corrected for barometric pressure.

3.1.19 *thermometer reading (or thermometer result), n*—the temperature of the saturated vapor measured in the neck of the flask below the vapor tube, as determined by the prescribed thermometer under the conditions of the test.

3.1.19.1 *corrected thermometer reading, n*—the thermometer reading, as described in 3.1.19, corrected for barometric pressure.

4. Summary of Test Method

4.1 Based on its composition, vapor pressure, expected IBP or expected EP, or combination thereof, the sample is placed in one of four groups. Apparatus arrangement, condenser temperature, and other operational variables are defined by the group in which the sample falls.

4.2 A 100-mL specimen of the sample is distilled under prescribed conditions for the group in which the sample falls. The distillation is performed in a laboratory batch distillation unit at ambient pressure under conditions that are designed to provide approximately one theoretical plate fractionation. Systematic observations of temperature readings and volumes of condensate are made, depending on the needs of the user of the data. The volume of the residue and the losses are also recorded.

4.3 At the conclusion of the distillation, the observed vapor temperatures can be corrected for barometric pressure and the data are examined for conformance to procedural requirements, such as distillation rates. The test is repeated if any specified condition has not been met.

4.4 Test results are commonly expressed as percent evaporated or percent recovered versus corresponding temperature, either in a table or graphically, as a plot of the distillation curve.

5. Significance and Use

5.1 The basic test method of determining the boiling range of a petroleum product by performing a simple batch distillation has been in use as long as the petroleum industry has existed. It is one of the oldest test methods under the jurisdiction of ASTM Committee D02, dating from the time when it was still referred to as the Engler distillation. Since the test method has been in use for such an extended period, a tremendous number of historical data bases exist for estimating end-use sensitivity on products and processes.

5.2 The distillation (volatility) characteristics of hydrocarbons have an important effect on their safety and performance, especially in the case of fuels and solvents. The boiling range gives information on the composition, the properties, and the behavior of the fuel during storage and use. Volatility is the major determinant of the tendency of a hydrocarbon mixture to produce potentially explosive vapors.

5.3 The distillation characteristics are critically important for both automotive and aviation gasolines, affecting starting, warm-up, and tendency to vapor lock at high operating temperature or at high altitude, or both. The presence of high boiling point components in these and other fuels can significantly affect the degree of formation of solid combustion deposits.

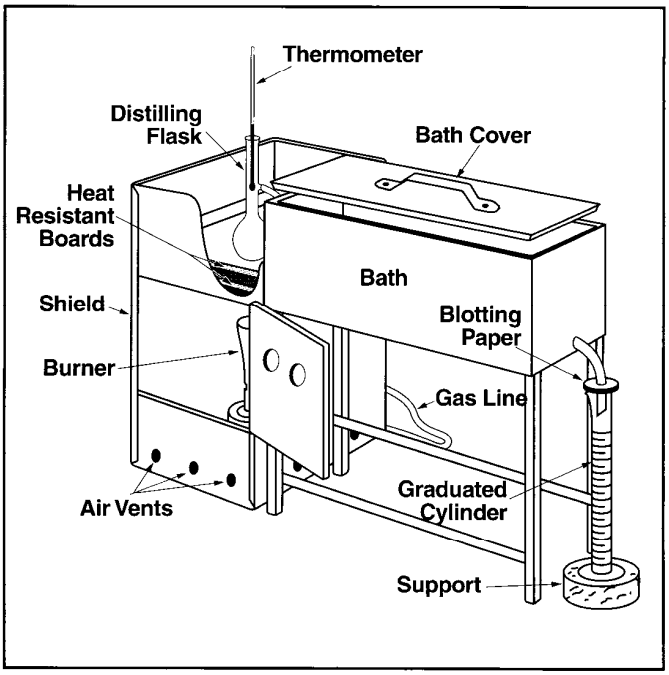


FIG. 1 Apparatus Assembly Using Gas Burner

5.4 Volatility, as it affects rate of evaporation, is an important factor in the application of many solvents, particularly those used in paints.

5.5 Distillation limits are often included in petroleum product specifications, in commercial contract agreements, process refinery/control applications, and for compliance to regulatory rules.

6. Apparatus

6.1 *Basic Components of the Apparatus*:

6.1.1 The basic components of the distillation unit are the distillation flask, the condenser and associated cooling bath, a metal shield or enclosure for the distillation flask, the heat source, the flask support, the temperature measuring device, and the receiving cylinder to collect the distillate.

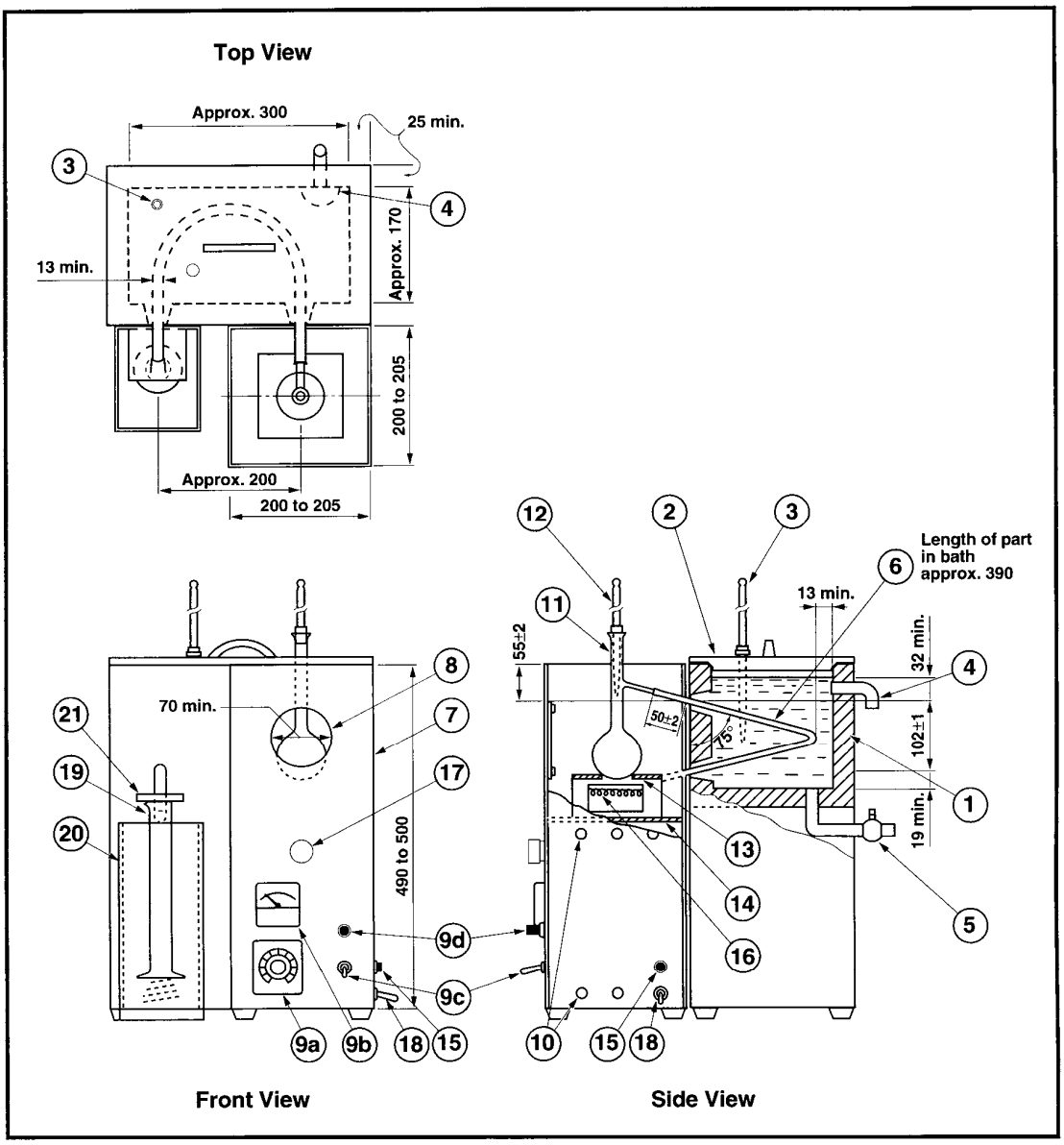
6.1.2 Figs. 1 and 2 are examples of manual distillation units.

6.1.3 In addition to the basic components described in 6.1.1, automated units also are equipped with a system to measure and automatically record the temperature and the associated recovered volume in the receiving cylinder.

6.2 A detailed description of the apparatus is given in Annex A2.

6.3 *Temperature Measuring Device*:

6.3.1 Mercury-in-glass thermometers, if used, shall be filled with an inert gas, graduated on the stem and enamel backed. They shall conform to Specification E 1 or IP Standard Methods for Analysis and Testing of Petroleum and Related Products 1996—Appendix A, or both, for thermometers ASTM



1–Condenser bath
2–Bath cover
3–Bath temperature sensor
4–Bath overflow
5–Bath drain
6–Condenser tube
7–Shield
8–Viewing window
9a–Voltage regulator
9b–Voltmeter or ammeter
9c–Power switch
9d–Power light indicator
10–Vent
11–Distillation flask
12–Temperature sensor
13–Flask support board
14–Flask support platform
15–Ground connection
16–Electric heater
17–Knob for adjusting level of support platform
18–Power source cord
19–Receiver cylinder
20–Receiver cooling bath
21–Receiver cover

FIG. 2 Apparatus Assembly Using Electric Heater

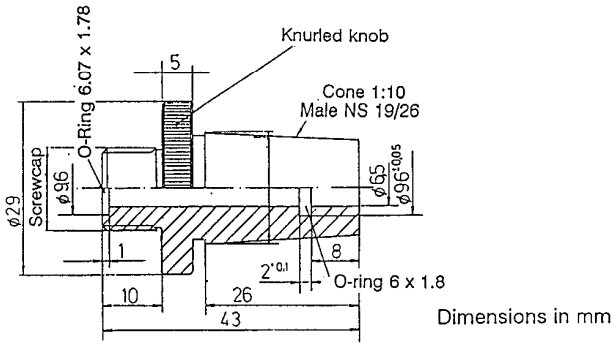


FIG. 3 PTFE Centering Device for Ground Glass Joint

7C/IP 5C and ASTM 7F for the low range thermometers, and ASTM 8C/IP 6C and ASTM 8F for the high range thermometers.

6.3.1.1 Thermometers that have been exposed for an extended period above an observed temperature of 370°C shall not be reused without a verification of the ice point or checked as prescribed in Specification E 1 and Test Method E 77.

NOTE 1—At an observed thermometer reading of 370°C, the temperature of the bulb is approaching a critical range in the glass and the thermometer may lose its calibration.

6.3.2 Temperature measurement systems other than those described in 6.3.1 are satisfactory for this test method, provided that they exhibit the same temperature lag, emergent stem effect, and accuracy as the equivalent mercury-in-glass thermometer.

6.3.2.1 The electronic circuitry or the algorithms, or both, used shall include the capability to simulate the temperature lag of a mercury-in-glass thermometer.

6.3.2.2 Alternatively, the sensor can also be placed in a casing with the tip of the sensor covered so that the assembly, because of its adjusted thermal mass and conductivity, has a temperature lag time similar to that of a mercury-in-glass thermometer.

NOTE 2—In a region where the temperature is changing rapidly during the distillation, the temperature lag of a thermometer can be as much as 3 seconds.

6.3.3 In case of dispute, the referee test method shall be carried out with the specified mercury-in-glass thermometer.

6.4 *Temperature Sensor Centering Device*:

6.4.1 The temperature sensor shall be mounted through a snug-fitting device designed for mechanically centering the sensor in the neck of the flask without vapor leakage. Examples of acceptable centering devices are shown in Figs. 3 and 4. (**Warning**—The use of a plain stopper with a hole drilled through the center is not acceptable for the purpose described in 6.4.1.)

NOTE 3—Other centering devices are also acceptable, as long as they position and hold the temperature sensing device in the proper position in the neck of the distillation column, as shown in Fig. 5 and described in 10.5.

NOTE 4—When running the test by the manual method, products with a low IBP may have one or more readings obscured by the centering device. See also 10.14.3.1.

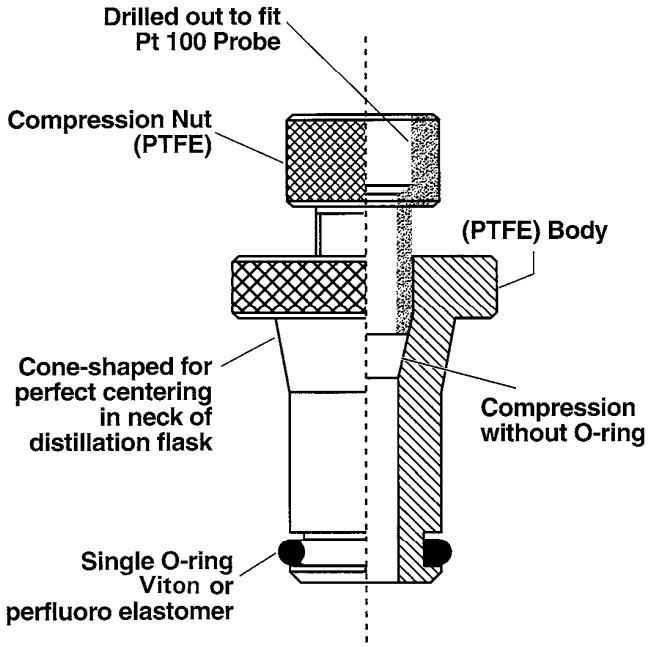


FIG. 4 Example of Centering Device Designs for Straight-Bore Neck Flasks

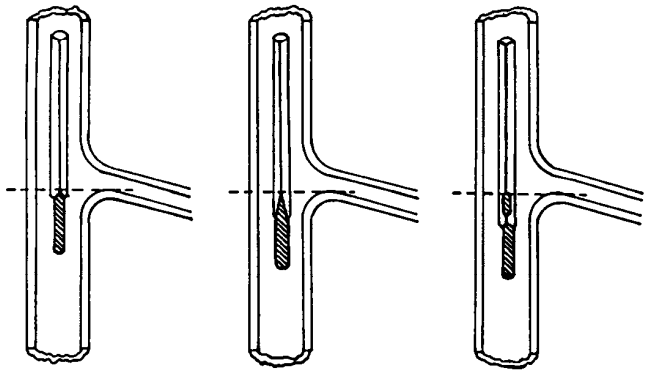


FIG. 5 Position of Thermometer in Distillation Flask

6.5 Automated equipment manufactured in 1999 and later shall be equipped with a device to automatically shut down power to the unit and to spray an inert gas or vapor in the chamber where the distillation flask is mounted in the event of fire.

NOTE 5—Some causes of fires are breakage of the distillation flask, electrical shorts, and foaming and spilling of liquid sample through the top opening of the flask.

6.6 *Barometer*—A pressure measuring device capable of measuring local station pressure with an accuracy of 0.1 kPa (1 mm Hg) or better, at the same elevation relative to sea level as the apparatus in the laboratory. (**Warning**—Do not take readings from ordinary aneroid barometers, such as those used

TABLE 2 Group Characteristics

	Group 1	Group 2	Group 3	Group 4
Sample characteristics				
Distillate type				
Vapor pressure at				
37.8°C, kPa	≥65.5	<65.5	<65.5	<65.5
100°F, psi	≥9.5	<9.5	<9.5	<9.5
(Test Methods D 323, D 4953, D 5190, D 5191, D 5482, IP 69 or IP 394)				
Distillation, IBP °C			≤100	>100
°F			≤212	>212
EP °C	≤250	≤250	>250	>250
°F	≤482	≤482	>482	>482

at weather stations and airports, since these are precorrected to give sea level readings.)

7. Sampling, Storage, and Sample Conditioning

7.1 Determine the Group characteristics that correspond to the sample to be tested (see Table 2). Where the procedure is dependent upon the group, the section headings will be so marked.

7.2 *Sampling*:

7.2.1 Sampling shall be done in accordance with Practice D 4057 or D 4177 and as described in Table 3.

7.2.1.1 *Group 1*—Condition the sample container to below 10°C, preferably by filling the bottle with the cold liquid sample and discarding the first sample. If this is not possible because, for instance, the product to be sampled is at ambient temperature, the sample shall be drawn into a bottle prechilled to below 10°C, in such a manner that agitation is kept at a minimum. Close the bottle immediately with a tight-fitting closure. (**Warning**—Do not completely fill and tightly seal a cold bottle of sample because of the likelihood of breakage on warming.)

7.2.1.2 *Groups 2, 3, and 4*—Collect the sample at ambient temperature. After sampling, close the sample bottle immediately with a tight-fitting closure.

7.2.1.3 If the sample received by the testing laboratory has been sampled by others and it is not known whether sampling has been performed as described in 7.2, the sample shall be assumed to have been so sampled.

7.3 *Sample Storage*:

7.3.1 If testing is not to start immediately after collection, store the samples as indicated in 7.3.2, 7.3.3, and Table 3. All samples shall be stored away from direct sunlight or sources of direct heat.

7.3.2 *Group 1*—Store the sample at a temperature below 10°C.

NOTE 6—If there are no, or inadequate, facilities for storage below 10°C, the sample may also be stored at a temperature below 20°C, provided the operator ensures that the sample container is tightly closed and leak-free.

7.3.3 *Group 2*—Store the sample at a temperature below 10°C.

NOTE 7—If there are no, or inadequate, facilities for storage below 10°C, the sample may also be stored at a temperature below 20°C, provided the operator ensures that the sample container is tightly closed and leak-free.

7.3.4 *Groups 3 and 4*—Store the sample at ambient or lower temperature.

7.4 *Sample Conditioning Prior to Analysis*:

7.4.1 Samples shall be conditioned to the temperature shown in Table 3 before opening the sample container.

7.4.1.1 *Groups 1 and 2*—Samples shall be conditioned to a temperature of less than 10°C (50°F) before opening the sample container.

7.4.1.2 *Groups 3 and 4*—If the sample is not fluid at ambient temperature, it is to be heated to a temperature of 9 to 21°C above its pour point (Test Method D 97, D 5949, or D 5985) prior to analysis. If the sample has partially or completely solidified during storage, it shall be vigorously shaken after melting prior to opening the sample container to ensure homogeneity.

7.4.1.3 If the sample is not fluid at room temperature, the temperature ranges shown in Table 3 for the flask and for the sample do not apply.

7.5 *Wet Samples*:

7.5.1 Samples of materials that visibly contain water are not suitable for testing. If the sample is not dry, obtain another sample that is free from suspended water.

7.5.2 *Groups 1 and 2*—If such a sample cannot be obtained, the suspended water can be removed by maintaining the sample at 0 to 10°C, adding approximately 10 g of anhydrous sodium sulfate per 100 mL of sample, shaking the mixture for approximately 2 min, and then allowing the mixture to settle for approximately 15 min. Once the sample shows no visible signs of water, use a decanted portion of the sample, maintained between 1 and 10°C, for the analysis. Note in the report that the sample has been dried by the addition of a desiccant.

NOTE 8—Suspended water in hazy samples in Groups 1 and 2 can be removed by the addition of anhydrous sodium sulfate and separating the liquid sample from the drying agent by decanting without statistically affecting the results of the test.[4]

7.5.3 *Groups 3 and 4*—In cases in which a water-free sample is not practical, the suspended water can be removed by shaking the sample with anhydrous sodium sulfate or other suitable drying agent and separating it from the drying agent by decanting. Note in the report that the sample has been dried by the addition of a desiccant.

8. Preparation of Apparatus

8.1 Refer to Table 1 and prepare the apparatus by choosing the appropriate distillation flask, temperature measuring device, and flask support board, as directed for the indicated group. Bring the temperature of the receiving cylinder, the flask, and the condenser bath to the indicated temperature.

8.2 Make any necessary provisions so that the temperature of the condenser bath and the receiving cylinder will be maintained at the required temperatures. The receiving cylinder shall be in a bath such that either the liquid level is at least

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: D02-1455.

TABLE 3 Sampling, Storage, and Sample Conditioning

		Group 1	Group 2	Group 3	Group 4
Temperature of sample bottle	°C	<10			
	°F	<50			
Temperature of stored sample	°C	<10[A]	<10	ambient	ambient
	°F	<50[A]	<50	ambient	ambient
Temperature of sample after conditioning prior to analysis	°C	<10	<10	Ambient or 9 to 21°C above pour point[B]	Ambient or
	°F	<50	<50	Ambient or 48 to 70°F above pour point[B]	Ambient or
If sample is wet		resample	resample	dry in accordance with 7.5.3	
If resample is still wet[C]		dry in accordance with 7.5.2			

[A] Under certain circumstances, samples can also be stored at temperatures below 20°C (68°F). See also 7.3.2 and 7.3.3.
[B] If sample is (semi)-solid at ambient temperature, see also 10.3.1.1.
[C] If sample is known to be wet, resampling may be omitted. Dry sample in accordance with 7.5.2 and 7.5.3.

as high as the 100-mL mark or the entire receiving cylinder is surrounded by an air circulation chamber.

8.2.1 *Groups 1, 2, and 3*—Suitable media for low temperature baths include, but are not limited to, chopped ice and water, refrigerated brine, and refrigerated ethylene glycol.

8.2.2 *Group 4*—Suitable media for ambient and higher bath temperatures include, but are not limited to, cold water, hot water, and heated ethylene glycol.

8.3 Remove any residual liquid in the condenser tube by swabbing with a piece of soft, lint-free cloth attached to a cord or wire.

9. Calibration and Standardization

9.1 *Temperature Measurement System*—Temperature measurement systems using other than the specified mercury-in-glass thermometers shall exhibit the same temperature lag, emergent stem effect, and accuracy as the equivalent mercury-in-glass thermometer. Confirmation of the calibration of these temperature measuring systems shall be made at intervals of not more than six months, and after the system has been replaced or repaired.

9.1.1 The accuracy and the calibration of the electronic circuitry or computer algorithms, or both, shall be verified by the use of a standard precision resistance bench. When performing this verification, no algorithms shall be used to correct the temperature for lag and the emergent stem effect (see manufacturer's instructions).

9.1.2 Verification of the calibration of temperature measuring devices shall be conducted by distilling toluene in accordance with Group 1 of this test method and comparing the 50 % recovered temperature with that shown in Table 4.[5]

9.1.2.1 If the temperature reading is not within the values shown in Table 4 for the respective apparatus being used (see Note 10 and Table 4), the temperature measurement system shall be considered defective and shall not be used for the test.

NOTE 9—Toluene is used as a verification fluid for calibration; it will yield almost no information on how well an electronic measurement system simulates the temperature lag of a liquid-in-glass thermometer.

9.1.2.2 Reagent grade toluene and hexadecane (cetane), conforming to the specifications of the Committee on Analytical Reagents of the American Chemical Society,[6] shall be used. However, other grades may also be used, provided it is first ascertained that the reagent is of sufficient purity to permit its use without lessening the accuracy of the determination.

NOTE 10—At 101.3 kPa, toluene is shown in reference manuals as boiling at 110.6°C when measured using a partial immersion thermometer. Because this test method uses thermometers calibrated for total immersion, the results typically will be lower and, depending on the thermometer and the situation, may be different for each thermometer. At 101.3 kPa, hexadecane is shown in reference manuals as boiling at 287.0°C when measured using a partial immersion thermometer. Because this test method uses thermometers calibrated for total immersion, the results typically will be lower, and, depending on the thermometer and the situation, may be different for each thermometer.

9.1.3 A procedure to determine the magnitude of the temperature lag is described in Annex A3.

9.1.4 A procedure to emulate the emergent stem effect is described in Appendix X4.

9.1.5 To verify the calibration of the temperature measurement system at elevated temperatures, use hexadecane. The temperature measurement system shall indicate, at 50% recovered, a temperature comparable to that shown in Table 4 for the respective apparatus under Group 4 distillation conditions.

NOTE 11—Because of the high melting point of hexadecane, Group 4 verification distillations will have to be carried out with condenser temperatures >20°C.

9.2 *Automated Method*:

9.2.1 *Level Follower*—For an automated distillation apparatus, the level follower/recording mechanism of the apparatus shall have a resolution of 0.1 mL or better with a maximum error of 0.3 mL between the 5 and 100 mL points. The calibration of the assembly shall be verified in accordance with manufacturer's instructions at intervals of not more than three months and after the system has been replaced or repaired.

NOTE 12—The typical calibration procedure involves verifying the output with the receiver containing 5 and 100 mL of material respectively.

9.2.2 *Barometric Pressure*—At intervals of not more than six months, and after the system has been replaced or repaired,

[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: D02–1580.

[6] *Reagent Chemicals, American Chemical Society Specifications*, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.

TABLE 4 True and Min and Max D 86 50 % Recovered Boiling Points (°C)[A]

		Manual		Automated	
		Distillation conditions min D 86 50 % boiling point	Distillation conditions max D 86 50 % boiling point	Distillation conditions min D 86 50 % boiling point	Distillation conditions max D 86 50 % boiling point
Toluene	ASTM/IP true boiling point	Group 1, 2, and 3	Group 1, 2, and 3	Group 1, 2, and 3	Group 1, 2, and 3
	110.6	105.9	111.8	108.5	109.7
Hexadecane	ASTM/IP true boiling point	Group 4	Group 4	Group 4	Group 4
	287.0	272.2	283.1	277.0	280.0

[A] The manual and automated temperatures show in this table are the values for the 95 % tolerance interval for the 99 % population coverage. The proposed tolerance is approximately 3 × sigma. Information on the values in this table can be found in RR:D02–1580.

the barometric reading of the instrument shall be verified against a barometer, as described in 6.6.

10. Procedure

10.1 Record the prevailing barometric pressure.

10.2 *Groups 1 and 2*—Fit a low range thermometer provided with a snug-fitting cork or stopper of silicone rubber, or equivalent polymeric material, tightly into the neck of the sample container and bring the temperature of the sample to the temperature indicated in Table 3.

10.3 *Groups 1, 2, 3, and 4*—Check that the temperature of the sample is as shown in Table 3. Pour the specimen precisely to the 100-mL mark of the receiving cylinder, and transfer the contents of the receiving cylinder as completely as practical into the distillation flask, ensuring that none of the liquid flows into the vapor tube.

NOTE 13—It is important that the difference between the temperature of the specimen and the temperature of the bath around the receiving cylinder is as small as practically possible. A difference of 5°C can make a difference of 0.7 mL.

10.3.1 *Groups 3 and 4*—If the sample is not fluid at ambient temperature, it is to be heated to a temperature between 9 and 21°C above its pour point (Test Methods D 97, D 5949, D 5950, or D 5985) prior to analysis. If the sample has partially or completely solidified in the intervening period, it shall be vigorously shaken after melting, and prior to sampling, to ensure homogeneity.

10.3.1.1 If the sample is not fluid at ambient temperatures, disregard the temperature range shown in Table 1 for the receiving cylinder and sample. Prior to analysis, heat the receiving cylinder to approximately the same temperature as the sample. Pour the heated specimen precisely to the 100-mL mark of the receiving cylinder, and transfer the contents of the receiving cylinder as completely as practical into the distillation flask, ensuring that none of the liquid flows into the vapor tube.

NOTE 14—Any material that evaporates during the transfer will contribute to the loss; any material that remains in the receiving cylinder will contribute to the observed recovery volume at the time of the IBP.

10.4 If the sample can be expected to demonstrate irregular boiling behavior, that is, bumping, add a few boiling chips to the specimen. The addition of a few boiling chips is acceptable for any distillation.

10.5 Fit the temperature sensor through a snug-fitting device, as described in 6.4, to mechanically center the sensor in the neck of the flask. In the case of a thermometer, the bulb is centered in the neck and the lower end of the capillary is level with the highest point on the bottom of the inner wall of the vapor tube (see Fig. 5). In the case of a thermocouple or resistance thermometer, follow the manufacturer's instructions as to placement (see Fig. 6).

NOTE 15—If vacuum grease is used on the mating surface of the centering device, use the minimum amount of grease that is practical.

10.6 Fit the flask vapor tube, provided with a snug-fitting cork or rubber stopper of silicone, or equivalent polymeric material, tightly into the condenser tube. Adjust the flask in a vertical position so that the vapor tube extends into the condenser tube for a distance from 25 to 50 mm. Raise and adjust the flask support board to fit it snugly against the bottom of the flask.

10.7 Place the receiving cylinder that was used to measure the specimen, without drying the inside of the cylinder, into its temperature-controlled bath under the lower end of the condenser tube. The end of the condenser tube shall be centered in the receiving cylinder and shall extend therein for a distance of at least 25 mm, but not below the 100-mL mark.

10.8 *Initial Boiling Point*:

10.8.1 *Manual Method*—To reduce evaporation loss of the distillate, cover the receiving cylinder with a piece of blotting paper, or similar material, that has been cut to fit the condenser tube snugly. If a receiver deflector is being used, start the distillation with the tip of the deflector just touching the wall of the receiving cylinder. If a receiver deflector is not used, keep the drip tip of the condenser away from the wall of the receiving cylinder. Note the start time. Observe and record the IBP to the nearest 0.5°C (1.0°F). If a receiver deflector is not being used, immediately move the receiving cylinder so that the tip of the condenser touches its inner wall.

10.8.2 *Automated Method*—To reduce evaporation loss of the distillate, use the device provided by the instrument manufacturer for this purpose. Apply heat to the distillation flask and contents with the tip of the receiver deflector just touching the wall of the receiving cylinder. Note the start time. Record the IBP to the nearest 0.1°C (0.2°F).

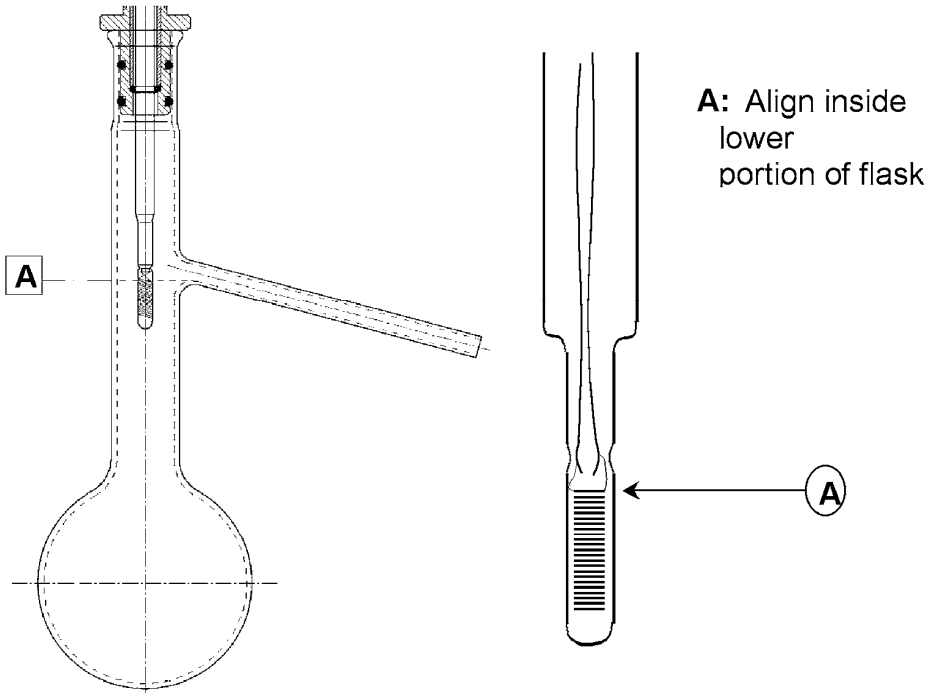


FIG. 6 Example of Recommended Placement of Pt-100 Probe Relative to Distillation Flask Sidearm for Automated D 86 Distillation Instrument

10.9 Regulate the heating so that the time interval between the first application of heat and the IBP is as specified in Table 5.

10.10 Regulate the heating so that the time from IBP to 5 or 10 % recovered is as indicated in Table 5.

10.11 Continue to regulate the heating so that the uniform average rate of condensation from 5 or 10 % recovered to 5 mL residue in the flask is 4 to 5 mL per min. (**Warning**—Due to the configuration of the boiling flask and the conditions of the test, the vapor and liquid around the temperature sensor are not in thermodynamic equilibrium. The distillation rate will consequently have an effect on the measured vapor temperature. The distillation rate shall, therefore, be kept as constant as possible throughout the test.)

NOTE 16—When testing gasoline samples, it is not uncommon to see the condensate suddenly form non-miscible liquid phases and bead up on the temperature measuring device and in the neck of the boiling flask at a vapor temperature of around 160°C. This may be accompanied by a sharp (about 3°C) dip in the vapor temperature and a drop in the recovery rate. The phenomenon, which may be due to the presence of trace water in the sample, may last for 10 to 30 s before the temperature recovers and the condensate starts flowing smoothly again. This point is sometimes colloquially referred to as the Hesitation Point.

10.12 Repeat any distillation that did not meet the requirements described in 10.9, 10.10, and 10.11.

10.13 If a decomposition point, as described in 3.1.3, is observed, discontinue the heating and proceed as directed in 10.17.

10.14 In the interval between the IBP and the end of the distillation, observe and record data necessary for the calculation and reporting of the results of the test as required by the specification involved, or as previously established for the sample under test. These observed data can include temperature readings at prescribed percentages recovered or percentages recovered at prescribed temperature readings, or both.

10.14.1 *Manual Method*—Record all volumes in the graduated cylinder to the nearest 0.5 mL, and all temperature readings to the nearest 0.5°C (1.0°F).

10.14.2 *Automated Method*—Record all volumes in the receiving cylinder to the nearest 0.1 mL, and all temperature readings to the nearest 0.1°C (0.2°F).

10.14.3 *Group 1, 2, 3, and 4*—In cases in which no specific data requirements have been indicated, record the IBP and the EP (FBP) or the dry point, or both, and temperature readings at 5, 15, 85, and 95 % recovered, and at each 10 % multiple of volume recovered from 10 to 90, inclusive.

10.14.3.1 *Group 4*—When a high range thermometer is used in testing aviation turbine fuels and similar products, pertinent thermometer readings can be obscured by the centering device. If these readings are required, perform a second distillation in accordance with Group 3. In such cases, reading from a low range thermometer can be reported in place of the obscured high range thermometer readings, and the test report shall so indicate. If, by agreement, the obscured readings are waived, the test report shall so indicate.

10.14.4 When it is required to report the temperature reading at a prescribed percent evaporated or recovered for a sample that has a rapidly changing slope of the distillation curve in the region of the prescribed percent evaporated or recovered reading, record temperature readings at every 1 % recovered. The slope is considered rapidly changing if the

TABLE 5 Conditions During Test Procedure

		Group 1	Group 2	Group 3	Group 4
Temperature of cooling bath[A]	°C	0–1	0–5	0–5	0–60
	°F	32–34	32–40	32–40	32–140
Temperature of bath around receiving cylinder	°C	13–18	13–18	13–18	±3
	°F	55–65	55–65	55–65	±5 of charge temperature
Time from first application of heat to initial boiling point, min		5–10	5–10	5–10	5–15
Time from initial boiling point to 5 % recovered, s		60–100	60–100		
to 10 % recovered, min					
Uniform average rate of condensation from 5 % recovered to 5 mL in flask, mL/min		4–5	4–5	4–5	4–5
Time recorded from 5 mL residue to end point, min		5 max	5 max	5 max	5 max

[A] the proper condenser bath temperature will depend upon the wax content of the sample and of its distillation fractions. The test is generally performed using one single condenser temperature. Wax formation in the condenser can be deduced from (*a*) the presence of wax particles in the distillate coming off the drip tip, (*b*) a higher distillation loss than what would be expected based on the initial boiling point of the specimen, (*c*) an erratic recovery rate and (*d*) the presence of wax particles during the removal of residual liquid by swabbing with a lint-free cloth (see 8.3). The minimum temperature that permits satisfactory operation shall be used. In general, a bath temperature in the 0 to 4°C range is suitable for kerosine, Grade No. 1 fuel oil and Grade No. 1-D diesel fuel oil. In some cases involving Grade No. 2 fuel oil, Grade No. 2-D diesel fuel oil, gas oils and similar distillates, it may be necessary to hold the condenser bath temperature in the 38 to 60°C range.

change in slope (C) of the data points described in 10.14.2 in that particular area is greater than 0.6 (change of slope (F) is greater than 1.0) as calculated by Eq 1 (Eq 2).

$$\text{Change of Slope } (C) = (C_2 - C_1)/(V_2 - V_1) - (C_3 - C_2)/(V_3 - V_2) \quad (1)$$

$$\text{Change of Slope } (F) = (F_2 - F_1)/(V_2 - V_1) - (F_3 - F_2)/(V_3 - V_2) \quad (2)$$

where:

C_1 = temperature at the volume % recorded one reading prior to the volume % in question, °C,
C_2 = temperature at the volume % recorded in question, °C,
C_3 = temperature at the volume % recorded following the volume % in question, °C,
F_1 = temperature at the volume % recorded one reading prior to the volume % in question, °F,
F_2 = temperature at the volume % recorded in question, °F,
F_3 = temperature at the volume % recorded following the volume % in question, °F,
V_1 = volume % recorded one reading prior to the volume % in question,
V_2 = volume % recorded at the volume % in question, and
V_3 = volume % recorded following the volume % in question.

10.15 When the residual liquid in the flask is approximately 5 mL, make a final adjustment of the heat. The time from the 5 mL of liquid residue in the flask to the EP (FBP) shall be within the limits prescribed in Table 5. If this condition is not satisfied, repeat the test with appropriate modification of the final heat adjustment.

NOTE 17—Since it is difficult to determine when there is 5 mL of boiling liquid left in the flask, this time is determined by observing the amount of liquid recovered in the receiving cylinder. The dynamic holdup has been determined to be approximately 1.5 mL at this point. If there are no front end losses, the amount of 5 mL in the flask can be assumed to correspond with an amount of 93.5 mL in the receiving cylinder. This amount has to be adjusted for the estimated amount of front end loss.

10.15.1 If the actual front end loss differs more than 2 mL from the estimated value, the test shall be rerun.

10.16 Observe and record the EP (FBP) or the dry point, or both, as required, and discontinue the heating.

10.17 Allow the distillate to drain into the receiving cylinder, after heating has been discontinued.

10.17.1 *Manual Method*—While the condenser tube continues to drain into the graduated cylinder, observe and note the volume of condensate to the nearest 0.5 mL at 2 min intervals until two successive observations agree. Measure the volume in the receiving cylinder accurately, and record it to the nearest 0.5 mL.

10.17.2 *Automated Method*—The apparatus shall continually monitor the recovered volume until this volume changes by no more than 0.1 mL in 2 min. Record the volume in the receiving cylinder accurately to the nearest 0.1 mL.

10.18 Record the volume in the receiving cylinder as percent recovery. If the distillation was previously discontinued under the conditions of a decomposition point, deduct the percent recovered from 100, report this difference as the sum of percent residue and percent loss, and omit the procedure given in 10.19.

10.19 After the flask has cooled and no more vapor is observed, disconnect the flask from the condenser, pour its contents into a 5-mL graduated cylinder, and with the flask suspended over the cylinder, allow the flask to drain until no appreciable increase in the volume of liquid in the cylinder is observed. Measure the volume in the graduated cylinder to the nearest 0.1 mL, and record as percent residue.

10.19.1 If the 5-mL graduated cylinder does not have graduations below 1 mL and the volume of liquid is less than 1 mL, prefill the cylinder with 1 mL of a heavy oil to allow a better estimate of the volume of the material recovered.

10.19.1.1 If a residue greater than expected is obtained, and the distillation was not purposely terminated before the EP,

check whether adequate heat was applied towards the end of the distillation and whether conditions during the test conformed to those specified in Table 5. If not, repeat test.

NOTE 18—The distillation residues of this test method for gasoline, kerosine, and distillate diesel are *typically* 0.9–1.3, 0.9–1.3, and 1.0–1.4 volume %, respectively.

NOTE 19—The test method is not designed for the analysis of distillate fuels containing appreciable quantities of residual material (see 1.2).

10.19.2 *Groups 1, 2, 3, and 4*—Record the volume in the 5-mL graduated cylinder, to the nearest 0.1 mL, as percent residue.

10.20 If the intent of the distillation is to determine the percent evaporated or percent recovered at a predetermined corrected temperature reading, modify the procedure to conform to the instructions described in Annex A4.

10.21 Examine the condenser tube and the side arm of the flask for waxy or solid deposits. If found, repeat the test after making adjustments described in Footnote A of Table 5.

11. Calculations

11.1 The percent total recovery is the sum of the percent recovery (see 10.18) and the percent residue (see 10.19). Deduct the percent total recovery from 100 to obtain the percent loss.

11.2 Do not correct the barometric pressure for meniscus depression, and do not adjust the pressure to what it would be at sea level.

NOTE 20—The observed barometric reading does not have to be corrected to a standard temperature and to standard gravity. Even without performing these corrections, the corrected temperature readings for the same sample between laboratories at two different locations in the world will, in general, differ less than 0.1°C at 100°C. Almost all data obtained earlier have been reported at barometric pressures that have not been corrected to standard temperature and to standard gravity.

11.3 Correct temperature readings to 101.3 kPa (760 mm Hg) pressure. Obtain the correction to be applied to each temperature reading by means of the Sydney Young equation as given in Eq 3, Eq 4, or Eq 5, as appropriate, or by the use of Table 6. For Celsius temperatures:

$$C_c = 0.0009\,(101.3 - P_k)\,(273 + t_c) \quad (3)$$

$$C_c = 0.00012\,(760 - P)\,(273 + t_c) \quad (4)$$

For Fahrenheit temperatures:

$$C_f = 0.00012\,(760 - P)\,(460 + t_f) \quad (5)$$

where:

t_c = the observed temperature reading in °C,
t_f = the observed temperature reading in °F,
C_c and C_f = corrections to be added algebraically to the observed temperature readings,
P_k = barometric pressure, prevailing at the time and location of the test, kPa, and
P = barometric pressure, prevailing at the time and location of the test, mm Hg.

After applying the corrections and rounding each result to the nearest 0.5°C (1.0°F) or 0.1°C (0.2°F), as appropriate to the apparatus being used, use the corrected temperature readings in all further calculations and reporting.

TABLE 6 Approximate Thermometer Reading Correction

Temperature Range		Correction[A] per 1.3 kPa (10 mm Hg) Difference in Pressure	
°C	°F	°C	°F
10–30	50–86	0.35	0.63
30–50	86–122	0.38	0.68
50–70	122–158	0.40	0.72
70–90	158–194	0.42	0.76
90–110	194–230	0.45	0.81
110–130	230–266	0.47	0.85
130–150	266–302	0.50	0.89
150–170	302–338	0.52	0.94
170–190	338–374	0.54	0.98
190–210	374–410	0.57	1.02
210–230	410–446	0.59	1.07
230–250	446–482	0.62	1.11
250–270	482–518	0.64	1.15
270–290	518–554	0.66	1.20
290–310	554–590	0.69	1.24
310–330	590–626	0.71	1.28
330–350	626–662	0.74	1.33
350–370	662–698	0.76	1.37
370–390	698–734	0.78	1.41
390–410	734–770	0.81	1.46

[A] Values to be added when barometric pressure is below 101.3 kPa (760 mm Hg) and to be subtracted when barometric pressure is above 101.3 kPa.

NOTE 21—Temperature readings are not corrected to 101.3 kPa (760 mm Hg) when product definitions, specifications, or agreements between the parties involved indicate, specifically, that such correction is not required or that correction shall be made to some other base pressure.

11.4 Correct the actual loss to 101.3 kPa (760 mm Hg) pressure when temperature readings are corrected to 101.3 kPa pressure. The corrected loss, L_c, is calculated from Eq 6 or Eq 7, as appropriate, or can be read from the tables presented as Fig. X3.1 or Fig. X3.2.

$$L_c = 0.5 + (L - 0.5)/\{1 + (101.3 - P_k)/8.00\} \quad (6)$$

$$L_c = 0.5 + (L - 0.5)/\{1 + (760 - P)/60.0\} \quad (7)$$

where:

L = observed loss,
L_c = corrected loss,
P_k = pressure, kPa, and
P = pressure, mm Hg.

NOTE 22—Eq 6 and 7 above have been derived from the data in Table 7 and Eqs 5 and 6 in Test Method D 86 – 95 and earlier versions. It is probable that Eq 6 and 7 shown were the original empirical equations from which the table and equations in the Test Method D 86 – 95 and earlier versions were derived.

11.4.1 Calculate the corresponding corrected percent recovery in accordance with the following equation:

$$R_c = R + (L - L_c) \quad (8)$$

where:

L = percent loss or observed loss,
L_c = corrected loss,
R = percent recovery, and
R_c = corrected percent recovery.

TABLE 7 Data Points for Determining Slope, S_C or S_F

Slope at %	IBP	5	10	20	30	40	50	60	70	80	90	95	EP
T_L at %	0	0	0	10	20	30	40	50	60	70	80	90	95
T_U at %	5	10	20	30	40	50	60	70	80	90	90	95	V_{EP}
V_U- V_L	5	10	20	20	20	20	20	20	20	20	10	5	V_{EP}–95

11.5 To obtain the percent evaporated at a prescribed temperature reading, add the percent loss to each of the observed percent recovered at the prescribed temperature readings, and report these results as the respective percent evaporated, that is:

$$P_e = P_r + L \quad (9)$$

where:
L = observed loss,
P_e = percent evaporated, and
P_r = percent recovered.

11.6 To obtain temperature readings at prescribed percent evaporated, and if no recorded temperature data is available within 0.1 volume % of the prescribed percent evaporated, use either of the two following procedures, and indicate on the report whether the arithmetical procedure or the graphical procedure has been used.

11.6.1 *Arithmetical Procedure*—Deduct the observed loss from each prescribed percent evaporated to obtain the corresponding percent recovered. Calculate each required temperature reading as follows:

$$T = T_L + (T_H - T_L)(R - R_L)/(R_H - R_L) \quad (10)$$

where:
R = percent recovered corresponding to the prescribed percent evaporated,
R_H = percent recovered adjacent to, and higher than R,
R_L = percent recovered adjacent to, and lower than R,
T = temperature reading at the prescribed percent evaporated,
T_H = temperature reading recorded at R_H, and
T_L = temperature reading recorded at R_L.

Values obtained by the arithmetical procedure are affected by the extent to which the distillation graphs are nonlinear. Intervals between successive data points can, at any stage of the test, be no wider than the intervals indicated in 10.18. In no case shall a calculation be made that involves extrapolation.

11.6.2 *Graphical Procedure*—Using graph paper with uniform subdivisions, plot each temperature reading corrected for barometric pressure, if required (see 11.3), against its corresponding percent recovered. Plot the IBP at 0 % recovered. Draw a smooth curve connecting the points. For each prescribed percent evaporated, deduct the distillation loss to obtain the corresponding percent recovered and take from the graph the temperature reading that this percent recovered indicates. Values obtained by graphical interpolation procedures are affected by the care with which the plot is made.

NOTE 23—See Appendix X1 for numerical examples illustrating the arithmetical procedure.

11.6.3 In most automated instruments, temperature-volume data are collected at 0.1 volume % intervals or less and stored in memory. To report a temperature reading at a prescribed percent evaporated, neither of the procedures described in 11.6.1 and 11.6.2 have to be used. Obtain the desired temperature directly from the database as the temperature closest to and within 0.1 volume % of the prescribed percent evaporated.

12. Report

12.1 Report the following information (see Appendix X5 for examples of reports):

12.2 Report the barometric pressure to the nearest 0.1 kPa (1 mm Hg).

12.3 Report all volumetric readings in percentages.

12.3.1 *Manual Method*—Report volumetric readings to the nearest 0.5, and all temperature readings to the nearest 0.5°C (1.0°F).

12.3.2 *Automated Method*—Report volumetric readings to the nearest 0.1, and all temperature readings to the nearest 0.1°C (0.2°F) or less.

12.4 After barometric corrections of the temperature readings have been made, the following data require no further calculation prior to reporting: IBP, dry point, EP (FBP), decomposition point, and all pairs of corresponding values involving percent recovered and temperature readings.

12.4.1 The report shall state if the temperature readings have not been corrected for barometric pressure.

12.5 When the temperature readings have not been corrected to 101.3 kPa (760 mm Hg) pressure, report the percent residue and percent loss as *observed* in accordance with 10.19 and 11.1, respectively.

12.6 Do not use the corrected loss in the calculation of percent evaporated.

12.7 It is advisable to base the report on relationships between temperature readings and percent evaporated when the sample is a gasoline, or any other product classified under Group 1, or in which the percent loss is greater than 2.0. Otherwise, the report can be based on relationships between temperature readings and percent evaporated or percent recovered. Every report must indicate clearly which basis has been used.

12.7.1 In the manual method, if results are given in percent evaporated versus temperature readings, report if the arithmetical or the graphical procedure was used (see 11.6).

12.8 Report if a drying agent, as described in 7.5.2 or 7.5.3, was used.

12.9 Fig. X1.1 is an example of a tabular report. It shows the percent recovered versus the corresponding temperature reading and versus the corrected temperature reading. It also shows the percent loss, the corrected loss, and the percent evaporated versus the corrected temperature reading.

TABLE 8 Repeatability and Reproducibility for Group 1

Evaporated Point, %	Manual Repeatability[A]		Manual Reproducibility[A]		Automated Repeatability[A]		Automated Reproducibility[A]	
	°C	°F	°C	°F	°C	°F	°C	°F
IBP	3.3	6	5.6	10	3.9	7	7.2	13
5	$1.9+0.86S_C$	$3.4+0.86S_F$	$3.1+1.74S_C$	$5.6+1.74S_F$	$2.1+0.67S_C$	$3.8+0.67S_F$	$4.4+2.0S_C$	$7.9+2.0S_F$
10	$1.2+0.86S_C$	$2.2+0.86S_F$	$2.0+1.74S_C$	$3.6+1.74S_F$	$1.7+0.67S_C$	$3.0+0.67S_F$	$3.3+2.0S_C$	$6.0+2.0S_F$
20	$1.2+0.86S_C$	$2.2+0.86S_F$	$2.0+1.74S_C$	$3.6+1.74S_F$	$1.1+0.67S_C$	$2.0+0.67S_F$	$3.3+2.0S_C$	$6.0+2.0S_F$
30–70	$1.2+0.86S_C$	$2.2+0.86S_F$	$2.0+1.74S_C$	$3.6+1.74S_F$	$1.1+0.67S_C$	$2.0+0.67S_F$	$2.6+2.0S_C$	$4.7+2.0S_F$
80	$1.2+0.86S_C$	$2.2+0.86S_F$	$2.0+1.74S_C$	$3.6+1.74S_F$	$1.1+0.67S_C$	$2.0+0.67S_F$	$1.7+2.0S_C$	$3.0+2.0S_F$
90	$1.2+0.86S_C$	$2.2+0.86S_F$	$0.8+1.74S_C$	$1.4+1.74S_F$	$1.1+0.67S_C$	$2.0+0.67S_F$	$0.7+2.0S_C$	$1.2+2.0S_F$
95	$1.2+0.86S_C$	$2.2+0.86S_F$	$1.1+1.74S_C$	$1.9+1.74S_F$	$2.5+0.67S_C$	$4.5+0.67S_F$	$2.6+2.0S_C$	$4.7+2.0S_F$
FBP	3.9	7	7.2	13	4.4	8	8.9	16

[A] S_C or S_F is the average slope (or rate of change) calculated in accordance with 13.2.

13. Precision and Bias

13.1 *Precision*:

13.1.1 The precision of this test method has been determined by the statistical examination of interlaboratory test results obtained by 26 laboratories on 14 gasolines, by 4 laboratories on 8 samples of kerosine by the manual procedure, 3 laboratories on 6 samples of kerosine by the automated procedure, and 5 laboratories on 10 samples of diesel fuel by both the manual and automated procedures. Table A1.1 lists which tables and figures are to be used for the different fuel groups, distillation methods, and temperature scales.

13.1.2 The following terms are used in this section: (*1*) r = repeatability and (*2*) R = reproducibility. The value of any of these terms will depend upon whether the calculations were carried out in °C or °F.

13.2 *Slope or Rate of Change of Temperature*:

13.2.1 To determine the precision of a result, it is generally necessary to determine the slope or rate of change of the temperature at that particular point. This variable, denoted as S_C or S_F, is equal to the change in temperature, either in °C or in °F, respectively, per percent recovered or evaporated.

13.2.2 For Group 1 in the manual method and for all groups in the automated method, the precision of the IBP and EP does not require any slope calculation.

13.2.3 With the exception stated in 13.2.2 and in 13.2.4, the slope at any point during the distillation is calculated from the following equations, using the values shown in Table 7:

$$S_C \text{ (or } S_F) = (T_U - T_L) / (V_U - V_L) \quad (11)$$

where:

S_C = is the slope, °C/volume %,
S_F = is the slope, °F/volume %,
T_U = is the upper temperature, °C (or °F),
T_L = is the lower temperature, °C (or °F),
V_U = is the volume % recovered or evaporated corresponding to T_U,
V_L = is the volume % recovered or evaporated corresponding to T_L, and
V_{EP} = is the volume % recovered or evaporated corresponding to the end point.

13.2.4 In the event that the distillation end point occurs prior to the 95 % point, the slope at the end point is calculated as follows:

$$S_C \text{ (or } S_F) = (T_{EP} - T_{HR}) / (V_{EP} - V_{HR}) \quad (12)$$

where:

T_{EP} or T_{HR} is the temperature, in °C or °F at the percent volume recovered indicated by the subscript,

V_{EP} or V_{HR} is the volume % recovered.

13.2.4.1 The subscripts in Eq 12 refer to:

EP = end point
HR = highest reading, either 80 % of 90 %, prior to the end point.

13.2.5 For points between 10 to 85 % recovered which are not shown in Table 7, the slope is calculated as follows:

$$S_C \text{ (or } S_F) = 0.05 \, (T_{(V+10)} - T_{(V-10)}) \quad (13)$$

13.2.6 For samples in Group 1, the precision data reported are based on slope values calculated from percent evaporated data.

13.2.7 For samples in Group 2, 3, and 4, the precision data reported (Table 8) are based on slope values calculated from percent recovered data.

13.2.8 When results are reported as volume % recovered, slope values for the calculation of precision are to be determined from percent recovered data; when results are reported as volume % evaporated slope values are to be determined from % evaporated data.

13.3 *Manual Method*:

13.3.1 *Repeatability*:

13.3.1.1 *GROUP 1*—The difference between successive results obtained by the same operator with the same apparatus under constant operating conditions on identical test material would, in the long run, in the normal and correct operation of this test method, exceed the values calculated from Table 9 in only one case in twenty.

13.3.1.2 *GROUPS 2, 3, and 4*—The difference between successive results obtained by the same operator with the same apparatus under constant operating conditions on identical test material would, in the long run, in the normal and correct operation of this test method, exceed the values calculated from the values in Table 9 in only one case in twenty.

13.3.2 *Reproducibility*:

TABLE 9 Repeatability and Reproducibility for Groups 2, 3 and 4 (Manual Method)

	Repeatability[A]		Reproducibility[A]	
	°C	°F	°C	°F
IBP	$1.0+0.35S_C$	$1.9+0.35S_F$	$2.8+0.93S_C$	$5.0+0.93S_F$
5—95 %	$1.0+0.41S_C$	$1.8+0.41S_F$	$1.8+1.33S_C$	$3.3+1.33S_F$
FBP	$0.7+0.36S_C$	$1.3+0.36S_F$	$3.1+0.42S_C$	$5.7+0.42S_F$
% volume at temperature reading	$0.7+0.92/S_C$	$0.7+1.66/S_F$	$1.5+1.78/S_C$	$1.53+3.20/S_F$

[A] Calculate S_C or S_F from 13.2.

13.3.2.1 *GROUP 1*—The difference between two single and independent results obtained by different operators working in different laboratories on identical test material would, in the normal and correct operation of this method, exceed the values calculated from Table 9 in only one case in twenty.[7]

13.3.2.2 *GROUPS 2, 3, and 4*—The difference between two single and independent results obtained by different operators working in different laboratories on identical test material would, in the normal and correct operation of this test method, exceed the values calculated from the data in Table 9 in only one case in twenty.[8]

13.4 *Automated Method*:

13.4.1 *Repeatability*:

13.4.1.1 *GROUP 1*—The difference between successive results obtained by the same operator with the same apparatus under constant operating conditions on identical test material would, in the long run, in the normal and correct operation of this test method, exceed the values calculated from Table 8 in only one case in twenty.

13.4.1.2 *GROUPS 2, 3, and 4*—The difference between successive results obtained by the same operator with the same apparatus under constant operating conditions on identical test material would, in the long run, in the normal and correct operation of this test method, exceed the values calculated from Table 10 in only one case in twenty.

13.4.2 *Reproducibility*:

13.4.2.1 *GROUP 1*—The difference between two single and independent results obtained by different operators working in different laboratories on identical test material would, in the normal and correct operation of this test method, exceed the values calculated from Table 8 in only one case in twenty.[7]

13.4.2.2 *GROUPS 2, 3, and 4*—The difference between two single and independent results obtained by different operators working in different laboratories on identical test material would, in the normal and correct operation of this test method, exceed the values calculated from Table 10 in only one case in twenty.

13.5 *Bias*:

13.5.1 *Bias*—Due to the use of total immersion thermometers, or temperature sensing systems designed to emulate them, the distillation temperatures in this test method are somewhat lower than the true temperatures. The amount of bias depends on the product being distilled and the thermometer used.

13.5.2 *Relative Bias*—There exists a bias between the empirical results of distillation properties obtained by this test method and the true boiling point distillation curve obtained by Test Method D 2892. The magnitude of this bias, and how it relates to test precision, has not been rigorously studied.

13.5.3 *Relative Bias*—An interlaboratory study[5] conducted in 2003 using manual and automated apparatus has concluded that there is no statistical evidence to suggest that there is a bias between manual and automated results.

14. Keywords

14.1 batch distillation; distillates; distillation; laboratory distillation; petroleum products

[7] Precision data obtained from RR study on both manual and automated D 86 units by North American and IP Laboratories.

[8] Table 9 has been derived from the nomographs in Figs. 6 and 7 in ASTM D 86–97.

TABLE 10 Repeatability and Reproducibility for Groups 2, 3 and 4 (Automated)

Collected, %	Repeatability[A]		Reproducibility[A]	
	°C	°F	°C	°F
IBP	3.5	6.3	8.5	15.3
2 %	3.5	6.3	$2.6 + 1.92S_C$	$4.7 + 1.92S_F$
5 %	$1.1 + 1.08S_C$	$2.0 + 1.08S_F$	$2.0 + 2.53S_C$	$3.6 + 2.53S_F$
10 %	$1.2 + 1.42S_C$	$2.2 + 1.42S_F$	$3.0 + 2.64S_C$	$5.4 + 2.64S_F$
20–70 %	$1.2 + 1.42S_C$	$2.2 + 1.42S_F$	$2.9 + 3.97S_C$	$5.2 + 3.97S_F$
80 %	$1.2 + 1.42S_C$	$2.2 + 1.42S_F$	$3.0 + 2.64S_C$	$5.4 + 2.64S_F$
90–95 %	$1.1 + 1.08S_C$	$2.0 + 1.08S_F$	$2.0 + 2.53S_C$	$3.6 + 2.53S_F$
FBP	3.5	6.3	10.5	18.9

[A] S_C or S_F is the average slope (or rate of change) calculated in accordance with 13.5.

ANNEXES

(Mandatory Information)

A1. REPEATABILITY AND REPRODUCIBILITY DEFINITION AIDS

A1.1 Table A1.1 is an aid for determining which repeatability and reproducibility table or section, is to be used.

TABLE A1.1 Summary of Aids for Definition of Repeatability and Reproducibility

Group	Method	Temperature Scale	Table or Section to Use	
			Repeatability	Reproducibility
1	Manual	°C	Table 8	Table 8
		°F	Table 8	Table 8
1	Automated	°C	Table 8	Table 8
		°F	Table 8	Table 8
2,3,4	Manual	°C	Table 9	Table 9
		°F	Table 9	Table 9
2,3,4	Automated	°C	Table 10	Table 10
		°F	Table 10	Table 10

A2. DETAILED DESCRIPTION OF APPARATUS

A2.1 *Distillation Flasks*—Flasks shall be of heat resistant glass, constructed to the dimensions and tolerances shown in Fig. A2.1 and shall otherwise comply with the requirements of Specification E 1405. Flask A (100 mL) may also be constructed with a ground glass joint, in which case the diameter of the neck shall be the same as the 125-mL flask.

NOTE A2.1—For tests specifying dry point, specially selected flasks with bottoms and walls of uniform thickness are desirable.

A2.2 *Condenser and Condenser Bath*—Typical types of condenser and condenser baths are illustrated in Figs. 1 and 2.

A2.2.1 The condenser shall be made of seamless noncorrosive metal tubing, 560 ± 5 mm in length, with an outside diameter of 14 mm and a wall thickness of 0.8 to 0.9 mm.

NOTE A2.2—Brass or stainless steel has been found to be a suitable material for this purpose.

A2.2.2 The condenser shall be set so that 393 ± 3 mm of the tube is in contact with the cooling medium, with 50 ± 3 mm outside the cooling bath at the upper end, and with 114 ± 3 mm outside at the lower end. The portion of the tube projecting at the upper end shall be set at an angle of 75 ± 3° with the vertical. The portion of the tube inside the condenser bath shall be either straight or bent in any suitable continuous smooth curve. The average gradient shall be 15 ± 1° with respect to the horizontal, with no 10-cm section having a gradient outside of the 15 ± 3° range. The projecting lower portion of the condenser tube shall be curved downward for a length of 76 mm and the lower end shall be cut off at an acute angle. Provisions shall be made to enable the flow of the distillate to run down the side of the receiving cylinder. This can be accomplished by using a drip-deflector, which is attached to the outlet of the tube. Alternatively, the lower portion of the condenser tube can be curved slightly backward to ensure

contact with the wall of the receiving cylinder at a point 25 to 32 mm below the top of the receiving cylinder. Fig. A2.3 is a drawing of an acceptable configuration of the lower end of the condenser tube.

A2.2.3 The volume and the design of the bath will depend on the cooling medium employed. The cooling capacity of the bath shall be adequate to maintain the required temperature for the desired condenser performance. A single condenser bath may be used for several condenser tubes.

A2.3 *Metal Shield or Enclosure for Flask.* (Manual units only).

A2.3.1 *Shield for Gas Burner (see* Fig. 1*)*—The purpose of this shield is to provide protection for the operator and yet allow easy access to the burner and to the distillation flask during operation. A typical shield would be 480-mm high, 280-mm long and 200-mm wide, made of sheet metal of 0.8-mm thickness (22 gauge). The shield shall be provided with at least one window to observe the dry point at the end of the distillation.

A2.3.2 *Shield for Electric Heater (see* Fig. 2*)*—A typical shield would be 440-mm high, 200-mm long, and 200-mm wide, made of sheet metal of approximately 0.8-mm thickness (22 gauge) and with a window in the front side. The shield shall be provided with at least one window to observe the dry point at the end of the distillation.

A2.4 *Heat Source:*

A2.4.1 *Gas Burner* (see Fig. 1), capable of bringing over the first drop from a cold start within the time specified and of continuing the distillation at the specified rate. A sensitive manual control valve and gas pressure regulator to give complete control of heating shall be provided.

A2.4.2 *Electric Heater* (see Fig. 2), of low heat retention.

NOTE A2.3—Heaters, adjustable from 0 to 1000 W, have been found to be suitable for this purpose.

A2.5 *Flask Support:*

A2.5.1 *Type 1*—Use a Type 1 flask support with a gas burner (see Fig. 1). This support consists of either a ring support of the ordinary laboratory type, 100 mm or larger in diameter, supported on a stand inside the shield, or a platform adjustable from the outside of the shield. On this ring or platform is mounted a hard board made of ceramic or other heat-resistant material, 3 to 6 mm in thickness, with a central opening 76 to 100 mm in diameter, and outside line dimensions slightly smaller than the inside boundaries of the shield.

A2.5.2 *Type 2*—Use a Type 2 flask support assembly with electric heating (see Fig. 2 as one example). The assembly consists of an adjustable system onto which the electric heater is mounted with provision for placement of a flask support board (see A2.6) above the electric heater. The whole assembly is adjustable from the outside of the shield.

A2.6 *Flask Support Board*—The flask support board shall be constructed of ceramic or other heat-resistant material, 3 to 6 mm in thickness. Flask support boards are classified as A, B, or C, based on the size of the centrally located opening, the dimension of which is shown in Table 1. The flask support board shall be of sufficient dimension to ensure that thermal heat to the flask only comes from the central opening and that extraneous heat to the flask other than through the central opening is minimized. (**Warning**—Asbestos-containing materials shall not be used in the construction of the flask support board.)

A2.7 The flask support board can be moved slightly in different directions on the horizontal plane to position the distillation flask so that direct heat is applied to the flask only through the opening in this board. Usually, the position of the flask is set by adjusting the length of the side-arm inserted into the condenser.

A2.8 Provision shall be made for moving the flask support assembly vertically so that the flask support board is in direct contact with the bottom of the distillation flask during the distillation. The assembly is moved down to allow for easy mounting and removal of the distillation flask from the unit.

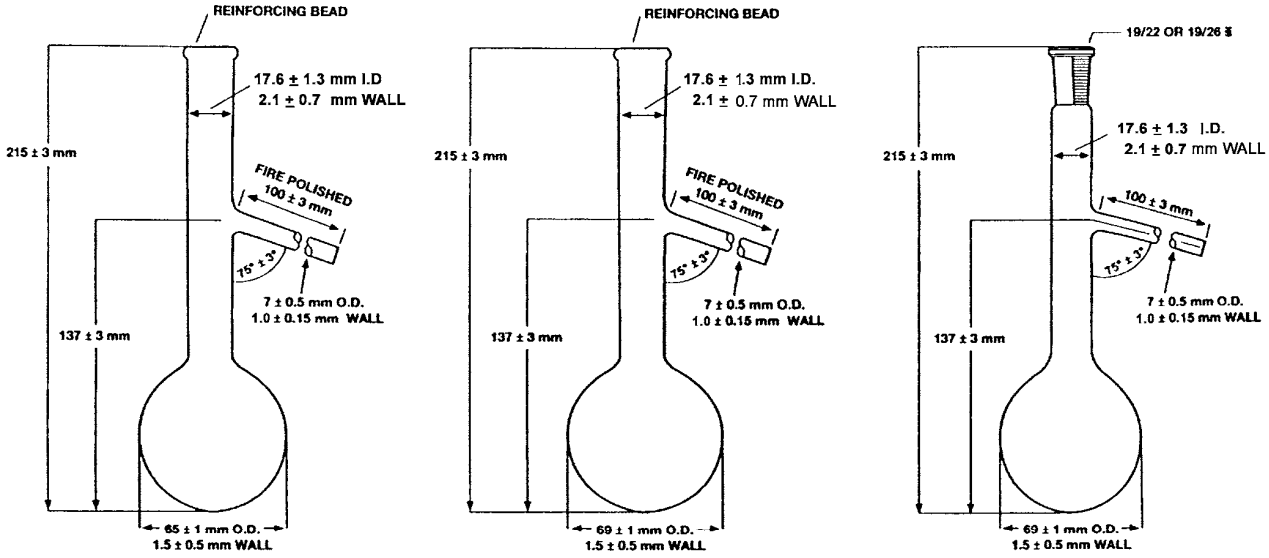
A2.9 *Receiving Cylinders*—The receiving cylinder shall have a capacity to measure and collect 100 mL. The shape of the base shall be such that the receiver does not topple when placed empty on a surface inclined at an angle of 13° from the horizontal.

A2.9.1 *Manual Method*—The cylinder shall be graduated at intervals of 1 mL and have a graduation at the 100-mL mark. Construction details and tolerances for the graduated cylinder are shown in Fig. A2.4.

A2.9.2 *Automated Method*—The cylinder shall conform to the physical specifications described in Fig. A2.4, except that graduations below the 100-mL mark are permitted, as long as they do not interfere with the operation of the level follower. Receiving cylinders for use in automated units may also have a metal base.

A2.9.3 If required, the receiving cylinder shall be immersed during the distillation to above the 100-mL graduation line in a cooling liquid contained in a cooling bath, such as a tall-form beaker of clear glass or transparent plastic. Alternatively, the receiving cylinder may be placed in a thermostated bath air circulation chamber.

A2.10 *Residue Cylinder*—The graduated cylinder shall have a capacity of 5 or 10 mL, with graduations into 0.1 mL subdivisions, beginning at 0.1 mL. The top of the cylinder may be flared, the other properties shall conform to Specification E 1272.



Flask A, 100 mL Flask B, 125 mL Flask B, 125 mL

FIG. A2.1 Flask A, 100 mL, Flask B, 125 mL, and Flask B with Ground Glass Joint, 125 mL

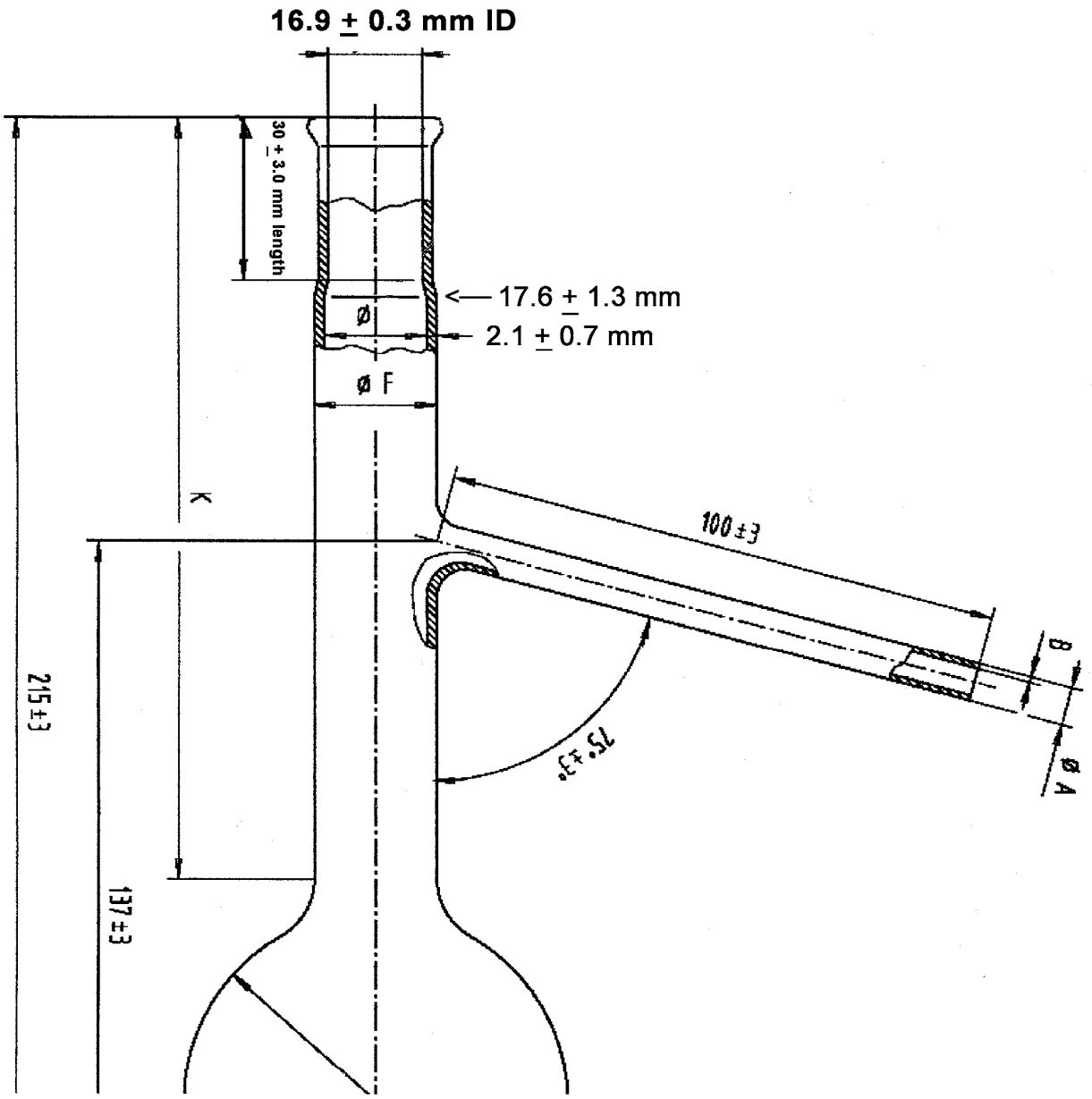
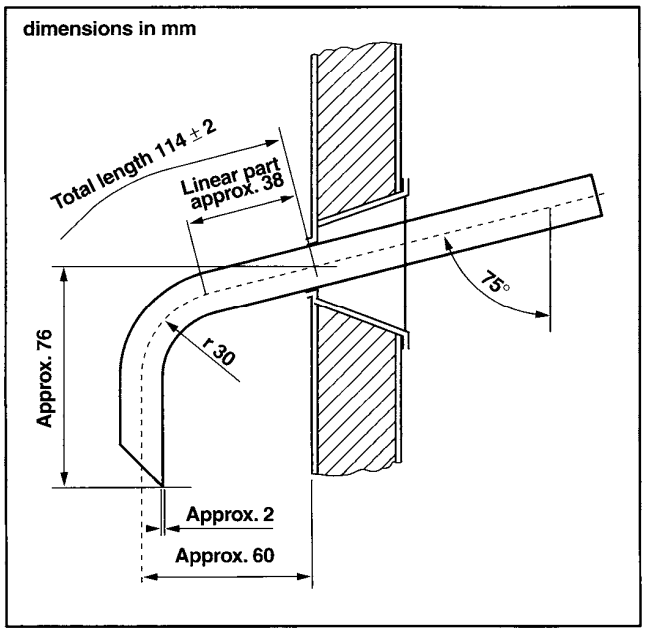
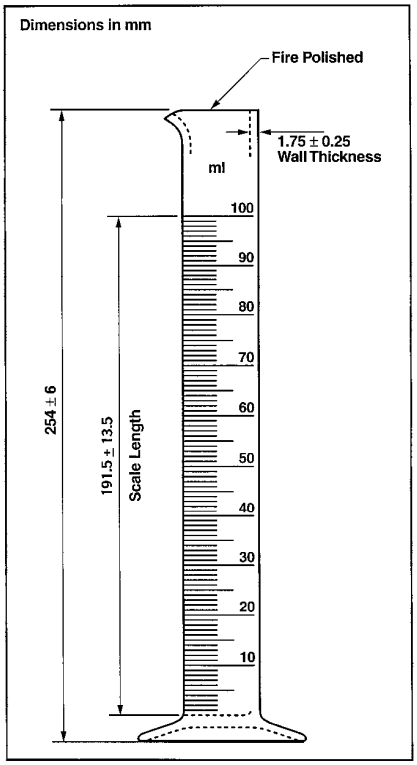


FIG. A2.2 Detail of Upper Neck Section



Lower End of Condenser Tube

FIG. A2.3 Lower End of Condenser Tube



NOTE—1 to 100 mL in 1 mL graduations; tolerance ± 1.0 mL.

FIG. A2.4 100 mL Graduated Cylinder

A3. DETERMINATION OF THE DIFFERENCE IN LAG TIME BETWEEN AN ELECTRONIC TEMPERATURE MEASUREMENT SYSTEM AND A MERCURY-IN-GLASS THERMOMETER

A3.1 The response time of an electronic temperature measuring device is inherently more rapid than that of a mercury-in-glass thermometer. The temperature measuring device assembly in general use, consisting of the sensor and its casing, or an electronic system and its associated software, or both, is so designed that the temperature measuring system will simulate the temperature lag of the mercury-in-glass thermometer.

A3.2 To determine the difference in lag time between such a temperature measuring system and a mercury-in-glass thermometer, analyze a sample such as gasoline, kerosine, jet fuel, or light diesel fuel with the electronic temperature measurement system in place and in accordance with the procedures described in this test method. In most cases this is the standard distillation step performed with an automated unit.

A3.2.1 Do not use a single pure compound, a very narrow boiling range product, or a synthetic blend of less than six compounds for this test.

A3.2.2 Best results are obtained with a sample that is typical of the sample load of the laboratory. Alternatively, use a full-range mixture with a 5 to 95 % boiling range of at least 100°C.

A3.3 Replace the electronic temperature measuring device with a low range or a high range mercury-in-glass thermometer, depending on the boiling range of the sample.

A3.4 Repeat the distillation with this thermometer, and manually record the temperature at the various percent recovered as described in 10.14.

A3.5 Calculate the values for the repeatability for the observed slope ($\Delta T/\Delta V$) for the different readings in the test.

A3.6 Compare the test data obtained using these two temperature measuring devices. The difference at any point shall be equal to, or less than, the repeatability of the method at that point. If this difference is larger, replace the electronic temperature measuring device or adjust the electronics involved, or both.

A4. PROCEDURE TO DETERMINE THE PERCENT EVAPORATED OR PERCENT RECOVERED AT A PRESCRIBED TEMPERATURE READING

A4.1 Many specifications require specific percentages evaporated or recovered at prescribed temperature readings, either as maxima, minima, or ranges. The procedures to determine these values are frequently designated by the terms Exxx or Rxxx, where xxx is the desired temperature.

NOTE A4.1—Regulatory standards on the certification of reformulated gasoline under the complex model procedure require the determination of E 200 and E 300, defined as the percent evaporated fuel at 93.3°C (200°F) and 148.9°C (300°F), respectively. E 158, the percent evaporated at a distillation temperature of 70°C (158°F), is also used in describing fuel volatility characteristics. Other typical temperatures are R 200 for kerosines and R 250 and R 350 for gas oils, where R 200, R 250, and R 350 are the percent recovered fuel at 200°C, 250°C, and 350°C, respectively.

A4.2 Determine the barometric pressure, and calculate the correction to the desired temperature reading using Eq 3, Eq 4, or Eq 5 for t = xxx°C (or t_f = xxx°F).

A4.2.1 *Manual Method*—Determine this correction to 0.5°C (1°F).

A4.2.2 *Automated Method*—Determine this correction to 0.1°C (0.2°F).

A4.3 Determine the expected temperature reading to yield xxx°C (or xxx°F) after the barometric correction. To obtain the expected value, add the absolute value of the calculated correction to the desired temperature if the barometric pressure is above 101.3 kPa. If the barometric pressure is below 101.3 kPa, subtract the absolute value of the calculated correction from the desired temperature.

A4.4 Perform the distillation, as described in Section 10, while taking into account A4.5 and A4.6.

A4.5 *Manual Distillation:*

A4.5.1 In the region between about 10°C below and 10°C above the desired expected temperature reading determined in A4.3 record the temperature reading in intervals of 1 volume %.

A4.5.2 If the intent of the distillation is to solely determine the value of Exxx or Rxxx, discontinue the distillation after at least another 2 mL of distillate have been collected. Otherwise, continue the distillation, as described in Section 10, and determine the observed loss, as described in 11.1.

A4.5.2.1 If the intent of the distillation is to determine the value of Exxx and the distillation was terminated after about 2 mL of distillate was collected beyond the desired temperature, allow the distillate to drain into the receiving graduate. Allow the contents of the flask to cool to below approximately 40°C and then drain its contents into the receiving graduate. Note the volume of product in the receiving graduate to the nearest 0.5 mL at 2 min intervals until two successive observations agree.

A4.5.2.2 The amount recovered in the receiving graduate is the percent recovery. Determine the amount of observed loss by subtracting the percent recovery from 100.0.

A4.6 *Automated Distillation:*

A4.6.1 In the region between about 10°C below and 10°C above the desired expected temperature reading determined in A4.3, collect temperature-volume data at 0.1 volume % intervals or less.

A4.6.2 Continue the distillation, as described in Section 10, and determine the percent loss, as described in 11.1.

A4.7 *Calculations:*

A4.7.1 *Manual Method*—If a volume % recovered reading is not available at the exact temperature calculated in A4.3, determine the percent recovered by interpolation between the two adjacent readings. Either the linear, as described in 11.6.1, or the graphical procedure, as described in 11.6.2, is permitted. The percent recovered is equal to Rxxx.

A4.7.2 *Automated Method*—Report the observed volume to 0.1 volume % corresponding to the temperature closest to the expected temperature reading. This is the percent recovered, or Rxxx.

A4.7.3 *Manual and Automated Methods*—To determine the value of Exxx, add the observed loss to the percent recovered, Rxxx, as determined in A4.7.1 or A4.7.2 and as described in Eq 9.

A4.7.3.1 As prescribed in 12.6, do not use the corrected loss.

A4.8 *Precision:*

A4.8.1 The statistical determination of the precision of the volume % evaporated or recovered at a prescribed temperature has not been directly measured in an interlaboratory program. It can be shown that the precision of the volume % evaporated or recovered at a prescribed temperature is equivalent to the precision of the temperature measurement at that point divided by the rate of change of temperature versus volume % evaporated or recovered. The estimation of precision becomes less precise at high slope values.

A4.8.2 Calculate the slope or rate of change in temperature reading, S_C(or S_F), as described in 13.2 and Eq 11 and using temperature values bracketing the desired temperature.

A4.8.3 Calculate the repeatability, r, or the reproducibility, R, from the slope, S_C (or S_F), and the data in Table 8, Table 9, or Table 10.

A4.8.4 Determine the repeatability or reproducibility, or both, of the volume % evaporated or recovered at a prescribed temperature from the following formulas:

$$^{r}\text{volume \%} = r/S_C\,(S_F) \quad \text{(A4.1)}$$

$$^{R}\text{volume \%} = R/S_C\,(S_F) \quad \text{(A4.2)}$$

where:

^{r}volume % = repeatability of the volume % evaporated or recovered,

^{R}volume % = reproducibility of the volume % evaporated or recovered,

r = repeatability of the temperature at the prescribed temperature at the observed percent distilled,

R = reproducibility of the temperature at the prescribed temperature at the observed percent distilled, and

$S_C(S_F)$ = rate of change in temperature reading in °C (°F) per the volume % evaporated or recovered.

A4.8.5 Examples on how to calculate the repeatability and the reproducibility are shown in Appendix X2.

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES ILLUSTRATING CALCULATIONS FOR REPORTING OF DATA

X1.1 The observed distillation data used for the calculation of the examples below are shown in the first three columns of Fig. X1.1.

X1.1.1 Temperature readings corrected to 101.3 kPa (760 mm Hg) pressure (see 11.3) are as follows:

$$\text{correction } (°C) = 0.0009\,(101.3 - 98.6)\,(273 + t_c) \quad \text{(X1.1)}$$

$$\text{correction } (°F) = 0.00012\,(760 - 740)\,(460 + t_f) \quad \text{(X1.2)}$$

X1.1.2 Loss correction to 101.3 kPa (see 11.4) are as follows. The data for the examples are taken from Fig. X1.1.

$$\text{corrected loss} = (0.5 + (4.7 - 0.5)/\{1 + (101.3 - 98.6)/8.0\} = 3.6 \quad \text{(X1.3)}$$

X1.1.3 Recovery correction to 101.3 kPa (see 11.4.1) are as follows:

$$\text{corrected recovery} = 94.2 + (4.7 - 3.6) = 95.3 \quad \text{(X1.4)}$$

X1.2 *Temperature Readings at Prescribed Percent Evaporated:*

X1.2.1 Temperature reading at 10 % evaporated (4.7 % observed loss = 5.3 % recovered) (see 11.6.1) are as follows:

$$T_{10E}\,(°C) = 33.7 + [(40.3 - 33.7)\,(5.3 - 5)/(10 - 5)] = 34.1°C \quad \text{(X1.5)}$$

$$T_{10E}\,(°F) = 92.7 + [(104.5 - 92.7)\,(5.3 - 5)/(10 - 5)] = 93.1°F \quad \text{(X1.6)}$$

X1.2.2 Temperature reading at 50 % evaporated (45.3 % recovered) (see 11.6.1) are as follows:

$$T_{50E}\,(°C) = 93.9 + [(108.9 - 93.9)\,(45.3 - 40)/(50 - 40)] = 101.9°C \quad \text{(X1.7)}$$

$$T_{50E}\,(°F) = 201 + [(228 - 201)\,(45.3 - 40)/(50 - 40)] = 215.3°F \quad \text{(X1.8)}$$

X1.2.3 Temperature reading at 90 % evaporated (85.3 % recovered) (see 11.6.1) are as follows:

$$T_{90E}\,(°C) = 181.6 + [(201.6 - 181.6)\,(85.3 - 85)/(90 - 85)\,] = 182.8°C \quad \text{(X1.9)}$$

$$T_{90E}\,(°F) = 358.9 + [(394.8 - 358.9) \quad \text{(X1.10)}$$
$$(85.3 - 85)/(90 - 85)] = 361.0°F$$

X1.2.4 Temperature reading at 90 % evaporated (85.3 % recovered) not corrected to 101.3 kPa pressure (see 11.6.1) are as follows:

$$T_{90E}\,(°C) = 180.5 + [(200.4 - 180.5) \quad \text{(X1.11)}$$
$$(85.3 - 85)/(90 - 85)] = 181.7°C$$
$$T_{90E}\,(°F) = 357 + [(392 - 357) \quad \text{(X1.12)}$$
$$(85.3 - 85)/(90 - 85)] = 359.1°F$$

NOTE X1.1—Results calculated from °C data may not correspond exactly to results calculated from °F data because of errors in rounding.

Sample ID:
Date analyzed:
Equipment No:
Remarks:

Barometric pressure: 98.6 kPa
Analyst:

% recovered	Barometric pressure observed 98.6 kPa 740 mm Hg °C	°F	corrected 101.3 kPa 760 mm Hg °C	°F	% evaporated	procedure arithmetical/~~graphical~~ T_{evap} °C	°F
IBP	25.5	78	26.2	79.2	5	26.7	80.0
5	33.0	91	33.7	92.7	10	34.1	93.4
10	39.5	103	40.3	104.5	15	40.7	105.2
15	46.0	115	46.8	116.2	20	47.3	117.1
20	54.5	130	55.3	131.5	30	65.7	150.2
30	74.0	165	74.8	166.7	40	84.9	184.9
40	93.0	199	93.9	201.0	50	101.9	215.3
50	108.0	226	108.9	228.0	60	116.9	242.4
60	123.0	253	124.0	255.1	70	134.1	273.3
70	142.0	288	143.0	289.4	80	156.0	312.8
80	166.5	332	167.6	333.6	85	168.4	335.1
85	180.5	357	181.6	358.9	90	182.8	361.0
90	200.4	393	201.6	394.8	95	202.4	396.3
EP	215.0	419	216.2	421.1			
recovered, %	94.2		95.3				
residue, %	1.1		1.1				
loss, %	4.7		3.6				

FIG. X1.1 Example of Test Report

X2. EXAMPLES OF CALCULATION OF REPEATABILITY AND REPRODUCIBILITY OF VOLUME % (RECOVERED OR EVAPORATED) AT A PRESCRIBED TEMPERATURE READING

X2.1 Some specifications require the reporting of the volume % evaporated or recovered at a prescribed temperature. Table X2.1 shows the distillation data of a Group 1 sample as obtained by an automated unit.

X2.2 *Example Calculation:*

X2.2.1 For a Group 1 sample exhibiting distillation characteristics as per Table X2.1, as determined by an automated unit, the reproducibility of the volume evaporated,^{R}volume %, at 93.3°C (200°F) is determined as follows:

X2.2.1.1 Determine first the slope at the desired temperature:

$$S_C\ \% = 0.1\ (T_{(20)} - T_{(10)}) \quad \text{(X2.1)}$$
$$= 0.1\ (94 - 83)$$
$$= 1.1$$
$$S_F\ \% = 0.1\ (T_{(20)} - T_{(10)})$$
$$= 0.1\ (201 - 182)$$
$$= 1.9$$

X2.2.2 From Table 9, determine the value of R, the reproducibility at the observed percentage distilled. In this case, the observed percentage distilled is 18 % and

$$R = 3.3 + 2.0\ (S_C) \quad \text{(X2.2)}$$
$$= 3.3 + 2.0 \times 1.1$$
$$= 5.5$$
$$R = 6.0 + 2.0\ (S_F)$$
$$= 6.0 + 2.0 \times 1.9$$
$$= 9.8$$

X2.2.3 From the calculated value of R, determine the value of volume, as described in A4.8.4.

$$R \text{ volume } \% = R/(S_C) \quad \text{(X2.3)}$$
$$= 5.5/1.1$$
$$= 5.0$$
$$R \text{ volume } \% = R/(S_F)$$
$$= 9.8/1.9$$
$$= 5.1$$

TABLE X2.1 Distillation Data from a Group 1 Sample Automated Distillation

Distillation Point Recovered, mL	Temperature° C	Temperature °F	Volume (mL) Recovered at 93.3°C (200°F)
			18.0
10	84	183	
20	94	202	
30	103	217	
40	112	233	
Distillation Point Evaporated, mL	**Temperature° C**	**Temperature° F**	**Volume (mL0 Evaporated at 93.3°C (200°F)**
			18.4
10	83	182	
20	94	201	
30	103	217	
40	111	232	

X3. TABLES OF CORRECTED LOSS FROM MEASURED LOSS AND BAROMETRIC PRESSURE

X3.1 The table presented as Fig. X3.1 can be used to determine the corrected loss from the measured loss and the barometric pressure in kPa.

X3.2 The table presented as Fig. X3.2 can be used to determine the corrected loss from the measured loss and the barometric pressure in mm Hg.

Barometric Pressure, kPa

from	76.1	80.9	84.5	87.3	89.6	91.5	93.1	94.1	95.5	96.4	97.2	97.9	98.4	98.9	99.5	100.0	100.4	100.8	101.2	101.5	102.0	102.4	102.8	103.2
through	80.8	84.4	87.2	89.5	91.4	93.0	94.0	95.4	96.3	97.1	97.8	98.3	98.8	99.4	99.9	100.3	100.7	101.1	101.4	101.9	102.3	102.7	103.1	103.5

Observed Loss	/– – Corrected Loss – – – – – >																						
Units																							
0	0.37	0.35	0.33	0.31	0.29	0.27	0.25	0.23	0.20	0.18	0.16	0.14	0.13	0.11	0.09	0.06	0.04	0.02	−0.00	−0.02	−0.06	−0.09	−0.13	−0.17
1	0.63	0.65	0.67	0.69	0.71	0.73	0.75	0.78	0.80	0.82	0.84	0.86	0.87	0.89	0.92	0.94	0.96	0.98	1.00	1.03	1.06	1.09	1.13	1.17
2	0.89	0.95	1.01	1.08	1.14	1.20	1.26	1.33	1.40	1.46	1.52	1.57	1.62	1.68	1.75	1.81	1.87	1.94	2.00	2.08	2.17	2.27	2.38	2.51
3	1.15	1.25	1.36	1.46	1.57	1.67	1.77	1.88	1.99	2.09	2.19	2.28	2.37	2.47	2.58	2.69	2.79	2.90	3.00	3.13	3.29	3.45	3.63	3.84
4	1.41	1.56	1.70	1.84	1.99	2.14	2.28	2.43	2.59	2.73	2.87	3.00	3.12	3.26	3.41	3.56	3.70	3.85	4.00	4.18	4.40	4.63	4.89	5.18
5	1.68	1.86	2.04	2.23	2.42	2.61	2.79	2.98	3.19	3.37	3.55	3.71	3.87	4.05	4.25	4.44	4.62	4.81	5.00	5.23	5.51	5.81	6.14	6.52
6	1.94	2.16	2.39	2.61	2.84	3.08	3.30	3.53	3.78	4.01	4.23	4.42	4.62	4.84	5.08	5.31	5.53	5.77	6.00	6.28	6.63	6.99	7.40	7.86
7	2.20	2.46	2.73	3.00	3.27	3.55	3.80	4.08	4.38	4.65	4.90	5.14	5.37	5.63	5.91	6.18	6.44	6.73	7.00	7.33	7.74	8.17	8.65	9.20
8	2.46	2.76	3.07	3.38	3.70	4.02	4.31	4.63	4.98	5.28	5.58	5.85	6.12	6.41	6.74	7.06	7.36	7.69	8.00	8.38	8.86	9.35	9.90	10.53
9	2.72	3.07	3.41	3.76	4.12	4.49	4.82	5.18	5.57	5.92	6.26	6.56	6.87	7.20	7.57	7.93	8.27	8.65	9.00	9.43	9.97	10.53	11.16	11.87
10	2.98	3.37	3.76	4.15	4.55	4.96	5.33	5.73	6.17	6.56	6.94	7.28	7.62	7.99	8.41	8.81	9.19	9.60	10.00	10.48	11.08	11.71	12.41	13.21
11	3.24	3.67	4.10	4.53	4.97	5.43	5.84	6.28	6.77	7.20	7.61	7.99	8.37	8.78	9.24	9.68	10.10	10.56	11.00	11.53	12.20	12.89	13.67	14.55
12	3.50	3.97	4.44	4.92	5.40	5.90	6.35	6.83	7.36	7.84	8.29	8.71	9.12	9.57	10.07	10.56	11.02	11.52	12.00	12.59	13.31	14.07	14.92	15.89
13	3.76	4.27	4.78	5.30	5.83	6.36	6.86	7.39	7.96	8.47	8.97	9.42	9.86	10.36	10.90	11.43	11.93	12.48	13.00	13.64	14.43	15.25	16.17	17.22
14	4.03	4.58	5.13	5.69	6.25	6.83	7.36	7.94	8.56	9.11	9.64	10.13	10.61	11.15	11.74	12.31	12.85	13.44	14.00	14.69	15.54	16.43	17.43	18.56
15	4.29	4.88	5.47	6.07	6.68	7.30	7.87	8.49	9.15	9.75	10.32	10.85	11.36	11.93	12.57	13.18	13.76	14.40	15.00	15.74	16.66	17.61	18.68	19.90
16	4.55	5.18	5.81	6.45	7.10	7.77	8.38	9.04	9.75	10.39	11.00	11.56	12.11	12.72	13.40	14.06	14.68	15.36	16.00	16.79	17.77	18.79	19.94	21.24
17	4.81	5.48	6.16	6.84	7.53	8.24	8.89	9.59	10.35	11.03	11.68	12.27	12.86	13.51	14.23	14.93	15.59	16.31	17.00	17.84	18.88	19.97	21.19	22.58
18	5.07	5.78	6.50	7.22	7.96	8.71	9.40	10.14	10.94	11.66	12.35	12.99	13.61	14.30	15.07	15.80	16.50	17.27	18.00	18.89	20.00	21.15	22.44	23.91
19	5.33	6.08	6.84	7.61	8.38	9.18	9.91	10.69	11.54	12.30	13.03	13.70	14.36	15.09	15.90	16.68	17.42	18.23	19.00	19.94	21.11	22.33	23.70	25.25
20	5.59	6.39	7.18	7.99	8.81	9.65	10.41	11.24	12.14	12.94	13.71	14.41	15.11	15.88	16.73	17.55	18.33	19.19	20.00	20.99	22.23	23.51	24.95	26.59
Tenths																								
0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.1	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.06	0.06	0.07	0.07	0.07	0.08	0.08	0.09	0.09	0.10	0.10	0.11	0.11	0.12	0.13	0.13
0.2	0.05	0.06	0.07	0.08	0.09	0.09	0.10	0.11	0.12	0.13	0.14	0.14	0.15	0.16	0.17	0.17	0.18	0.19	0.20	0.21	0.22	0.24	0.25	0.27
0.3	0.08	0.09	0.10	0.12	0.13	0.14	0.15	0.17	0.18	0.19	0.20	0.21	0.22	0.24	0.25	0.26	0.27	0.29	0.30	0.32	0.33	0.35	0.38	0.40
0.4	0.10	0.12	0.14	0.15	0.17	0.19	0.20	0.22	0.24	0.26	0.27	0.29	0.30	0.32	0.33	0.35	0.37	0.38	0.40	0.42	0.45	0.47	0.50	0.54
0.5	0.13	0.15	0.17	0.19	0.21	0.23	0.25	0.28	0.30	0.32	0.34	0.36	0.37	0.39	0.42	0.44	0.46	0.48	0.50	0.53	0.56	0.59	0.63	0.67
0.6	0.16	0.18	0.21	0.23	0.26	0.28	0.31	0.33	0.36	0.38	0.41	0.43	0.45	0.47	0.50	0.52	0.55	0.58	0.60	0.63	0.67	0.71	0.75	0.80
0.7	0.18	0.21	0.24	0.27	0.30	0.33	0.36	0.39	0.42	0.45	0.47	0.50	0.52	0.55	0.58	0.61	0.64	0.67	0.70	0.74	0.78	0.83	0.88	0.94
0.8	0.21	0.24	0.27	0.31	0.34	0.38	0.41	0.44	0.48	0.51	0.54	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.84	0.89	0.94	1.00	1.07
0.9	0.24	0.27	0.31	0.35	0.38	0.42	0.46	0.50	0.54	0.57	0.61	0.64	0.67	0.71	0.75	0.79	0.82	0.86	0.90	0.95	1.00	1.06	1.13	1.20

FIG. X3.1 Corrected Loss from Observed Loss and Barometric Pressure kPa

Barometric Pressure, mm Hg.

from	571	607	634	655	672	686	698	706	716	723	729	734	738	742	746	750	753	756	759	762	765	768	771	774
through	606	633	654	671	685	697	705	715	722	728	733	737	741	745	749	752	755	758	761	764	767	770	773	776

Observed Loss	/– – Corrected Loss – – – – – >																						
Units																							
0	0.37	0.35	0.33	0.31	0.29	0.27	0.25	0.23	0.20	0.18	0.16	0.14	0.13	0.11	0.09	0.07	0.05	0.02	−0.00	−0.03	−0.06	−0.09	−0.13	−0.17
1	0.63	0.65	0.67	0.69	0.71	0.73	0.75	0.77	0.80	0.82	0.84	0.86	0.87	0.89	0.91	0.93	0.95	0.98	1.00	1.03	1.06	1.09	1.13	1.17
2	0.89	0.95	1.01	1.07	1.14	1.20	1.26	1.32	1.39	1.45	1.51	1.57	1.62	1.68	1.74	1.80	1.86	1.93	2.00	2.08	2.17	2.27	2.38	2.50
3	1.15	1.25	1.36	1.46	1.56	1.67	1.77	1.87	1.99	2.09	2.19	2.28	2.36	2.46	2.57	2.67	2.77	2.88	3.00	3.13	3.28	3.44	3.63	3.83
4	1.41	1.55	1.70	1.84	1.99	2.14	2.27	2.42	2.58	2.72	2.86	2.99	3.11	3.25	3.40	3.54	3.68	3.83	4.00	4.19	4.39	4.62	4.88	5.17
5	1.67	1.86	2.04	2.22	2.41	2.61	2.78	2.97	3.18	3.36	3.54	3.70	3.86	4.03	4.23	4.41	4.59	4.79	5.00	5.24	5.50	5.80	6.13	6.50
6	1.93	2.16	2.38	2.61	2.84	3.07	3.29	3.52	3.77	3.99	4.21	4.41	4.60	4.82	5.05	5.28	5.50	5.74	6.00	6.29	6.61	6.97	7.38	7.84
7	2.19	2.46	2.72	2.99	3.26	3.54	3.79	4.07	4.36	4.63	4.88	5.12	5.35	5.60	5.88	6.15	6.41	6.69	7.00	7.34	7.72	8.15	8.63	9.17
8	2.46	2.76	3.07	3.37	3.69	4.01	4.30	4.62	4.96	5.27	5.56	5.83	6.09	6.38	6.71	7.02	7.32	7.64	8.00	8.40	8.84	9.33	9.88	10.50
9	2.72	3.06	3.41	3.76	4.11	4.48	4.81	5.17	5.55	5.90	6.23	6.54	6.84	7.17	7.54	7.89	8.23	8.60	9.00	9.45	9.95	10.50	11.13	11.84
10	2.98	3.36	3.75	4.14	4.54	4.94	5.31	5.71	6.15	6.54	6.91	7.25	7.58	7.95	8.37	8.76	9.14	9.55	10.00	10.50	11.06	11.68	12.38	13.17
11	3.24	3.66	4.09	4.52	4.96	5.41	5.82	6.26	6.74	7.17	7.58	7.96	8.33	8.74	9.19	9.63	10.05	10.50	11.00	11.56	12.17	12.86	13.63	14.51
12	3.50	3.96	4.43	4.91	5.39	5.88	6.33	6.81	7.34	7.81	8.26	8.67	9.07	9.52	10.02	10.50	10.96	11.46	12.00	12.61	13.28	14.03	14.88	15.84
13	3.76	4.27	4.78	5.29	5.81	6.35	6.83	7.36	7.93	8.44	8.93	9.38	9.82	10.31	10.85	11.37	11.87	12.41	13.00	13.66	14.39	15.21	16.13	17.17
14	4.02	4.57	5.12	5.67	6.24	6.82	7.34	7.91	8.53	9.08	9.61	10.09	10.57	11.09	11.68	12.24	12.78	13.36	14.00	14.71	15.51	16.39	17.38	18.51
15	4.28	4.87	5.46	6.06	6.66	7.28	7.85	8.46	9.12	9.71	10.28	10.80	11.31	11.88	12.51	13.11	13.68	14.31	15.00	15.77	16.62	17.57	18.63	19.84
16	4.54	5.17	5.80	6.44	7.09	7.75	8.35	9.01	9.72	10.35	10.95	11.51	12.06	12.66	13.33	13.98	14.59	15.27	16.00	16.82	17.73	18.74	19.88	21.18
17	4.80	5.47	6.14	6.82	7.51	8.22	8.86	9.56	10.31	10.98	11.63	12.22	12.80	13.45	14.16	14.85	15.50	16.22	17.00	17.87	18.84	19.92	21.13	22.51
18	5.06	5.77	6.49	7.21	7.94	8.69	9.37	10.11	10.91	11.62	12.30	12.93	13.55	14.23	14.99	15.72	16.41	17.17	18.00	18.93	19.95	21.10	22.38	23.84
19	5.32	6.07	6.83	7.59	8.36	9.15	9.88	10.65	11.50	12.25	12.98	13.64	14.29	15.02	15.82	16.59	17.32	18.12	19.01	19.98	21.06	22.27	23.64	25.18
20	5.58	6.37	7.17	7.97	8.79	9.62	10.38	11.20	12.09	12.89	13.65	14.35	15.04	15.80	16.64	17.46	18.23	19.08	20.01	21.03	22.17	23.45	24.89	26.51
Tenths																								
0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.1	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.07	0.07	0.07	0.08	0.08	0.09	0.09	0.10	0.10	0.11	0.11	0.12	0.13	0.13
0.2	0.05	0.06	0.07	0.08	0.08	0.09	0.10	0.11	0.12	0.13	0.13	0.14	0.15	0.16	0.17	0.17	0.18	0.19	0.20	0.21	0.22	0.24	0.25	0.27
0.3	0.08	0.09	0.10	0.11	0.13	0.14	0.15	0.16	0.18	0.19	0.20	0.21	0.22	0.24	0.25	0.26	0.27	0.29	0.30	0.32	0.33	0.35	0.38	0.40
0.4	0.10	0.12	0.14	0.15	0.17	0.19	0.20	0.22	0.24	0.25	0.27	0.28	0.30	0.31	0.33	0.35	0.36	0.38	0.40	0.42	0.44	0.47	0.50	0.53
0.5	0.13	0.15	0.17	0.19	0.21	0.23	0.25	0.27	0.30	0.32	0.34	0.36	0.37	0.39	0.41	0.43	0.45	0.48	0.50	0.53	0.56	0.59	0.63	0.67
0.6	0.16	0.18	0.21	0.23	0.25	0.28	0.30	0.33	0.36	0.38	0.40	0.43	0.45	0.47	0.50	0.52	0.55	0.57	0.60	0.63	0.67	0.71	0.75	0.80
0.7	0.18	0.21	0.24	0.27	0.30	0.33	0.35	0.38	0.42	0.44	0.47	0.50	0.52	0.55	0.58	0.61	0.64	0.67	0.70	0.74	0.78	0.82	0.88	0.93
0.8	0.21	0.24	0.27	0.31	0.34	0.37	0.41	0.44	0.48	0.51	0.54	0.57	0.60	0.63	0.66	0.70	0.73	0.76	0.80	0.84	0.89	0.94	1.00	1.07
0.9	0.23	0.27	0.31	0.34	0.38	0.42	0.46	0.49	0.54	0.57	0.61	0.64	0.67	0.71	0.75	0.78	0.82	0.86	0.90	0.95	1.00	1.06	1.13	1.20

FIG. X3.2 Corrected Loss from Observed Loss and Barometric Pressure mm Hg

X4. PROCEDURE TO EMULATE THE EMERGENT STEM ERROR OF A MERCURY-IN-GLASS THERMOMETER

X4.1 When an electronic or other sensor without an emergent stem error is used, the output of this sensor or the associated data system should emulate the output of a mercury-in-glass thermometer. Based on information supplied by four manufacturers of automated Test Method D 86 equipment, the averaged equations shown in X4.2 and X4.3 have been reported to be in use.

X4.1.1 The equations shown in X4.2 have limited applicability and are shown for information purposes only. In addition to the correction for the emergent stem, the electronic sensor and associated data system will also have to emulate the lag in response time observed for mercury-in-glass thermometers.

X4.2 When a low range thermometer would have been used, no stem correction is to be applied below 20°C. Above this temperature, the correction is calculated using the following formula:

$$ASTM\ 7C\ T_{elr} = T_t - 0.000162 \times (T_t - 20°C)^2 \quad \text{(X4.1)}$$

X4.3 When a high range thermometer would have been used, no stem correction is to be applied below 35°C. Above this temperature the correction is calculated using the following formula:

$$ASTM\ 8C\ T_{ehr} = T_t - 0.000131 \times (T_t - 35°C)^2 \quad \text{(X4.2)}$$

where:

T_{elr} = emulated temperature in °C for low range thermometers,
T_{ehr} = emulated temperature in °C for high range thermometers, and
T_t = true temperature in °C.

X5. EXPLANATORY REPORT FORMS

X5.1 Fig. X5.1 and Fig. X5.2 show report forms.

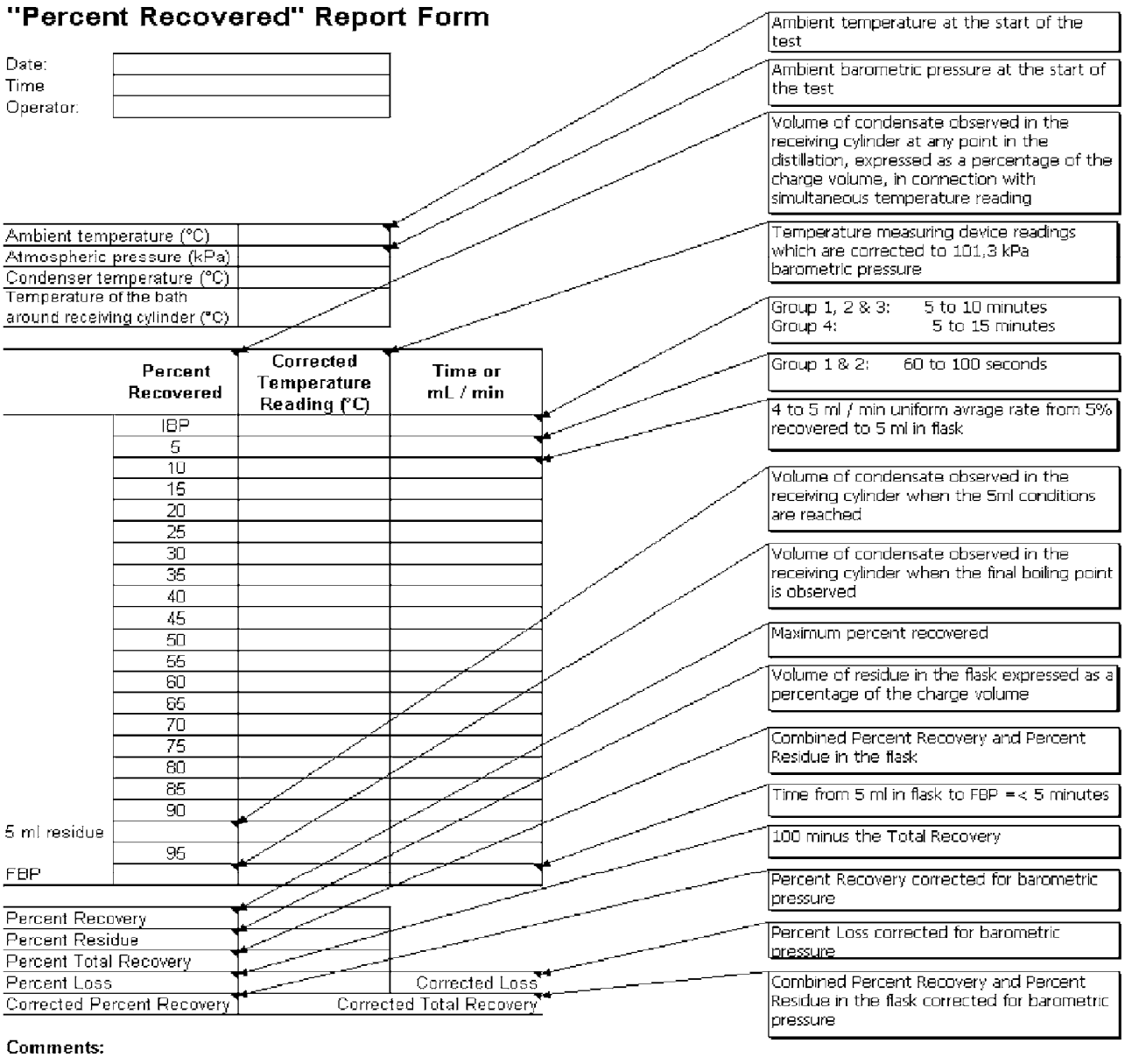


FIG. X5.1 Percent Recovered Report Form

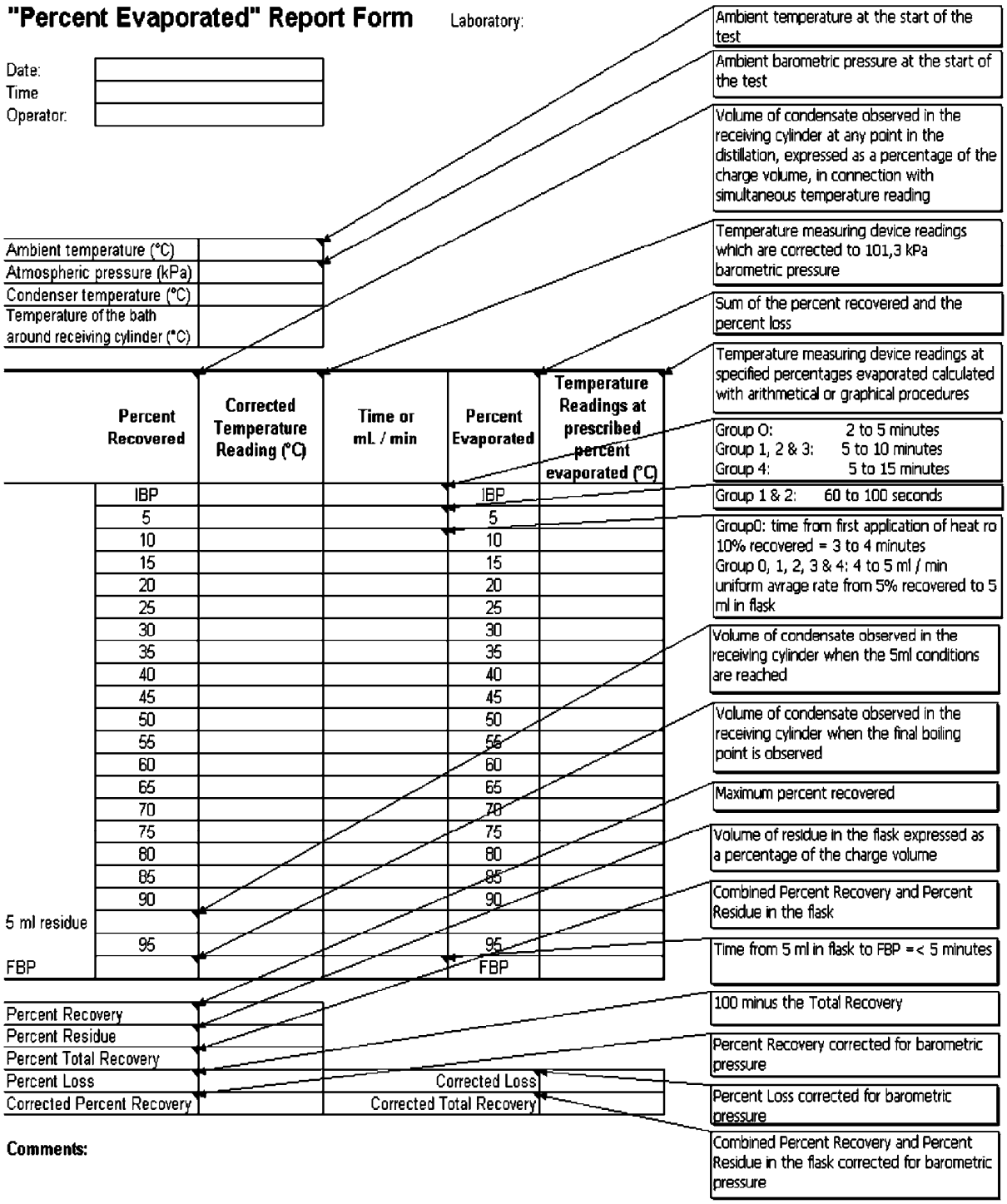


FIG. X5.2 Percent Evaporated Report Form

SUMMARY OF CHANGES

Subcommittee D02.08 has identified the location of selected changes to this standard since the last issue (D 86–05) that may impact the use of this standard. (Approved Jan. 15, 2007.)

(*1*) Deleted "natural gasolines" from 1.1.
(*2*) Deleted "Group 0" from the entire standard.
(*3*) Added Fig. 6.

Subcommittee D02.08 has identified the location of selected changes to this standard since the last issue, (D 86–04b), that may impact the use of this standard. (Approved July 1, 2005.)

(*1*) Replaced Table 4 with new values.
(*2*) Revised 9.1.2-9.1.2.2, 9.1.5, and Notes 9-11.
(*3*) Added 13.5.3 and footnote reference to the research report.
(*4*) Added Appendix X5, and cross-reference in Section 12.1.

EXHIBIT 7

Designation: D 975 – 07

An American National Standard

Standard Specification for Diesel Fuel Oils[1]

This standard is issued under the fixed designation D 975; 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.

1. Scope*

1.1 This specification covers seven grades of diesel fuel oils suitable for various types of diesel engines. These grades are described as follows:

1.1.1 *Grade No. 1-D S15*—A special-purpose, light middle distillate fuel for use in diesel engine applications requiring a fuel with 15 ppm sulfur (maximum) and higher volatility than that provided by Grade No. 2-D S15 fuel.[2]

1.1.2 *Grade No. 1-D S500*—A special-purpose, light middle distillate fuel for use in diesel engine applications requiring a fuel with 500 ppm sulfur (maximum) and higher volatility than that provided by Grade No. 2-D S500 fuel.[2]

1.1.3 *Grade No. 1-D S5000*—A special-purpose, light middle distillate fuel for use in diesel engine applications requiring a fuel with 5000 ppm sulfur (maximum) and higher volatility than that provided by Grade No. 2-D S5000 fuels.

1.1.4 *Grade No. 2-D S15*—A general purpose, middle distillate fuel for use in diesel engine applications requiring a fuel with 15 ppm sulfur (maximum). It is especially suitable for use in applications with conditions of varying speed and load.[2]

1.1.5 *Grade No. 2-D S500*—A general-purpose, middle distillate fuel for use in diesel engine applications requiring a fuel with 500 ppm sulfur (maximum). It is especially suitable for use in applications with conditions of varying speed and load.[2]

1.1.6 *Grade No. 2-D S5000*—A general-purpose, middle distillate fuel for use in diesel engine applications requiring a fuel with 5000 ppm sulfur (maximum), especially in conditions of varying speed and load.

1.1.7 *Grade No. 4-D*—A heavy distillate fuel, or a blend of distillate and residual oil, for use in low- and medium-speed diesel engines in applications involving predominantly constant speed and load.

NOTE 1—A more detailed description of the grades of diesel fuel oils is given in X1.2.

NOTE 2—The Sxxx designation has been adopted to distinguish grades by sulfur rather than using words such as "Low Sulfur" as previously because the number of sulfur grades is growing and the word descriptions were thought to be not precise. S5000 grades correspond to the so-called "regular" sulfur grades, the previous No. 1-D and No. 2-D. S500 grades correspond to the previous "Low Sulfur" grades. S15 grades were not in the previous grade system and are commonly referred to as "Ultra-Low Sulfur" grades or ULSD.

1.2 This specification, unless otherwise provided by agreement between the purchaser and the supplier, prescribes the required properties of diesel fuels at the time and place of delivery.

1.2.1 Nothing in this specification shall preclude observance of federal, state, or local regulations which may be more restrictive.

NOTE 3—The generation and dissipation of static electricity can create problems in the handling of distillate diesel fuel oils. For more information on the subject, see Guide D 4865.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

2. Referenced Documents

2.1 *ASTM Standards:* [3]

D 56 Test Method for Flash Point by Tag Closed Cup Tester

D 86 Test Method for Distillation of Petroleum Products at Atmospheric Pressure

D 93 Test Methods for Flash Point by Pensky-Martens Closed Cup Tester

D 129 Test Method for Sulfur in Petroleum Products (General Bomb Method)

D 130 Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test

D 445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)

D 482 Test Method for Ash from Petroleum Products

[1] This specification is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.E0.02 on Diesel Fuel Oils.

Current edition approved Feb. 1, 2007. Published March 2007. Originally approved in 1948. Last previous edition approved in 2006 as D 975–06b.

[2] This fuel complies with 40 CFR Part 80—Control of Air Pollution from New Motor Vehicles: Heavy-Duty Engines and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements: Final Rule. Regulation of Fuels and Fuel Additives: Fuel Quality Regulations for Highway Diesel Fuel Sold in 1993 and Later Calendar Years.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard.**

D 524 Test Method for Ramsbottom Carbon Residue of Petroleum Products
D 613 Test Method for Cetane Number of Diesel Fuel Oil
D 1266 Test Method for Sulfur in Petroleum Products (Lamp Method)
D 1319 Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption
D 1552 Test Method for Sulfur in Petroleum Products (High-Temperature Method)
D 1796 Test Method for Water and Sediment in Fuel Oils by the Centrifuge Method (Laboratory Procedure)
D 2274 Test Method for Oxidation Stability of Distillate Fuel Oil (Accelerated Method)
D 2500 Test Method for Cloud Point of Petroleum Products
D 2622 Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-ray Fluorescence Spectrometry
D 2709 Test Method for Water and Sediment in Middle Distillate Fuels by Centrifuge
D 2880 Specification for Gas Turbine Fuel Oils
D 2887 Test Method for Boiling Range Distribution of Petroleum Fractions by Gas Chromatography
D 3117 Test Method for Wax Appearance Point of Distillate Fuels
D 3120 Test Method for Trace Quantities of Sulfur in Light Liquid Petroleum Hydrocarbons by Oxidative Microcoulometry
D 3828 Test Methods for Flash Point by Small Scale Closed Cup Tester
D 4057 Practice for Manual Sampling of Petroleum and Petroleum Products
D 4177 Practice for Automatic Sampling of Petroleum and Petroleum Products
D 4294 Test Method for Sulfur in Petroleum and Petroleum Products by Energy-Dispersive X-ray Fluorescence Spectrometry
D 4306 Practice for Aviation Fuel Sample Containers for Tests Affected by Trace Contamination
D 4539 Test Method for Filterability of Diesel Fuels by Low-Temperature Flow Test (LTFT)
D 4737 Test Method for Calculated Cetane Index by Four Variable Equation
D 4865 Guide for Generation and Dissipation of Static Electricity in Petroleum Fuel Systems
D 5453 Test Method for Determination of Total Sulfur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence
D 5771 Test Method for Cloud Point of Petroleum Products (Optical Detection Stepped Cooling Method)
D 5772 Test Method for Cloud Point of Petroleum Products (Linear Cooling Rate Method)
D 5773 Test Method for Cloud Point of Petroleum Products (Constant Cooling Rate Method)
D 5842 Practice for Sampling and Handling of Fuels for Volatility Measurement
D 5854 Practice for Mixing and Handling of Liquid Samples of Petroleum and Petroleum Products
D 6078 Test Method for Evaluating Lubricity of Diesel Fuels by the Scuffing Load Ball-on-Cylinder Lubricity Evaluator (SLBOCLE)
D 6079 Test Method for Evaluating Lubricity of Diesel Fuels by the High-Frequency Reciprocating Rig (HFRR)
D 6217 Test Method for Particulate Contamination in Middle Distillate Fuels by Laboratory Filtration
D 6371 Test Method for Cold Filter Plugging Point of Diesel and Heating Fuels
D 6468 Test Method for High Temperature Stability of Distillate Fuels
D 6469 Guide for Microbial Contamination in Fuels and Fuel Systems
D 6890 Test Method for Determination of Ignition Delay and Derived Cetane Number (DCN) of Diesel Fuel Oils by Combustion in a Constant Volume Chamber
D 6898 Test Method for Evaluating Diesel Fuel Lubricity by an Injection Pump Rig

2.2 *Other Documents:*
26 CFR Part 48 Manufacturers and Realtors Excise Taxes[4]
40 CFR Part 80 Regulation of Fuels and Fuel Additives[4]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *S(numerical specification maximum)*—indicates the maximum sulfur content, in weight ppm (μg/g), allowed by this specification in a diesel fuel grade.

3.1.1.1 *Discussion*—Of the seven diesel fuel grades specified in this standard, six have important distinguishing maximum sulfur regulatory requirements. These are Grades No. 1-D S15, No. 1-D S500, No. 1-D S5000, No. 2-D S15, No. 2-D S500 and No. 2-D S5000. The seventh grade, No. 4-D, is distinguished from these other grades by many major properties in addition to sulfur (unregulated maximum), and therefore is not included in this designation system. Thus, Grade No. 4-D does not have the designation S20000 as part of its grade name.

4. Sampling, Containers, and Sample Handling

4.1 It is strongly advised to review all test methods prior to sampling to understand the importance and effects of sampling technique, proper containers, and special handling required for each test method.

4.2 Correct sampling procedures are critical to obtaining a representative sample of the diesel fuel oil to be tested. Refer to Appendix X2 for recommendations. The recommended procedures or practices provide techniques useful in the proper sampling or handling of diesel fuels.

5. Test Methods

5.1 The requirements enumerated in this specification shall be determined in accordance with the following methods:

5.1.1 *Flash Point*—Test Methods D 93, except where other methods are prescribed by law. For all grades, Test Method D 3828 may be used as an alternate with the same limits. For Grades No. 1-D S15, No. 1-D S500 , No. 1-D S5000, No. 2-D

[4] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

S15, No. 2-D S500, and No. 2-D S5000, Test Method D 56 may be used as an alternate with the same limits, provided the flash point is below 93°C and the viscosity is below 5.5 mm^2/s at 40°C. This test method will give slightly lower values. In cases of dispute, Test Methods D 93 shall be used as the referee method. Test Method D 56 can not be used as the alternate method for Grade No. 4-D because its minimum viscosity limit is 5.5 mm^2/s at 40°C.

5.1.2 *Cloud Point*—Test Method D 2500. For all fuel grades in Table 1, the automatic Test Methods D 5771, D 5772, or D 5773 can be used as alternates with the same limits. Test Method D 3117 can also be used since it is closely related to Test Method D 2500. In case of dispute, Test Method D 2500 shall be the referee method.

5.1.3 *Water and Sediment*—Test Method D 2709 is used for fuel Grades No. 1-D S15, No. 1-D S500, No. 1-D S5000, No. 2-D S15, No. 2-D S500, and No. 2-D S5000. Test Method D 1796 is used for Grade No. 4-D.

5.1.4 *Carbon Residue*—Test Method D 524 is used for fuel Grades No. 1-D S15, No. 1-D S500, No. 1-D S5000, No. 2-D

TABLE 1 Detailed Requirements for Diesel Fuel Oils[A]

Property	ASTM Test Method[B]	Grade						
		No. 1-D S15	No. 1-D S500[C]	No. 1-D S5000[D]	No. 2-D S15	No. 2-D S500[C,E]	No. 2-D S5000[D,E]	No. 4-D[D]
Flash Point, °C, min.	D 93	38	38	38	52[E]	52[E]	52[E]	55
Water and Sediment, % vol, max	D 2709	0.05	0.05	0.05	0.05	0.05	0.05	...
	D 1796	...	...	...	...	...	...	0.50
Distillation: one of the following requirements shall be met:								
1. Physical Distillation	D 86							
Distillation Temperature, °C 90 % , % vol recovered								
min		...	...	...	282[E]	282[E]	282[E]	...
max		288	288	288	338	338	338	...
2. Simulated Distillation	D 2887							
Distillation Temperature, °C 90 %, % vol recovered								
min						300[E]	300[E]	
max			304	304		356	356	
Kinematic Viscosity, mm^2/S at 40°C	D 445							
min		1.3	1.3	1.3	1.9[E]	1.9[E]	1.9[E]	5.5
max	...	2.4	2.4	2.4	4.1	4.1	4.1	24.0
Ash % mass, max	D 482	0.01	0.01	0.01	0.01	0.01	0.01	0.10
Sulfur, ppm (μg/g)[F] max	D 5453	15	...	...	15	...	...	...
% mass, max	D 2622[G]	...	0.05	...	...	0.05	...	...
% mass, max	D 129	...	...	0.50	...	...	0.50	2.00
Copper strip corrosion rating max 3 h at 50°C	D 130	No. 3	No. 3	No. 3	No. 3	No. 3	No. 3	...
Cetane number, min[H]	D 613	40[I]	40[I]	40[I]	40[I]	40[I]	40[I]	30[I]
One of the following properties must be met:								
(1) Cetane index, min.	D 976–80[G]	40	40	...	40	40	...	...
(2) Aromaticity, % vol, max	D 1319[G]	35	35	...	35	35	...	...
Operability Requirements								
Cloud point, °C, max	D 2500	[J]	[J]	[J]	[J]	[J]	[J]	...
or								
LTFT/CFPP, °C, max	D 4539/ D 6371							
Ramsbottom carbon residue on 10 % distillation residue, % mass, max	D 524	0.15	0.15	0.15	0.35	0.35	0.35	...
Lubricity, HFRR @ 60°C, micron, max	D 6079	520	520	520	520	520	520	...

[A] To meet special operating conditions, modifications of individual limiting requirements may be agreed upon between purchaser, seller, and manufacturer.

[B] The test methods indicated are the approved referee methods. Other acceptable methods are indicated in 5.1.

[C] Under United States regulations, if Grades No. 1–D S500 or No. 2–D S500 are sold for tax exempt purposes then, at or beyond terminal storage tanks, they are required by 26 CFR Part 48 to contain the dye Solvent Red 164 at a concentration spectrally equivalent to 3.9 lb per thousand barrels of the solid dye standard Solvent Red 26, or the tax must be collected.

[D] Under United States regulations, Grades No.1–D S5000, No. 2–D S5000, and No. 4–D are required by 40 CFR Part 80 to contain a sufficient amount of the dye Solvent Red 164 so its presence is visually apparent. At or beyond terminal storage tanks, they are required by 26 CFR Part 48 to contain the dye Solvent Red 164 at a concentration spectrally equivalent to 3.9 lb per thousand barrels of the solid dye standard Solvent Red 26.

[E] When a cloud point less than –12°C is specified, as can occur during cold months, it is permitted and normal blending practice to combine Grades No. 1 and No. 2 to meet the low temperature requirements. In that case, the minimum flash point shall be 38°C, the minimum viscosity at 40°C shall be 1.7 mm^2/s, and the minimum 90 % recovered temperature shall be waived.

[F] Other sulfur limits can apply in selected areas in the United States and in other countries.

[G] These test methods are specified in 40 CFR Part 80.

[H] Where cetane number by Test Method D 613 is not available, Test Method D 4737 can be used as an approximation.

[I] Low ambient temperatures as well as engine operation at high altitudes may require the use of fuels with higher cetane ratings.

[J] It is unrealistic to specify low temperature properties that will ensure satisfactory operation at all ambient conditions. In general, cloud point (or wax appearance point) Low Temperature Flow Test, and Cold Filter Plugging Point Test may be used as an estimate of operating temperature limits for Grades No. 1–D S500; No. 2–D S500; and No. 1–D S5000 and No. 2–D S5000 diesel fuel oils. However, satisfactory operation below the cloud point (or wax appearance point) may be achieved depending on equipment design, operating conditions, and the use of flow-improver additives as described in X5.1.2. Appropriate low temperature operability properties should be agreed upon between the fuel supplier and purchaser for the intended use and expected ambient temperatures. Test Methods D 4539 and D 6371 may be especially useful to estimate vehicle low temperature operability limits when flow improvers are used. Due to fuel delivery system, engine design, and test method differences, low temperature operability tests may not provide the same degree of protection in various vehicle operating classes. Tenth percentile minimum air temperatures for U.S. locations are provided in Appendix X5 as a means of estimating expected regional temperatures. The tenth percentile minimum air temperatures may be used to estimate expected regional target temperatures for use with Test Methods D 2500, D 4539, and D 6371. Refer to X5.1.3 for further general guidance on test application.

S15, No. 2-D S500 and No. 2-D S5000. Grade No. 4-D does not have a limit for carbon residue.

5.1.5 *Ash*—Test Method D 482 is used for all grades in Table 1.

5.1.6 *Distillation*—Test Method D 86 is used for Grades No. 1-D S15, No. 1-D S500, No. 1-D S5000, No. 2-D S15, No. 2-D S500 and No. 2-D S5000. For all grades, Test Method D 2887 can be used as an alternate with the limits listed in Table 1. In case of dispute, Test Method D 86 shall be the referee method. Grade No. 4-D does not have distillation requirements.

5.1.7 *Viscosity*—Test Method D 445 is used for all fuel grades in Table 1.

5.1.8 *Sulfur*—The following list shows the referee test methods and alternate test methods for sulfur, the range over which each test method applies and the corresponding fuel grades.

Sulfur Test Method	Range	Grades
D 129 (referee)	>0.1 mass %	No. 1-D S5000, No. 2-D S5000, No. 4-D
D 1266	0.0005 to 0.4 mass % 5 to 4000 mg/kg (wt ppm)	No. 1-D S500, No. 2-D S500
D 1552	>0.06 mass %	No. 1- D S5000, No. 2-D S5000, No. 4-D
D 2622 (referee for S500 Grades)	0.0003 to 5.3 mass % 3 to 53 000 mg/kg (wt ppm)	All Grades
D 3120	3.0 to 100 mg/kg (wt ppm)	No. 1-D S15, No. 2-D S15 No. 1-D S500, No. 2-D S500 (S500 grades must be diluted before testing)
D 4294	0.0150 to 5.00 mass % 150 to 50 000 mg/kg (wt ppm)	No. 1- D S5000, No. 2-D S5000, No. 4-D
D 5453 (referee for S15 grades)	0.0001 to 0.8 mass % 1.0 to 8000 mg/kg (wt ppm)	All Grades

NOTE 4—The units used to report results in the above test methods are:

D 129	mass %
D 1266	mass %
D 1552	mass %
D 2622	mass %
D 3120	ppm (µg/g)
D 4294	mass %
D 5453	ppm (µg/g)

Results reported in mg/kg and in ppm (µg/g) are numerically the same. The units used in Table 1 for the sulfur requirements are the units in which results for the referee test are reported.

5.1.9 *Copper Corrosion*—Test Method D 130, 3 h test at 50°C. This test method is used for fuel Grades No. 1-D S15, No. 1-D S500, No. 1-D S5000, No. 2-D S15, No. 2-D S500 and No. 2-D S5000. Grade No. 4-D does not have a copper corrosion requirement.

5.1.10 *Cetane Number*—Test Method D 613 is used for all fuel grades in Table 1. Test Method D 6890 is used for all No. 1-D and No. 2-D grades with the DCN result being compared to the cetane number specification requirement of 40. Test Method D 613 shall be the referee method.

5.1.11 *Cetane Index*—Test Methods D 976–80 is used for fuel Grades No. 1-D S15, No. 1-D S500, No. 2-D S15 and No. 2-D S500. Grades No. 1-D S5000, No. 2-D S5000 and No. 4-D do not have an aromatics content requirement, so do not use this test method as a surrogate for aromatics content.

5.1.12 *Aromaticity*—Test Method D 1319. This test method provides an indication of the aromatics content of fuels. For fuels with a maximum final boiling point of 315°C, this method is a measurement of the aromatic content of the fuel. This test method is used for fuel Grades No. 1-D S15, No. 1-D S500, No. 2-D S15 and No. 2-D S500. Grades No. 1-D S5000, No. 2-D S5000 and No. 4-D do not have an aromatics content requirement.

5.1.13 *Lubricity*—Test Method D 6079.

6. Workmanship

6.1 The diesel fuel shall be visually free of undissolved water, sediment, and suspended matter.

7. Requirements

7.1 The grades of diesel fuel oils herein specified shall be hydrocarbon oils conforming to the detailed requirements shown in Table 1.

7.2 *Grades No. 2-D S15, No. 2-D S500 and No. 2–D S5000*—When a cloud point less than −12°C is specified, as can occur during cold months, it is permitted and normal blending practice to combine Grades No. 1 and No. 2 to meet the low temperature requirements. In that case, the minimum flash point shall be 38°C, the minimum viscosity at 40°C shall be 1.7 mm^2/s, and the minimum 90 % recovered temperature shall be waived.

8. Keywords

8.1 diesel; fuel oil; petroleum and petroleum products

APPENDIXES

(Nonmandatory Information)

X1. SIGNIFICANCE OF ASTM SPECIFICATION FOR DIESEL FUEL OILS

X1.1 Introduction

X1.1.1 The properties of commercial fuel oils depend on the refining practices employed and the nature of the crude oils from which they are produced. Distillate fuel oils, for example, may be produced within the boiling range of 150 and 400°C having many possible combinations of various properties, such as volatility, ignition quality, viscosity, and other characteristics.

X1.2 Grades

X1.2.1 This specification is intended as a statement of permissible limits of significant fuel properties used for specifying the wide variety of commercially available diesel fuel oils. Limiting values of significant properties are prescribed for seven grades of diesel fuel oils. These grades and their general applicability for use in diesel engines are broadly indicated as follows:

X1.2.2 *Grade No. 1-D S15*—Grade No. 1-D S15 comprises the class of very low sulfur, volatile fuel oils from kerosine to the intermediate middle distillates. Fuels within this grade are applicable for use in *(1)* high-speed diesel engines and diesel engine applications that require ultra-low sulfur fuels, *(2)* applications necessitating frequent and relatively wide variations in loads and speeds, and *(3)* applications where abnormally low operating temperatures are encountered.

X1.2.3 *Grade No. 1-D S500*—Grade No. 1-D S500 comprises the class of low-sulfur, volatile fuel oils from kerosine to the intermediate middle distillates. Fuels within this grade are applicable for use in *(1)* high-speed diesel engines that require low sulfur fuels, *(2)* in applications necessitating frequent and relatively wide variations in loads and speeds, and *(3)* in applications where abnormally low operating temperatures are encountered.

X1.2.4 *Grade No. 1-D S5000*—Grade No. 1-D S5000 comprises the class of volatile fuel oils from kerosine to the intermediate middle distillates. Fuels within this grade are applicable for use in high-speed diesel engines applications necessitating frequent and relatively wide variations in loads and speeds, and also for use in cases where abnormally low operating temperatures are encountered.

X1.2.5 *Grade No. 2-D S15*—Grade No. 2-D S15 includes the class of very low sulfur, middle distillate gas oils of lower volatility than Grade No. 1-D S15. These fuels are applicable for use in *(1)* high speed diesel engines and diesel engine applications that require ultra-low sulfur fuels, *(2)* applications necessitating relatively high loads and uniform speeds, or *(3)* diesel engines not requiring fuels having higher volatility or other properties specified in Grade No. 1-D S15.

X1.2.6 *Grade No. 2-D S500*—Grade No. 2-D S500 includes the class of low-sulfur, middle distillate gas oils of lower volatility than Grade No. 1-D S500. These fuels are applicable for use in *(1)* high-speed diesel engine applications that require low sulfur fuels, *(2)* applications necessitating relatively high loads and uniform speeds, or *(3)* diesel engines not requiring fuels having higher volatility or other properties specified for Grade No. 1-D S500.

X1.2.7 *Grade No. 2-D S5000*—Grade No. 2-D S5000 includes the class of middle distillate gas oils of lower volatility than Grade No. 1-D S5000. These fuels are applicable for use in *(1)* high-speed diesel engines in applications necessitating relatively high loads and uniform speeds, or *(2)* in diesel engines not requiring fuels having higher volatility or other properties specified for Grade No. 1-D S5000.

X1.2.8 *Grade No. 4-D*—Grade No. 4-D comprises the class of more viscous middle distillates and blends of these middle distillates with residual fuel oils. Fuels within this grade are applicable for use in low- and medium-speed diesel engines in applications necessitating sustained loads at substantially constant speed.

X1.3 Selection of Particular Grade

X1.3.1 The selection of a particular diesel fuel oil from one of these seven ASTM grades for use in a given engine requires consideration of the following factors:

X1.3.1.1 Fuel price and availability,

X1.3.1.2 Maintenance considerations,

X1.3.1.3 Engine size and design,

X1.3.1.4 Emission control systems,

X1.3.1.5 Speed and load ranges,

X1.3.1.6 Frequency of speed and load changes, and

X1.3.1.7 Atmospheric conditions. Some of these factors can influence the required fuel properties outlined as follows:

X1.4 Cetane Number

X1.4.1 Cetane number is a measure of the ignition quality of the fuel and influences combustion roughness. The cetane number requirements depend on engine design, size, nature of speed and load variations, and on starting and atmospheric conditions. Increase in cetane number over values actually required does not materially improve engine performance. Accordingly, the cetane number specified should be as low as possible to assure maximum fuel availability.

X1.5 Distillation

X1.5.1 The fuel volatility requirements depend on engine design, size, nature of speed and load variations, and starting and atmospheric conditions. For engines in services involving rapidly fluctuating loads and speeds as in bus and truck operation, the more volatile fuels may provide best performance, particularly with respect to smoke and odor. However, best fuel economy is generally obtained from the heavier types of fuels because of their higher heat content.

X1.6 Viscosity

X1.6.1 For some engines it is advantageous to specify a minimum viscosity because of power loss due to injection pump and injector leakage. Maximum viscosity, on the other hand, is limited by considerations involved in engine design and size, and the characteristics of the injection system.

X1.7 Carbon Residue

X1.7.1 Carbon residue gives a measure of the carbon depositing tendencies of a fuel oil when heated in a bulb under prescribed conditions. While not directly correlating with engine deposits, this property is considered an approximation.

X1.8 Sulfur

X1.8.1 The effect of sulfur content on engine wear and deposits appears to vary considerably in importance and depends largely on operating conditions. Fuel sulfur can affect emission control systems performance. To assure maximum availability of fuels, the permissible sulfur content should be specified as high as is practicable, consistent with maintenance considerations.

X1.9 Flash Point

X1.9.1 The flash point as specified is not directly related to engine performance. It is, however, of importance in connection with legal requirements and safety precautions involved in fuel handling and storage, and is normally specified to meet insurance and fire regulations.

X1.10 Cloud Point

X1.10.1 Cloud point is of importance in that it defines the temperature at which a cloud or haze of wax crystals appears in the oil under prescribed test conditions which generally relates to the temperature at which wax crystals begin to precipitate from the oil in use.

X1.11 Ash

X1.11.1 Ash-forming materials may be present in fuel oil in two forms: *(1)* abrasive solids, and *(2)* soluble metallic soaps. Abrasive solids contribute to injector, fuel pump, piston and ring wear, and also to engine deposits. Soluble metallic soaps have little effect on wear but may contribute to engine deposits.

X1.12 Copper Strip Corrosion

X1.12.1 This test serves as a measure of possible difficulties with copper and brass or bronze parts of the fuel system.

X1.13 Aromaticity

X1.13.1 This test is used as an indication of the aromatics content of diesel fuel. Aromatics content is specified to prevent an increase in the average aromatics content in Grades No. 1-D S15, No. 1-D S500, No. 2-D S15 and No. 2-D S500 fuels and is required by 40 CFR Part 80. Increases in aromatics content of fuels over current levels may have a negative impact on emissions.

X1.14 Cetane Index

X1.14.1 Cetane Index is specified as a limitation on the amount of high aromatic components in Grades No. 1-D S15, No. 1-D S500, No. 2-D S15 and No. 2-D S500.

X1.15 Other

X1.15.1 *Microbial Contamination*—Refer to Guide D 6469 for a discussion of this form of contamination.

X2. SAMPLING, CONTAINERS AND SAMPLE HANDLING

X2.1 Introduction

X2.1.1 This appendix provides guidance on methods and techniques for the proper sampling of diesel fuel oils. As diesel fuel oil specifications become more stringent and contaminants and impurities become more tightly controlled, even greater care needs to be taken in collecting and storing samples for quality assessment.

X2.2 Sampling, Containers and Sample Handling Recommendations

X2.2.1 Appropriate manual method sampling procedures can be found in Practice D 4057 and automatic method sampling is covered in Practice D 4177.

X2.2.2 The correct sample volume and appropriate container selection are also important decisions that can impact test results. Practice D 4306 for aviation fuel container selection for tests sensitive to trace contamination may be useful. Practice D 5854 for procedures on container selection and sample mixing and handling is recommended. For cetane number determination protection from light is important. Collection and storage of diesel fuel oil samples in an opaque container, such as a dark brown glass bottle, metal can, or a minimally reactive plastic container to minimize exposure to UV emissions from sources such as sunlight or fluorescent lamps, is recommended. According to Paragraph 8.2 of Test Method D 6079, "Because of sensitivity of lubricity measurements to trace materials, sample containers shall be only fully epoxy-lined metal, amber borosilicate glass, or polytetrafluoroethylene as specified in Practice D 4306."

X2.2.3 For volatility determination of a sample, Practice D 5842 for special precautions recommended for representative sampling and handling techniques may be appropriate.

X3. STORAGE AND THERMAL STABILITY OF DIESEL FUELS

X3.1 Scope

X3.1.1 This appendix provides guidance for consumers of diesel fuels who may wish to store quantities of fuels for extended periods or use the fuel in severe service or high temperature applications. Fuels containing residual components are excluded. Consistently successful long-term fuel storage or use in severe applications requires attention to fuel selection, storage conditions, handling and monitoring of properties during storage and prior to use.

X3.1.2 Normally produced fuels have adequate stability properties to withstand normal storage and use without the formation of troublesome amounts of insoluble degradation products. Fuels that are to be stored for prolonged periods or used in severe applications should be selected to avoid formation of sediments or gums, which can overload filters or plug injectors. Selection of these fuels should result from supplier-user discussions.

X3.1.3 These suggested practices are general in nature and should not be considered substitutes for any requirements imposed by the warranty of the distillate fuel equipment manufacturer or by federal, state, or local government regulations. Although they cannot replace a knowledge of local conditions or good engineering and scientific judgment, these suggested practices do provide guidance in developing an individual fuel management system for the middle distillate fuel user. They include suggestions in the operation and maintenance of existing fuel storage and handling facilities and for identifying where, when, and how fuel quality should be monitored or selected for storage or severe use.

X3.2 Definitions

X3.2.1 *bulk fuel*—fuel in the storage facility.

X3.2.2 *fuel contaminants*—foreign materials that make fuel less suitable or unsuitable for the intended use.

X3.2.2.1 *Discussion*—Fuel contaminants include materials introduced subsequent to the manufacture of fuel and fuel degradation products.

X3.2.3 *fuel-degradation products*—those materials that are formed in fuel during extended storage or exposure to high temperatures.

X3.2.3.1 *Discussion*—Insoluble degradation products may combine with other fuel contaminants to reinforce deleterious effects. Soluble degradation products (soluble gums) are less volatile than fuel and may carbonize to form deposits due to complex interactions and oxidation of small amounts of olefinic or sulfur-, oxygen- or nitrogen-containing compounds present in fuels. The formation of degradation products may be catalyzed by dissolved metals, especially copper salts. When dissolved copper is present it can be deactivated with metal deactivator additives.

X3.2.4 *long-term storage*—storage of fuel for longer than 12 months after it is received by the user.

X3.2.5 *severe use*—use of the fuel in applications which may result in engines operating under high load conditions that may cause the fuel to be exposed to excessive heat.

X3.3 Fuel Selection

X3.3.1 Certain distilled refinery products are generally more suitable for long-term storage and severe service than others. The stability properties of middle distillates are highly dependent on the crude oil sources, severity of processing, use of additives and whether additional refinery treatment has been carried out.

X3.3.2 The composition and stability properties of middle distillate fuels produced at specific refineries may be different. Any special requirements of the user, such as long-term storage or severe service, should be discussed with the supplier.

X3.3.3 Blends of fuels from various sources may interact to give stability properties worse than expected based on the characteristics of the individual fuels.

X3.4 Fuel Additives

X3.4.1 Available fuel additives can improve the suitability of marginal fuels for long-term storage and thermal stability, but may be unsuccessful for fuels with markedly poor stability properties. Most additives should be added at the refinery or during the early weeks of storage to obtain maximum benefits.

X3.4.2 Biocides or biostats destroy or inhibit the growth of fungi and bacteria, which can grow at fuel-water interfaces to give high particulate concentrations in the fuel. Available biocides are soluble in both the fuel and water or in the water phase only.

X3.5 Tests for Fuel Quality

X3.5.1 At the time of manufacture, the storage stability of fuel may be assessed using Test Method D 2274 or D 5304. However, these accelerated stability tests may not correlate well with field storage stability due to varying field conditions and to fuel composition.

X3.5.2 Performance criteria for accelerated stability tests that assure satisfactory long-term storage of fuels have not been established.

X3.5.3 Test Method D 6468, provides an indication of thermal oxidative stability of middle distillate fuels when heated to temperatures near 150°C.

X3.6 Fuel Monitoring

X3.6.1 A plan for monitoring the quality of bulk fuel during prolonged storage is an integral part of a successful program. A plan to replace aged fuel with fresh product at established intervals is also desirable.

X3.6.2 Stored fuel should be periodically sampled and its quality assessed. Practice D 4057 provides guidance for sampling. Fuel contaminants and degradation products will usually settle to the bottom of a quiescent tank. A "Bottom" or "Clearance" sample, as defined in Practice D 4057, should be included in the evaluation along with an "All Level" sample.

X3.6.3 The quantity of insoluble fuel contaminants present in fuel can be determined using Test Method D 6217.

X3.6.4 Test Method D 6468, can be used for investigation of operational problems that might be related to fuel thermal

stability. Testing samples from the fuel tank or from bulk storage may give an indication as to the cause of filter plugging. It is more difficult to monitor the quality of fuels in vehicle tanks since operation may be on fuels from multiple sources.

X3.6.5 Some additives exhibit effects on fuels tested in accordance with Test Method D 6468 that may or may not be observed in the field. Data have not been developed that correlate results from the test method for various engine types and levels of operating severity.

X3.7 Fuel Storage Conditions

X3.7.1 Contamination levels in fuel can be reduced by storage in tanks kept free of water, and tankage should have provisions for water draining on a scheduled basis. Water promotes corrosion, and microbiological growth may occur at a fuel-water interface. Underground storage is preferred to avoid temperature extremes; above-ground storage tanks should be sheltered or painted with reflective paint. High storage temperatures accelerate fuel degradation. Fixed roof tanks should be kept full to limit oxygen supply and tank breathing.

X3.7.2 Copper and copper-containing alloys should be avoided. Copper can promote fuel degradation and may produce mercaptide gels. Zinc coatings can react with water or organic acids in the fuel to form gels that rapidly plug filters.

X3.7.3 Appendix X2 of Specification D 2880 discusses fuel contaminants as a general topic.

X3.8 Fuel Use Conditions

X3.8.1 Many diesel engines are designed so that the diesel fuel is used for heat transfer. In modern heavy-duty diesel engines, for example, only a portion of the fuel that is circulated to the fuel injectors is actually delivered to the combustion chamber. The remainder of the fuel is circulated back to the fuel tank, carrying heat with it. Thus adequate high temperature stability can be a necessary requirement in some severe applications or types of service.

X3.8.2 Inadequate high temperature stability may result in the formation of insoluble degradation products.

X3.9 Use of Degraded Fuels

X3.9.1 Fuels that have undergone mild-to-moderate degradation can often be consumed in a normal way, depending on the fuel system requirements. Filters and other cleanup equipment can require special attention and increased maintenance. Burner nozzle or injector fouling can occur more rapidly.

X3.9.2 Fuels containing very large quantities of fuel degradation products and other contaminants or with runaway microbiological growth require special attention. Consultation with experts in this area is desirable. It can be possible to drain the sediment or draw off most of the fuel above the sediment layer and use it with the precautions described in X3.9.1. However, very high soluble gum levels or corrosion products from microbiological contamination can cause severe operational problems.

X3.10 Thermal Stability Guidelines

X3.10.1 Results from truck fleet experience suggests that Test Method D 6468 can be used to qualitatively indicate whether diesel fuels have satisfactory thermal stability performance properties.[5,6]

X3.10.2 Performance in engines has not been sufficiently correlated with results from Test Method D 6468 to provide definitive specification requirements. However, the following guidelines are suggested.

X3.10.2.1 Fuels giving a Test Method D 6468 reflectance value of 70 % or more in a 90 minute test at the time of manufacture should give satisfactory performance in normal use.

X3.10.2.2 Fuels giving a Test Method D 6468 reflectance value of 80 % or more in a 180 minute test at the time of manufacture should give satisfactory performance in severe use.

X3.10.3 Thermal stability as determined by Test Method D 6468 is known to degrade during storage.[7] The guidance above is for fuels used within six months of manufacture.

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[5] Bacha, John D., and Lesnini, David G., "Diesel Fuel Thermal Stability at 300°F," *Proceedings of the 6th International Conference on Stability and Handling of Liquid Fuels*, Vancouver, B.C., October 1997.

[6] Schwab, Scott D., Henly, Timothy J., Moxley, Joel F., and Miller, Keith, "Thermal Stability of Diesel Fuel," *Proceedings of the 7th International Conference on Stability and Handling of Liquid Fuels* , Graz, Austria September 2000.

[7] Henry, C. P., "The DuPont F21 149°C (300°F) Accelerated Stability Test," *Distillate Fuel Stability and Cleanliness, ASTM STP 751*, 1981, pp. 22-33.

X4. DIESEL FUEL LUBRICITY

X4.1 Introduction

X4.1.1 Diesel fuel functions as a lubricant in most components of fuel injection equipment such as pumps and injectors. In limited cases, fuel with specific properties will have insufficient lubricating properties which will lead to a reduction in the normal service life and functional performance of diesel fuel injection systems.

X4.2 Fuel Characteristics Affecting Equipment Wear

X4.2.1 Currently, two fuel characteristics affect equipment wear. These are low viscosity and lack of sufficient quantities of trace components that have an affinity for surfaces. If fuel viscosity meets the requirements of a particular engine, a fuel film is maintained between the moving surfaces of the fuel system components. This prevents excessive metal-to-metal

contact and avoids premature failure due to wear. Similarly, certain surface active molecules in the fuel adhere to, or combine with, surfaces to produce a protective film which also can protect surfaces against excessive wear.

X4.3 Fuel Lubricity

X4.3.1 The concern about fuel lubricity is limited to situations in which fuels with lower viscosities than those specified for a particular engine are used or in which fuels that have been processed in a manner that results in severe reduction of the trace levels of the surface active species that act as surface protecting agents. Presently the only fuels of the latter type shown to have lubricity problems resulted from sufficiently severe processing to reduce aromatics or sulfur.

X4.3.2 Work in the area of diesel fuel lubricity is ongoing by several organizations, such as the International Organization for Standardization (ISO), the ASTM Diesel Fuel Lubricity Task Force, and the Coordinating Research Council (CRC) Diesel Performance Group. These groups include representatives from the fuel injection equipment manufacturers, fuel producers, and additive suppliers. The charge of the ASTM task force has been the recommendation of test methods and fuel lubricity requirements for Specification D 975. Two test methods were proposed and approved. These are Test Method D 6078, a scuffing load ball-on-cylinder lubricity evaluator method, SLBOCLE, and Test Method D 6079, a high frequency reciprocating rig (HFRR) method. Use of these tests raises three issues: 1) The correlation of the data among the two test methods and the fuel injection equipment is not perfect, 2) Both methods in their current form do not apply to all fuel-additive combinations, and 3) The reproducibility values for both test methods are large. In order to protect diesel fuel injection equipment, an HFRR Wear Scar Diameter (WSD) of 520 microns has been placed in Specification D 975.[8]

X4.3.3 Most experts agree that fuels having a SLBOCLE lubricity value below 2000 g might not prevent excessive wear in injection equipment[9] while fuels with values above 3100 g should provide sufficient lubricity in all cases.[10] Experts also agree that if HFFR test at 60°C is used, fuels with values above 600 microns might not prevent excessive wear,[11] while fuels with values below 450 microns should provide sufficient lubricity in all cases.[10] More accurately, an industry-accepted long-term durability pump test, such as Test Method D 6898, can be used to evaluate the lubricity of a diesel fuel. A poor result in such a test indicates that the fuel has low lubricity and may not be able to provide sufficient protection.

NOTE X4.1—Some injection equipment can be fitted with special components that can tolerate low lubricity fuels.

[8] Mitchell, K., "Diesel Fuel Lubricity—Base Fuel Effects," SAE Technical Paper 2001-01-1928, 2001.

[9] Westbrook, S. R., "Survey of Low Sulfur Diesel Fuels and Aviation Kerosenes from U.S. Military Installations," SAE Technical Paper 952369, 1995.

[10] Nikanjam, M., "ISO Diesel Fuel Lubricity Round Robin Program," SAE Technical Paper 952372, 1995.

[11] Nikanjam, M., "*Diesel Fuel Lubricity: On the Path to Specifications*," SAE Technical Paper 1999-01-1479, 1999.

X5. TENTH PERCENTILE MINIMUM AMBIENT AIR TEMPERATURES FOR THE UNITED STATES (EXCEPT HAWAII)

X5.1 Introduction

X5.1.1 The tenth percentile minimum ambient air temperatures shown on the following maps (Figs. X5.1-X5.12) and in Table X5.1 were derived from an analysis of historical hourly temperature readings recorded over a period of 15 to 21 years from 345 weather stations in the United States. This study was conducted by the U.S. Army Mobility Equipment Research and Development Center (USAMERDC), Coating and Chemical Laboratory, Aberdeen Proving Ground, MD 21005. The tenth percentile minimum ambient air temperature is defined as the lowest ambient air temperature which will not go lower on average more than 10 % of the time. In other words, the daily minimum ambient air temperature would on average not be expected to go below the monthly tenth percentile minimum ambient air temperature more than 3 days for a 30-day month. See Table X5.1.

X5.1.2 These data may be used to estimate low temperature operability requirements. In establishing low temperature operability requirements, consideration should be given to the following. These factors, or any combination, may make low temperature operability more or less severe than normal. As X5.1.2.1 through X5.1.2.12 indicate, field work suggests that cloud point (or wax appearance point) is a fair indication of the low temperature operability limit of fuels without cold flow additives in most vehicles.

X5.1.2.1 Long term weather patterns (Average winter low temperatures will be exceeded on occasion).

X5.1.2.2 Short term local weather conditions (Unusual cold periods do occur).

X5.1.2.3 Elevation (High locations are usually colder than surrounding lower areas).

X5.1.2.4 Specific engine design.

X5.1.2.5 Fuel system design (Recycle rate, filter location, filter capacity, filter porosity, and so forth.)

X5.1.2.6 Fuel viscosity at low temperatures

X5.1.2.7 Equipment add-ons (Engine heaters, radiator covers, fuel line and fuel filter heaters and so forth.)

X5.1.2.8 Types of operation (Extensive idling, engine shutdown, or unusual operation).

X5.1.2.9 Low temperature flow improver additives in fuel.

X5.1.2.10 Geographic area for fuel use and movement between geographical areas.

X5.1.2.11 General housekeeping (Dirt and/or water in fuel or fuel supply system).

X5.1.2.12 Impact failure for engine to start or run (Critical vs. non-critical application).

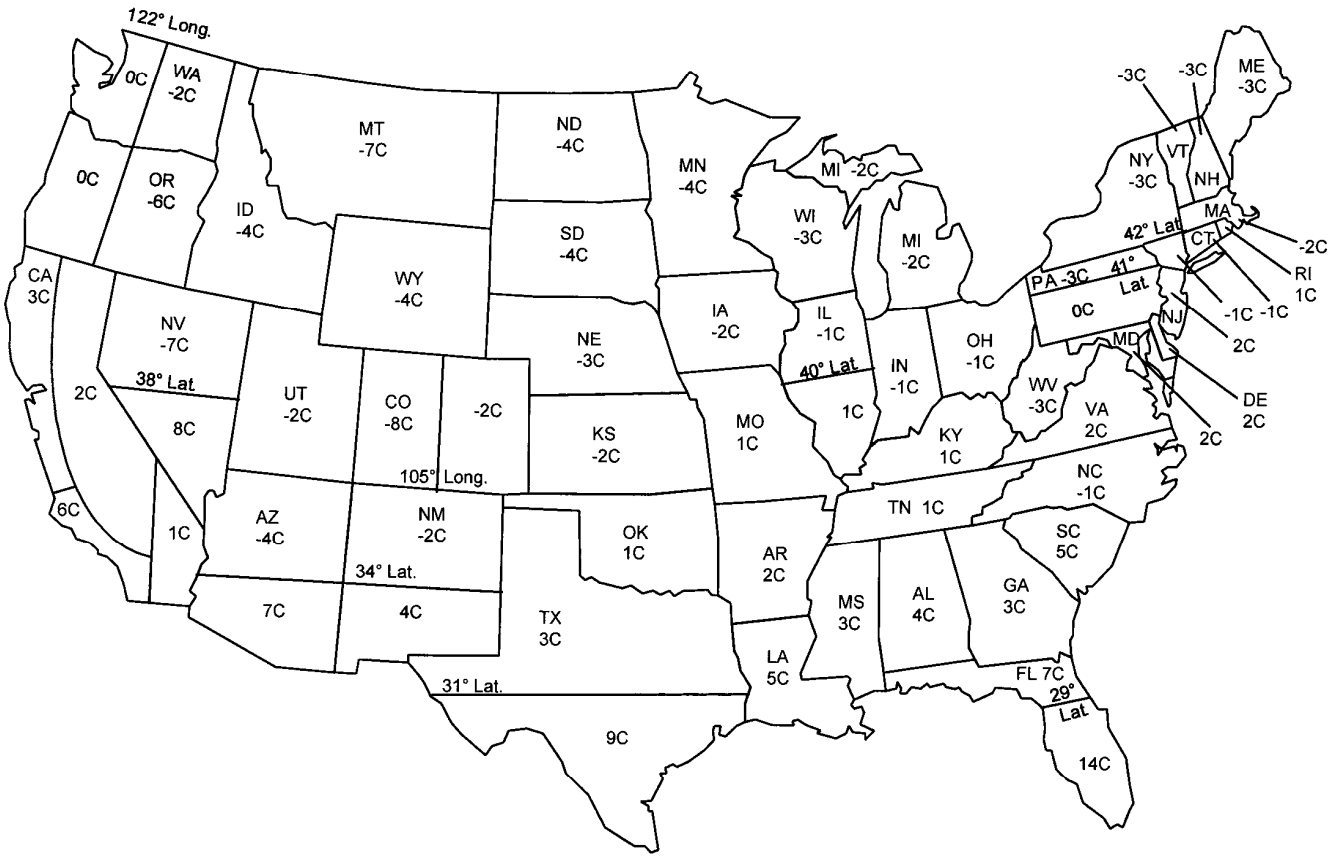

FIG. X5.1 October—10th Percentile Minimum Temperatures

X5.1.3 *Historical Background*—Three test methods have been widely used to estimate or correlate with low temperature vehicle operability. Cloud point, Test Method D 2500, is the oldest of the three and most conservative of the tests. The cloud point test indicates the earliest appearance of wax precipitation that might result in plugging of fuel filters or fuel lines under prescribed cooling conditions. Although not 100 % failsafe, it is the most appropriate test for applications that can not tolerate much risk. The Cold Filter Plugging Point (CFPP) test, Test Method D 6371, was introduced in Europe in 1965. The CFPP was designed to correlate with the majority of European vehicles. Under rapid cooling conditions, 20 cc fuel is drawn through a 45 micron screen then allowed to flow back through the screen for further cooling. This process is continued every 1°C until either the 20 cc fuel fails to be drawn through the screen in 60 s or it fails to return through the screen in 60 s. It was field tested many times in Europe[12] before being widely accepted as a European specification. Field tests have also shown CFPP results more than 10°C below the cloud point should be viewed with caution because those results did not necessarily reflect the true vehicle low temperature operability limits.[13] CFPP has been applied to many areas of the world where similar vehicle designs are used. The Low Temperature Flow Test (LTFT), Test Method D 4539, was designed to correlate with the most severe and one of the most common fuel delivery systems used in North American Heavy Duty trucks. Under prescribed slow cool conditions (1°C/h), similar to typical field conditions, several 200 cc fuel specimens in glass containers fitted with 17 μm screen assemblies are cooled. At 1°C intervals one specimen is drawn through the screen under a 20 kPa vacuum. Approximately 90 % of the fuel must come over in 60 s or less for the result to be a pass. This process is continued at lower temperatures (1°C increments) until the fuel fails to come over in the allotted 60 s. The lowest passing temperature is defined as the LTFT for that fuel. In 1981, a CRC program was conducted to evaluate the efficacy of cloud point, CFPP, pour point, and LTFT for protecting the diesel vehicle population in North America and to determine what benefit flow-improvers could provide. The field test consisted of 3 non-flow improved diesel fuels, 5 flow improved diesel fuels, 4 light-duty passenger cars, and 3 heavy-duty trucks. The field trial resulted in two documents[14,15] that provide insight into correlating laboratory tests to North

[12] "Low Temperature Operability of Diesels. A Report by CEC Investigation Group IGF-3," CEC P-171–82.

[13] "SFPP-A New Laboratory Test for Assessment of Low Temperature Operability of Modern Diesel Fuels," CEC/93/EF 15, 5–7, May 1993.

[14] CRC Report No. 537, "The Relationship Between Vehicle Fuel Temperature and Ambient Temperature, 1981 CRC Kapuskasing Field Test," December 1983.

[15] CRC Report No. 528, "1981 CRC Diesel Fuel Low-Temperature Operability Field Test," September 1983.

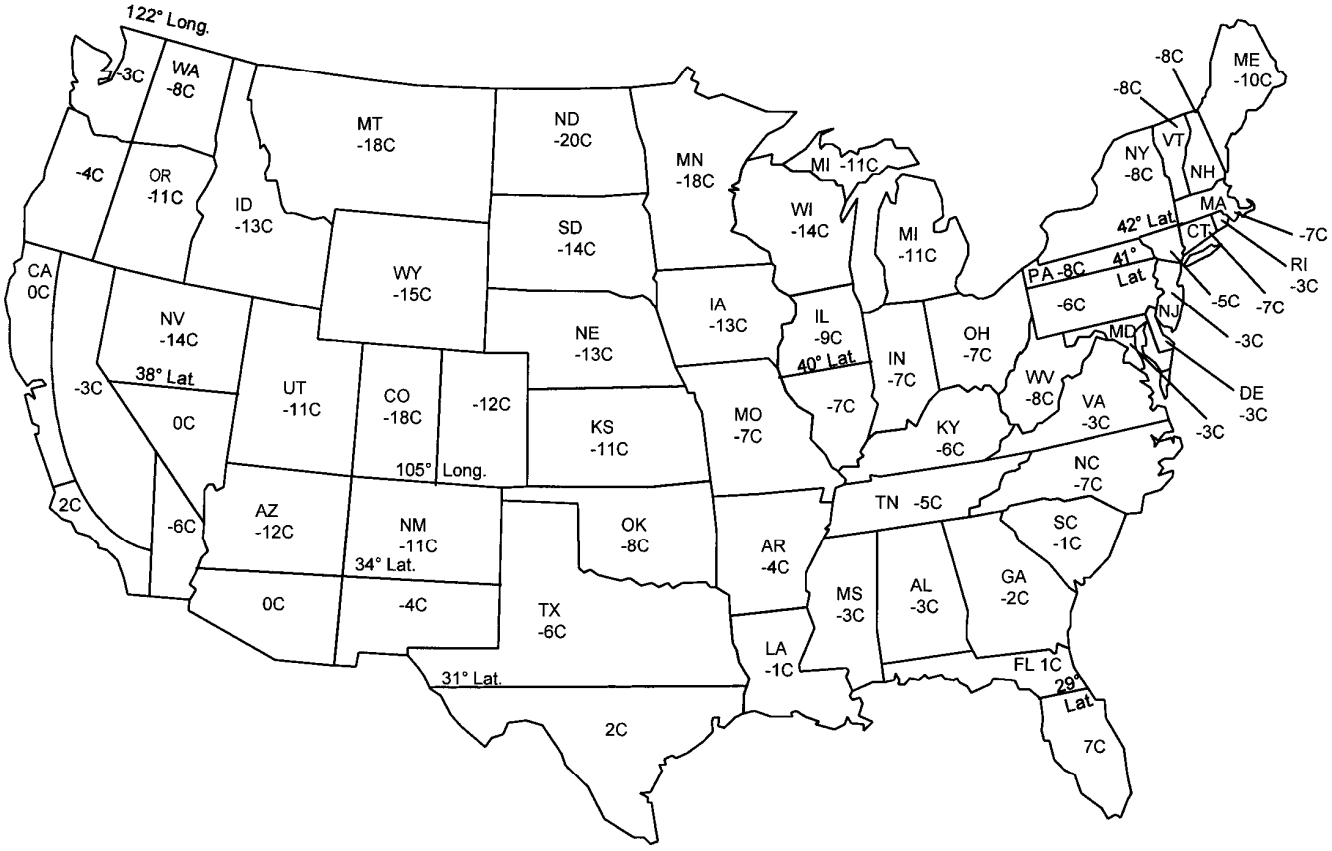

FIG. X5.2 November—10th Percentile Minimum Ambient Air Temperatures

American vehicle performance in the field. The general conclusions of the study were:

(1) In overnight cool down, 30 % of the vehicles tested had a final fuel tank temperature within 2°C of the overnight minimum ambient temperature.

(2) The use of flow-improved diesel fuel permits some vehicles to operate well below the fuel cloud point.

(3) Significant differences exist in the severity of diesel vehicles in terms of low temperature operation.

(4) No single laboratory test was found that adequately predicts the performance of all fuels in all vehicles.

(5) CFPP was a better predictor than pour point, but both methods over-predicted, minimum operating temperatures in many vehicles. For this reason, these tests were judged inadequate predictors of low-temperature performance and dismissed from further consideration.

(6) Cloud point and LTFT showed varying degrees of predictive capability, and offered distinctively different advantages. Both predicted the performance of the base fuels well, but LTFT more accurately predicted the performance of the flow-improved fuels. On the other hand, cloud point came closest to a fail-safe predictor of vehicle performance for all vehicles.

Since the 1981 field test, non-independent studies[16] using newer vehicles verified the suitability of the LTFT for North American heavy-duty trucks. Users are advised to review these and any more recent publications when establishing low temperature operability requirements and deciding upon test methods.

X5.1.3.1 *Current Practices*—It is recognized that fuel distributors, producers, and end users in the United States use cloud point, wax appearance point, CFPP, and LTFT to estimate vehicle low temperature operability limits for diesel fuel. No independent data has been published in recent years to determine test applicability for today's fuels and vehicles.

X5.2 Maps

X5.2.1 The maps in the following figures were derived from CCL Report No. 316, "A Predictive Study for Defining Limiting Temperatures and Their Application in Petroleum Product Specifications," by John P. Doner. This report was published by the U.S. Army Mobility Equipment Research and Development Center (USAMERDC), Coating and Chemical Laboratory, and it is available from the National Technical

[16] SAE 962197, SAE 982576, SAE 2000-01-2883.

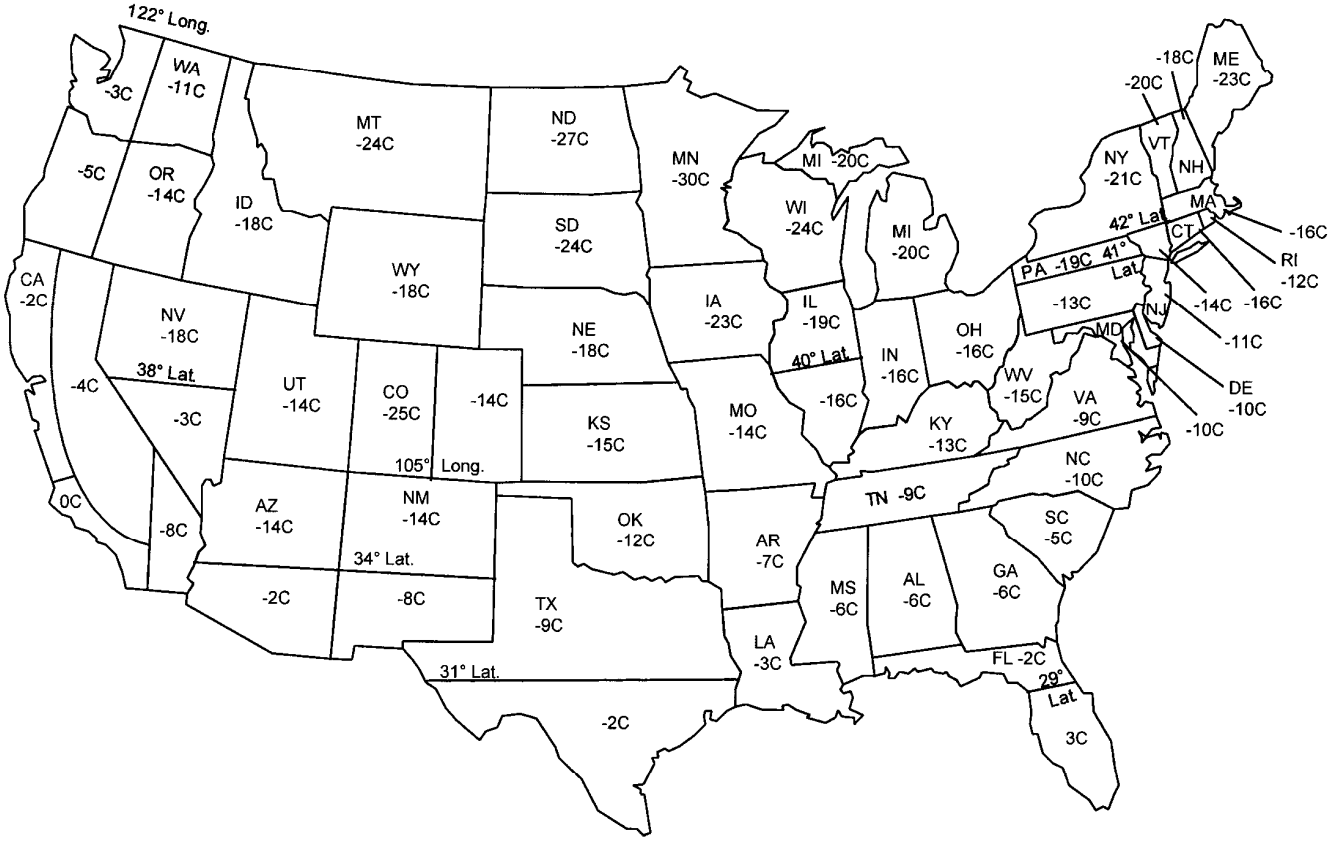

FIG. X5.3 December—10th Percentile Minimum Ambient Air Temperatures

Information Service, Springfield, VA 22151, by requesting Publication No. AD756-420.

X5.2.2 Where states are divided the divisions are noted on the maps and table with the exception of California, which is divided by counties as follows:

California, North Coast—Alameda, Contra Costa, Del Norte, Humbolt, Lake, Marin, Mendocino, Monterey, Napa, San Benito, San Francisco, San Mateo, Santa Clara, Santa Cruz, Solano, Sonoma, Trinity.

California, Interior—Lassen, Modoc, Plumas, Sierra, Siskiyou, Alpine, Amador, Butte, Calaveras, Colusa, El Dorado, Fresno, Glenn, Kern (except that portion lying east of the Los Angeles County Aqueduct), Kings, Madera, Mariposa, Merced, Placer, Sacramento, San Joaquin, Shasta, Stanislaus, Sutter, Tehama, Tulare, Tuolumne, Yolo, Yuba, Nevada.

California, South Coast—Orange, San Diego, San Luis Obispo, Santa Barbara, Ventura, Los Angeles (except that portion north of the San Gabriel Mountain range and east of the Los Angeles County Aqueduct).

California, Southeast—Imperial, Riverside, San Bernardino, Los Angeles (that portion north of the San Gabriel Mountain range and east of the Los Angeles County Aqueduct), Mono, Inyo, Kern (that portion lying east of the Los Angeles County Aqueduct).

X5.2.3 The temperatures in CCL Report No. 316 were in degrees Fahrenheit. The degree Celsius temperatures in Appendix X5 were obtained by converting the original degree Fahrenheit temperatures.

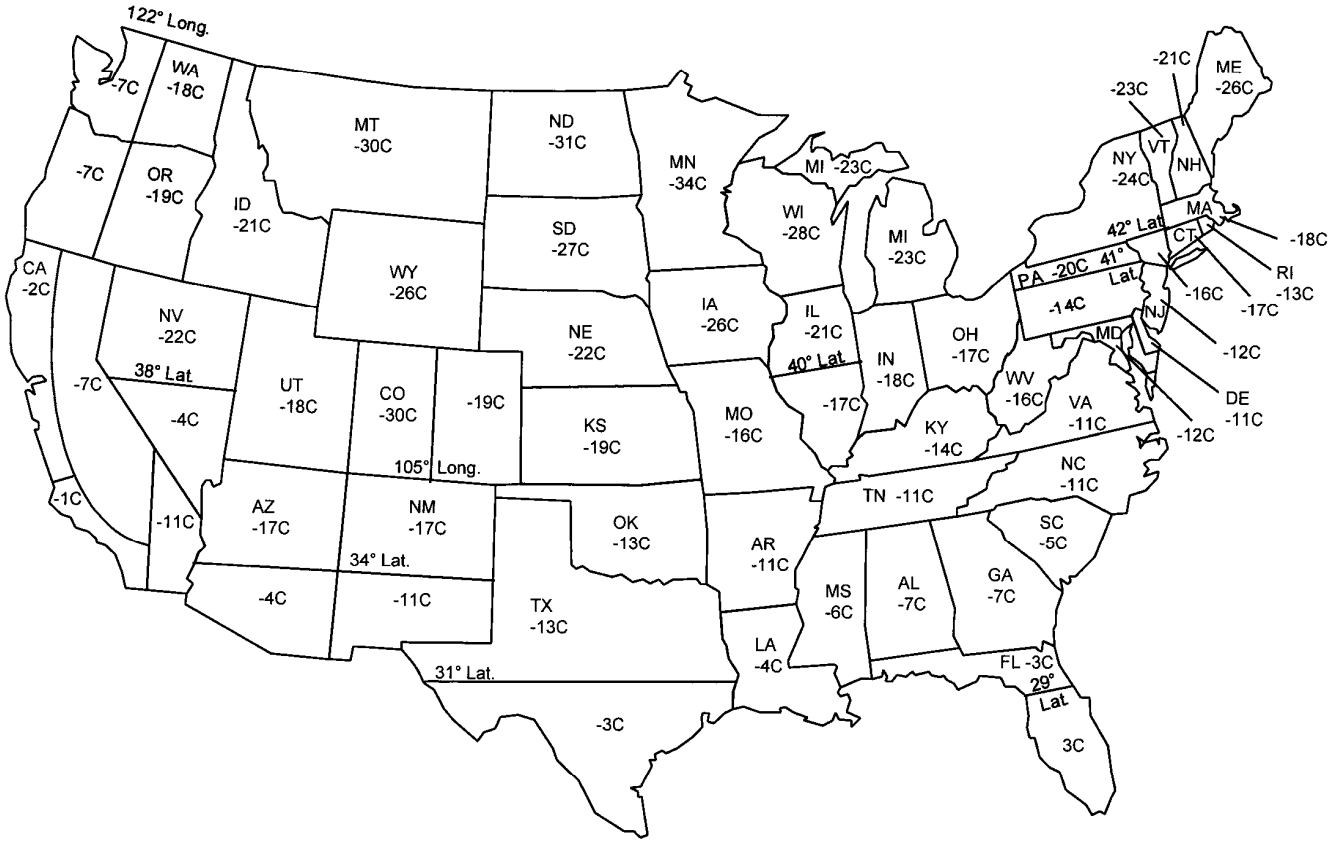

FIG. X5.4 January—10th Percentile Minimum Ambient Air Temperatures

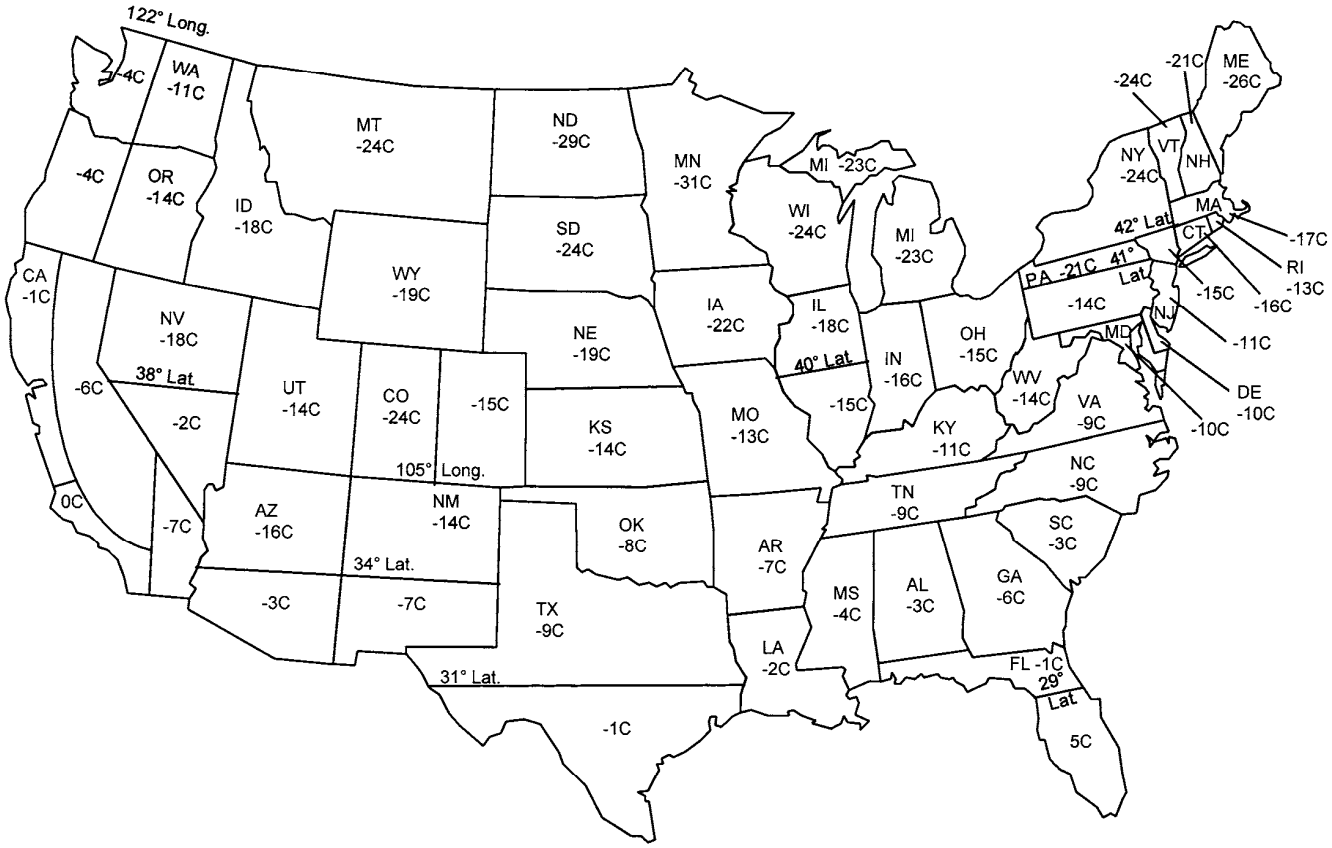

FIG. X5.5 February—10th Percentile Minimum Ambient Air Temperatures

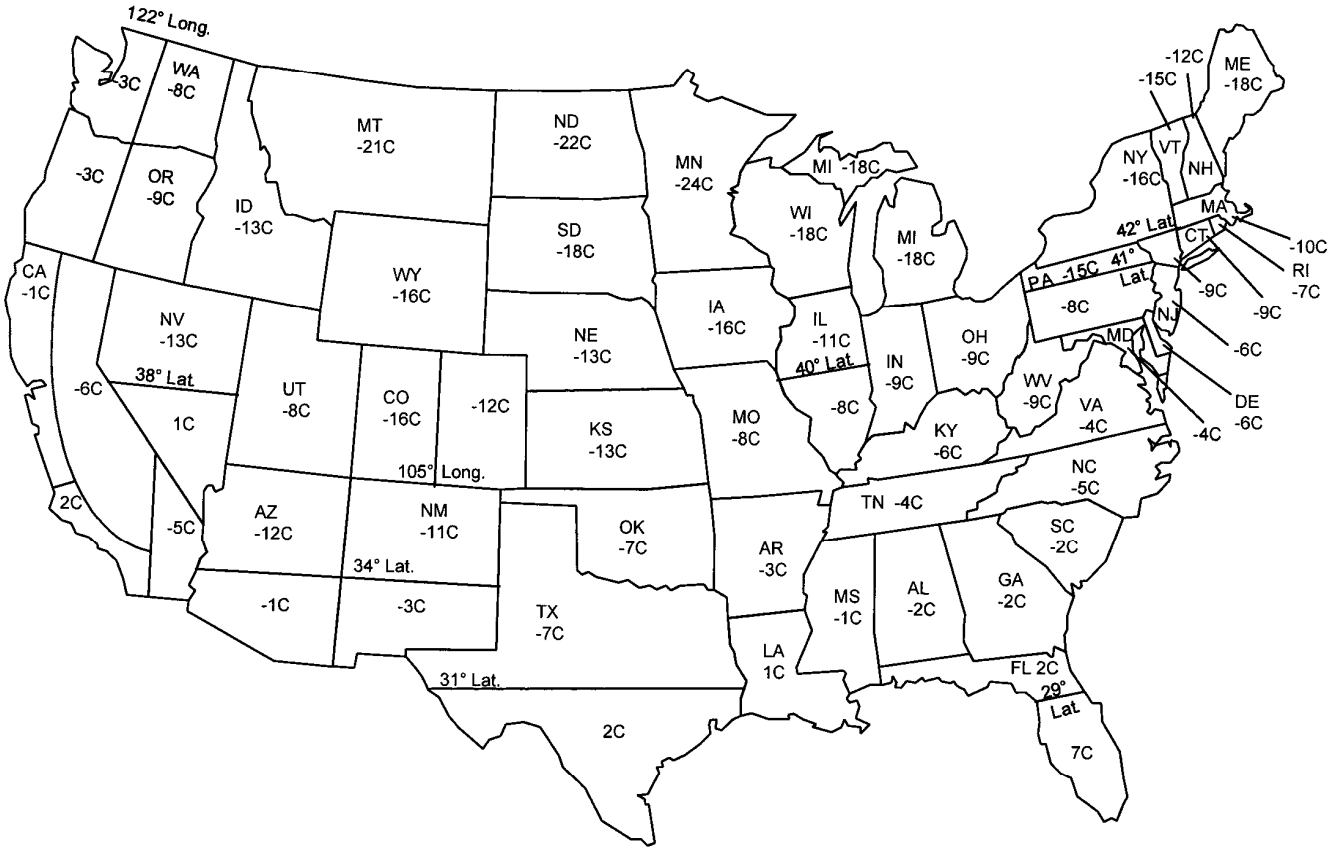

FIG. X5.6 March—10th Percentile Minimum Ambient Air Temperatures

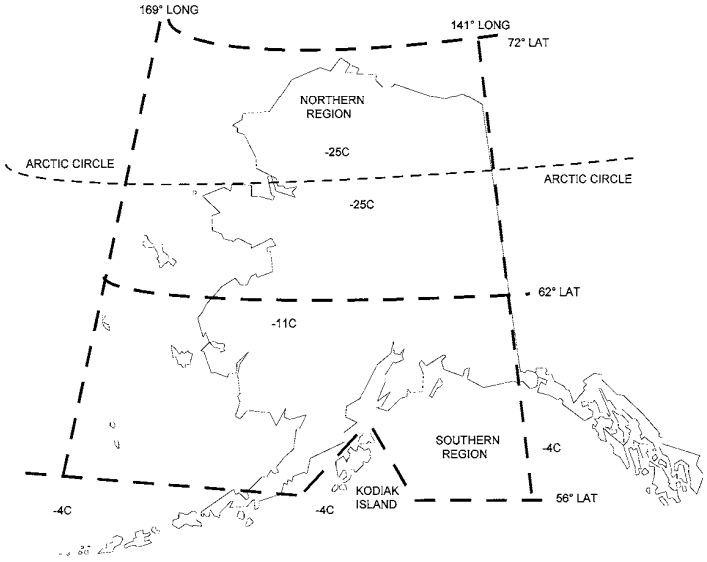

FIG. X5.7 October—10th Percentile Minimum Ambient Air Temperatures

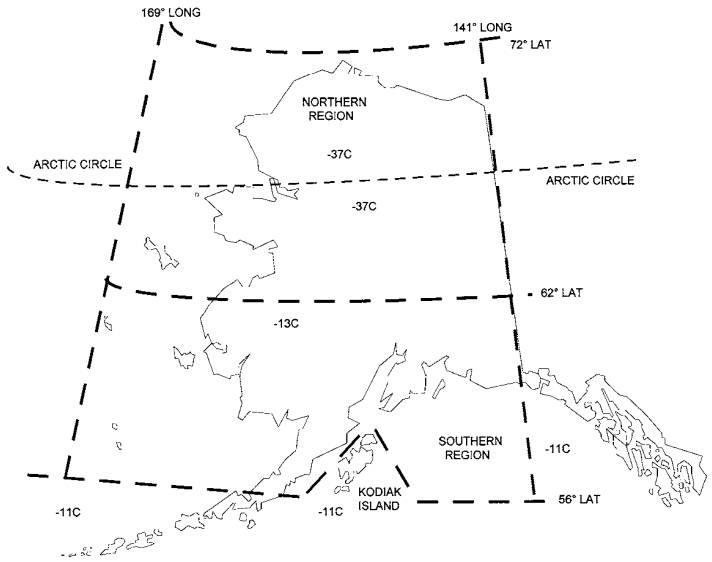

FIG. X5.8 November—10th Percentile Minimum Ambient Air Temperatures

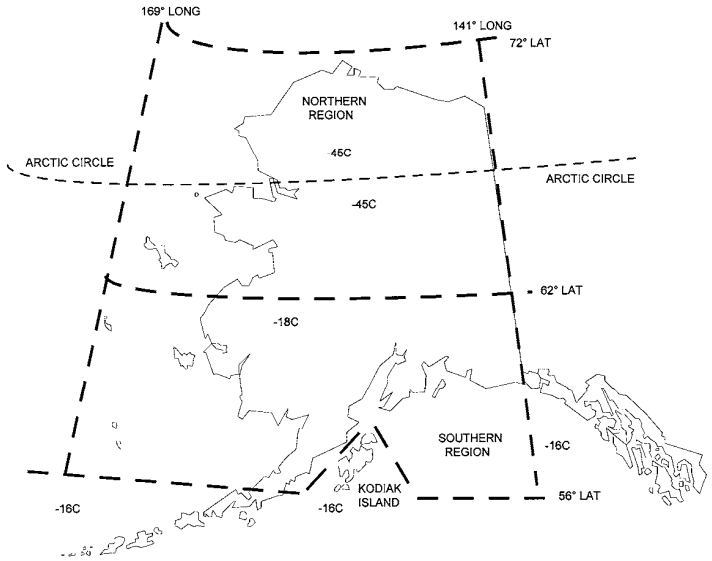

FIG. X5.9 December—10th Percentile Minimum Ambient Air Temperatures

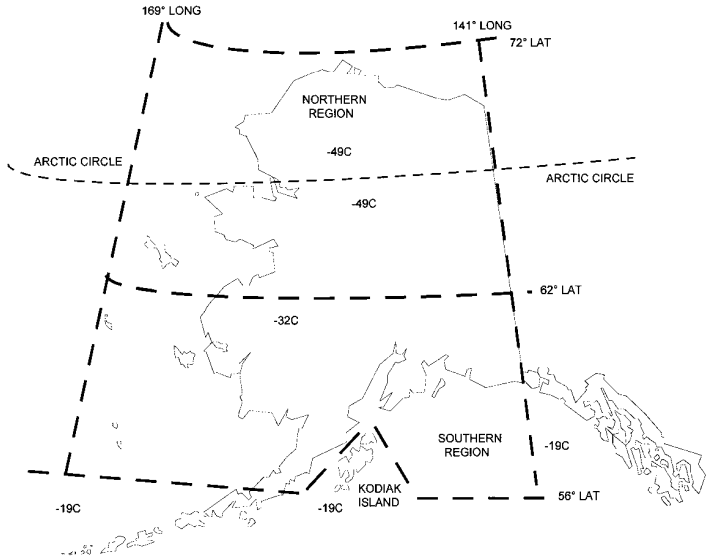

FIG. X5.10 January—10th Percentile Minimum Ambient Air Temperatures

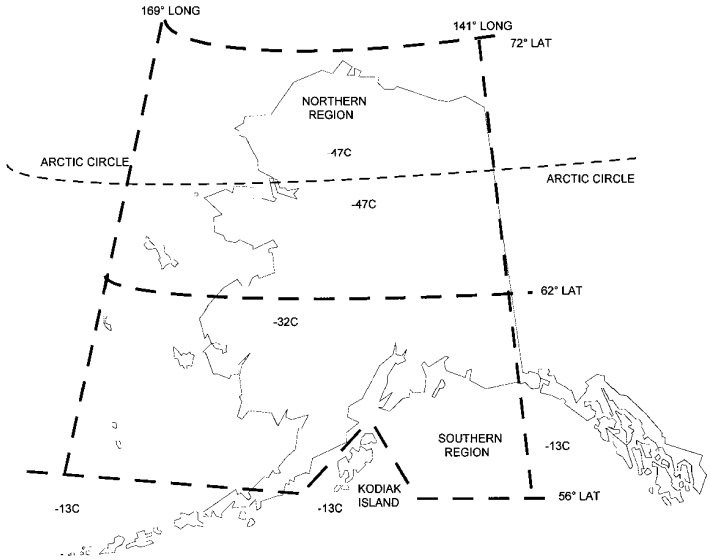

FIG. X5.11 February—10th Percentile Minimum Ambient Air Temperatures

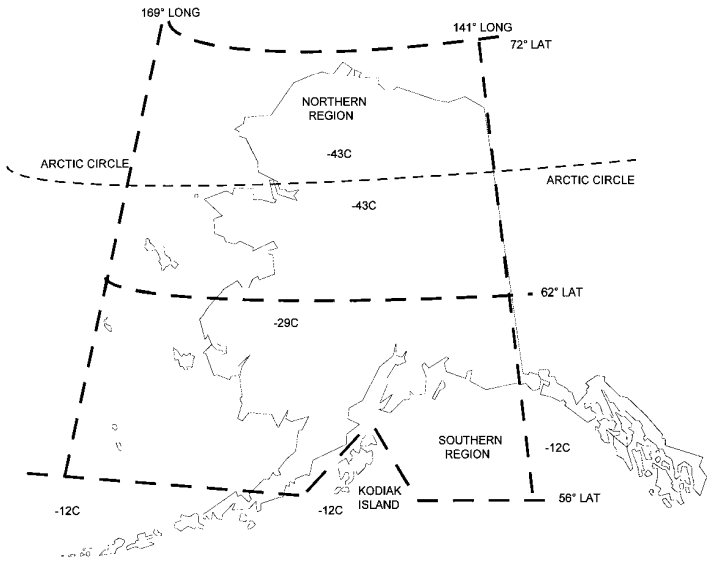

FIG. X5.12 March—10th Percentile Minimum Ambient Air Temperatures

TABLE X5.1 Tenth Percentile Minimum Ambient Air Temperatures for the United States (except Hawaii)

State		10th Percentile Temperature°C, min					
		Oct.	Nov.	Dec.	Jan.	Feb.	March
Alabama		4	−3	−6	−7	−3	−2
Alaska	Northern	−25	−37	−45	−49	−47	−43
	Southern	−11	−13	−18	−32	−32	−29
	South East	−4	−11	−16	−19	−13	−12
Arizona	North 34° latitude	−4	−12	−14	−17	−16	−12
	South 34° latitude	7	0	−2	−4	−3	−1
Arkansas		2	−4	−7	−11	−7	−3
California	North Coast	3	0	−2	−2	−1	−1
	Interior	2	−3	−4	−7	−6	−6
	South Coast	6	2	0	−1	0	2
	Southeast	1	−6	−8	−11	−7	−5
Colorado	East 105° long	−2	−12	−14	−19	−15	−12
	West 105° long	−8	−18	−25	−30	−24	−16
Connecticut		−1	−7	−16	−17	−16	−9
Delaware		2	−3	−10	−11	−10	−6
Florida	North 29° latitude	7	1	−2	−3	−1	2
	South 29° latitude	14	7	3	3	5	7
Georgia		3	−2	−6	−7	−6	−2
Idaho		−4	−13	−18	−21	−18	−13
Illinois	North 40° latitude	−1	−9	−19	−21	−18	−11
	South 40° latitude	1	−7	−16	−17	−15	−8
Indiana		−1	−7	−16	−18	−16	−9
Iowa		−2	−13	−23	−26	−22	−16
Kansas		−2	−11	−15	−19	−14	−13
Kentucky		1	−6	−13	−14	−11	−6
Louisiana		5	−1	−3	−4	−2	1
Maine		−3	−10	−23	−26	−26	−18
Maryland		2	−3	−10	−12	−10	−4
Massachusetts		−2	−7	−16	−18	−17	−10
Michigan		−2	−11	−20	−23	−23	−18
Minnesota		−4	−18	−30	−34	−31	−24
Mississippi		3	−3	−6	−6	−4	−1
Missouri		1	−7	−14	−16	−13	−8
Montana		−7	−18	−24	−30	−24	−21
Nebraska		−3	−13	−18	−22	−19	−13
Nevada	North 38° latitude	−7	−14	−18	−22	−18	−13
	South 38° latitude	8	0	−3	−4	−2	1
New Hampshire		−3	−8	−18	−21	−21	−12
New Jersey		2	−3	−11	−12	−11	−6
New Mexico	North 34° latitude	−2	−11	−14	−17	−14	−11
	South 34° latitude	4	−4	−8	−11	−7	−3
New York	North 42° latitude	−3	−8	−21	−24	−24	−16
	South 42° latitude	−1	−5	−14	−16	−15	−9
North Carolina		−1	−7	−10	−11	−9	−5
North Dakota		−4	−20	−27	−31	−29	−22
Ohio		−1	−7	−16	−17	−15	−9
Oklahoma		1	−8	−12	−13	−8	−7
Oregon	East 122° long	−6	−11	−14	−19	−14	−9
	West 122° long	0	−4	−5	−7	−4	−3
Pennsylvania	North 41° latitude	−3	−8	−19	−20	−21	−15
	South 41° latitude	0	−6	−13	−14	−14	−8
Rhode Island		1	−3	−12	−13	−13	−7
South Carolina		5	−1	−5	−5	−3	−2
South Dakota		−4	−14	−24	−27	−24	−18
Tennessee		1	−5	−9	−11	−9	−4
Texas	North 31° latitude	3	−6	−9	−13	−9	−7
	South 31° latitude	9	2	−2	−3	−1	2
Utah		−2	−11	−14	−18	−14	−8
Vermont		−3	−8	−20	−23	−24	−15
Virginia		2	−3	−9	−11	−9	−4
Washington	East 122° long	−2	−8	−11	−18	−11	−8
	West 122° long	0	−3	−3	−7	−4	−3
West Virginia		−3	−8	−15	−16	−14	−9
Wisconsin		−3	−14	−24	−28	−24	−18
Wyoming		−4	−15	−18	−26	−19	−16

SUMMARY OF CHANGES

Subcommittee D02.E0.02 has identified the location of selected changes to this standard since the last issue (D 975–06b) that may impact the use of this standard. (Approved Feb. 1, 2007.)

(*1*) Added standards to the Referenced Documents.
(*2*) Added Section 4.
(*3*) Added X2.2.2.

Subcommittee D02.E0.02 has identified the location of selected changes to this standard since the last issue (D 975–06a) that may impact the use of this standard. (Approved Nov. 1, 2006.)

(*1*) Revised Appendix X4.

Subcommittee D02.E0.02 has identified the location of selected changes to this standard since the last issue (D 975–06) that may impact the use of this standard. (Approved Oct. 1, 2006.)

(*1*) Added Test Method D 6890.
(*2*) Revised 5.1.10.

Subcommittee D02.E0.02 has identified the location of selected changes to this standard since the last issue (D 975–05) that may impact the use of this standard. (Approved May 15, 2006.)

(*1*) Deleted Test Method D 6920 from this standard.

Subcommittee D02.E0.02 has identified the location of selected changes to this standard since the last issue (D 975–04c$^{\epsilon 1}$) that may impact the use of this standard. (Approved June 1, 2005.)

(*1*) Removed footnote J from Grade No. 4–D in Table 1.

EXHIBIT 8

Designation: D 396 – 98

An American National Standard

AMERICAN SOCIETY FOR TESTING AND MATERIALS
100 Barr Harbor Dr., West Conshohocken, PA 19428
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Standard Specification for Fuel Oils[1]

This standard is issued under the fixed designation D 396; 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.

1. Scope

1.1 This specification (Note 1) covers grades of fuel oil intended for use in various types of fuel-oil-burning equipment under various climatic and operating conditions. These grades are described as follows:

1.1.1 Grades 1 and 2 are distillate fuels for use in domestic and small industrial burners. Grade 1 is particularly adapted to vaporizing type burners or where storage conditions require low pour point fuel.

1.1.2 Grades 4 (Light) and 4 are heavy distillate fuels or distillate/residual fuel blends used in commercial/industrial burners equipped for this viscosity range.

1.1.3 Grades 5 (Light), 5 (Heavy), and 6 are residual fuels of increasing viscosity and boiling range, used in industrial burners. Preheating is usually required for handling and proper atomization.

NOTE 1—For information on the significance of the terminology and test methods used in this specification, see Appendix X1.

NOTE 2—A more detailed description of the grades of fuel oils is given in X1.3.

1.2 This specification is for the use of purchasing agencies in formulating specifications to be included in contracts for purchases of fuel oils and for the guidance of consumers of fuel oils in the selection of the grades most suitable for their needs.

1.3 Nothing in this specification shall preclude observance of federal, state, or local regulations which can be more restrictive.

1.4 All values are stated in SI units and are regarded as standard.

NOTE 3—The generation and dissipation of static electricity can create problems in the handling of distillate burner fuel oils. For more information on the subject, see Guide D 4865.

2. Referenced Documents

2.1 *ASTM Standards:*

D 56 Test Method for Flash Point by Tag Closed Tester[2]
D 86 Test Method for Distillation of Petroleum Products[2]
D 93 Test Methods for Flash Point by Pensky-Martens Closed Cup Tester[2]
D 95 Test Method for Water in Petroleum Products and Bituminous Materials by Distillation[2]
D 97 Test Method for Pour Point of Petroleum Oils[2]
D 129 Test Method for Sulfur in Petroleum Products (General Bomb Method)[2]
D 130 Test Method for Detection of Copper Corrosion from Petroleum Products by the Copper Strip Tarnish Test[2]
D 445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity)[2]
D 473 Test Method for Sediment in Crude Oils and Fuel Oils by the Extraction Method[2]
D 482 Test Method for Ash from Petroleum Products[2]
D 524 Test Method for Ramsbottom Carbon Residue of Petroleum Products[2]
D 1266 Test Method for Sulfur in Petroleum Products (Lamp Method)[2]
D 1298 Practice for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method[2]
D 1552 Test Method for Sulfur in Petroleum Products (High-Temperature Method)[2]
D 2622 Test Method for Sulfur in Petroleum Products by X-Ray Spectrometry[3]
D 2709 Test Method for Water and Sediment in Distillate Fuels by Centrifuge[3]
D 3245 Test Method for Pumpability of Industrial Fuel Oils[3]
D 3828 Test Methods for Flash Point by Small Scale Closed Tester[3]
D 4052 Test Method for Density and Relative Density of Liquids by Digital Density Meter[3]
D 4057 Practice for Manual Sampling of Petroleum and Petroleum Products[3]
D 4294 Test Method for Sulfur in Petroleum Products by Energy-Dispersive X-Ray Fluorescence Spectrometry[3]
D 4865 Guide for Generation and Dissipation of Static Electricity in Petroleum Fuel Systems[4]
D 5949 Test Method for Pour Point of Petroleum Products

[1] This specification is under the jurisdiction of ASTM Committee D-2 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.E on Burner, Diesel, Non-aviation Gas Turbine, and Marine Fuels .

Current edition approved Apr. 10, 1998. Published September 1998. Originally published as D 396 – 34 T. Last previous edition D 396 – 96.

[2] *Annual Book of ASTM Standards*, Vol 05.01.

[3] *Annual Book of ASTM Standards*, Vol 05.02.

[4] *Annual Book of ASTM Standards*, Vol 05.03.

(Automatic Pressure Pulsing Method)[4]

D 5950 Test Method for Pour Point of Petroleum Products (Automatic Tilt Method)[4]

D 5985 Test Method for Pour Point of Petroleum Products (Rotational Method)[4]

2.2 *Other Documents:*[5]

26 CFR Part 48 Diesel Fuel Excise Tax; Dye Color and Concentration

40 Part 80 Regulation of Fuel and Fuel Additives

3. General Requirements

3.1 The grades of fuel oil specified herein shall be homogeneous hydrocarbon oils, free from inorganic acid, and free from excessive amounts of solid or fibrous foreign matter.

3.2 All grades containing residual components shall remain uniform in normal storage and not separate by gravity into light and heavy oil components outside the viscosity limits for the grade.

4. Detailed Requirements

4.1 The various grades of fuel oil shall conform to the limiting requirements shown in Table 1. A representative sample shall be taken for testing in accordance with Practice D 4057.

4.2 Modifications of limiting requirements to meet special operating conditions agreed upon between the purchaser, the seller, and the supplier shall fall within limits specified for each grade, except as stated in supplementary footnotes for Table 1.

5. Test Methods

5.1 The requirements enumerated in this specification shall be determined in accordance with the following ASTM test methods,[6] except as may be required under 5.1.1.

5.1.1 *Flash Point*—Test Method D 93, except where other methods are prescribed by law. For all grades, Test Method D 3828 may be used as an alternate with the same limits. For Grades No. 1 and No. 2, Test Method D 56 may be used as an alternate with the same limits, provided the flash point is below

[5] Available from Superintendent of Documents, U. S. Government Printing Office, Washington, DC 20402.

[6] For information on the precision of the ASTM test methods for fuel oils refer to "An Evaluation of Methods for Determination of Sulfur in Fuel Oils" by A. R. Crawford, Esso Mathematics & Systems Inc. and G. V. Dyroff, Esso Research and Engineering Co., 1969. This document is available from the Publications Section, API Library American Petroleum Institute, 1220 L St., N.W., Washington, DC 20005.

TABLE 1 Detailed Requirements for Fuel Oils[A]

Property	ASTM Test Method[B]	No. 1[C]	No. 2[C]	Grade No. 4 (Light)[C]	No. 4	No. 5 (Light)	No. 5 (Heavy)	No. 6
Flash Point °C, min	D 93	38	38	38	55	55	55	60
Water and sediment, % vol, max	D 2709	0.05	0.05	...	...	...	...	...
	D 95 + D 473	...	...	(0.50)[D]	(0.50)[D]	(1.00)[D]	(1.00)[D]	(2.00)[D]
Distillation temperature °C	D 86							
10 % volume recovered, max		215	...	...	...	...	...	...
90 % volume recovered, min		...	282	...	...	...	...	...
max		288	338	...	...	...	...	...
Kinematic viscosity at 40°C, mm^2/s	D 445							
min		1.3	1.9	1.9	>5.5	...	...	...
max		2.1	3.4	5.5	24.0[E]			
Kinematic viscosity at 100°C, mm^2/s	D 445							
min		...	...	...	...	5.0	9.0	15.0
max		...	...	...	...	8.9[E]	14.9[E]	50.0[E]
Ramsbottom carbon residue on 10 % distillation residue % mass, max	D 524	0.15	0.35	...	...	...	...	...
Ash, % mass, max	D 482	...	...	0.05	0.10	0.15	0.15	...
Sulfur, % mass max[F]	D 129	0.50	0.50	...	...	...	...	...
Copper strip corrosion rating, max, 3 h at 50°C	D 130	No. 3	No. 3	...	...	...	...	...
Density at 15°C, kg/m^3	D 1298							
min		...	...	>876[G]	...	...	...	...
max		850	876	...	...	...	...	...
Pour Point °C, max[H]	D 97	−18	−6	−6	−6	...	...	[I]

[A] It is the intent of these classifications that failure to meet any requirement of a given grade does not automatically place an oil in the next lower grade unless in fact it meets all requirements of the lower grade. However, to meet special operating conditions modifications of individual limiting requirements may be agreed upon among the purchaser, seller and manufacturer.

[B] The test methods indicated are the approved referee methods. Other acceptable methods are indicated in Section 2 and 5.1.

[C] Under United States regulations, Grades No. 1, No. 2, and No.4 (Light) are required by 40 CFR Part 80 to contain a sufficient amount of the dye Solvent Red 164 so its presence is visually apparent. At or beyond terminal storage tanks, they are required by 26 CFR Part 48 to contain the dye Solvent Red 164 at a concentration spectrally equivalent to 3.9 lbs per thousand barrels of the solid dye standard SolventRed 26.

[D] The amount of water by distillation by Test Method D 95 plus the sediment by extraction by Test Method D 473 shall not exceed the value shown in the table. For Grade No. 6 fuel oil, the amount of sediment by extraction shall not exceed 0.50 mass %, and a deduction in quantity shall be made for all water and sediment in excess of 1.0 mass %.

[E] Where low sulfur fuel oil is required, fuel oil falling in the viscosity range of a lower numbered grade down to and including No. 4 can be supplied by agreement between the purchaser and supplier. The viscosity range of the initial shipment shall be identified and advance notice shall be required when changing from one viscosity range to another. This notice shall be in sufficient time to permit the user to make the necessary adjustments.

[F] Other sulfur limits may apply in selected areas in the United States and in other countries.

[G] This limit assures a minimum heating value and also prevents misrepresentation and misapplication of this product as Grade No. 2.

[H] Lower or higher pour points can be specified whenever required by conditions of storage or use. When a pour point less than − 18°C is specified, the minimum viscosity at 40°C for grade No. 2 shall be 1.7 mm^2/s and the minimum 90 % recovered temperature shall be waived.

[I] Where low sulfur fuel oil is required, Grade No. 6 fuel oil will be classified as Low Pour (+ 15°C max) or High Pour (no max). Low Pour fuel oil should be used unless tanks and lines are heated.

93°C and the viscosity is below 5.5 mm^2/s at 40°C. This test method will give slightly lower values. In cases of dispute, Test Method D 93 shall be used as the reference method.

5.1.2 *Pour Point*—Test Method D 97. For all grades, the automatic Test Methods D 5949, D 5950, and D 5985 can be used as alternates with the same limits. In case of dispute, Test Method 97 shall be used as the referee method. Alternative test methods that indicate flow point properties can be used for low sulfur residual fuels by agreement between purchaser and supplier.

5.1.3 *Water and Sediment*—The water and sediment in Grade Nos. 1 and 2 shall be determined in accordance with Test Method D 2709 and in Grade Nos. 4, 5, and 6 by Test Method D 95 and Test Method D 473. A density of 1.0 kg/L shall be used for the Test Method D 95 water.

5.1.4 *Carbon Residue*—Test Method D 524.

5.1.5 *Ash*—Test Method D 482.

5.1.6 *Distillation*—Distillation of Grade No. 1 and No. 2 oils shall be determined in accordance with Test Method D 86.

5.1.7 *Viscosity*—Viscosity shall be determined in accordance with Test Method D 445.

5.1.8 *Density*—Practice D 1298. Test Method D 4052 can be used as an alternate with the same limits. In case of dispute, Practice D 1298 shall be used as the referee method.

5.1.9 *Corrosion*—Test Method D 130, 3 h test at 50°C.

5.1.10 *Sulfur*—Test Method D 129. Test Methods D 1552, D 2622, and D 4294 can also be used for all grades. In addition, Test Method D 1266 can be used for Grade 1, but only with samples having sulfur contents of 0.4 mass per cent and less (down to 0.01 %). In case of dispute, Test Method D 129 is the referee test method for this specification.

6. Keywords

6.1 burner fuels; fuel oils; furnace oils; petroleum and petroleum products; specifications

APPENDIX

(Nonmandatory Information)

X1. SIGNIFICANCE OF ASTM SPECIFICATION FOR FUEL OILS

X1.1 Scope

X1.1.1 This specification divides fuel oils into grades based upon the types of burners for which they are suitable. It places limiting values on several of the properties of the oils in each grade. The properties selected for limitation are those that are believed to be of the greatest significance in determining the performance characteristics of the oils in the types of burners in which they are most commonly used.

X1.2 Classes

X1.2.1 Because of the methods employed in their production, fuel oils fall into two broad classifications: distillates and residuals. The distillates consist of overhead or distilled fractions. The residuals are bottoms remaining from the distillation, or blends of these bottoms with distillates. In this specification, Grades No. 1 and No. 2 are distillates and the grades from No. 4 to No. 6 are usually residual, although some heavy distillates can be sold as Grade No. 4.

X1.3 Grades

X1.3.1 *Grade No. 1* is a light distillate intended for use in burners of the vaporizing type in which the oil is converted to a vapor by contact with a heated surface or by radiation. High volatility is necessary to ensure that evaporation proceeds with a minimum of residue.

X1.3.2 *Grade No. 2* is a heavier distillate than grade No. 1. It is intended for use in atomizing type burners which spray the oil into a combustion chamber where the tiny droplets burn while in suspension. This grade of oil is used in most domestic burners and in many medium capacity commercial-industrial burners where its ease of handling and ready availability sometimes justify its higher cost over the residual fuels.

X1.3.3 *Grade No. 4 (Light)* is a heavy distillate fuel or distillate/residual fuel blend meeting the specification viscosity range. It is intended for use both in pressure-atomizing commercial-industrial burners not requiring higher cost distillates and in burners equipped to atomize oils of higher viscosity. Its permissible viscosity range allows it to be pumped and atomized at relatively low-storage temperatures.

X1.3.4 *Grade No. 4* is usually a heavy distillate/residual fuel blend but can be a heavy distillate fuel meeting the specification viscosity range. It is intended for use in burners equipped with devices that atomize oils of higher viscosity than domestic burners can handle. Its permissible viscosity range allows it to be pumped and atomized at relatively low storage temperatures. Thus, in all but extremely cold weather it requires no preheating for handling.

X1.3.5 *Grade No. 5 (Light)* is residual fuel of intermediate viscosity for burners capable of handling fuel more viscous than grade No. 4 without preheating. Preheating may be necessary in some types of equipment for burning and in colder climates for handling.

X1.3.6 *Grade No. 5 (Heavy)* is a residual fuel more viscous than Grade No. 5 (Light) and is intended for use in similar service. Preheating may be necessary in some types of equipment for burning and in colder climates for handling.

X1.3.7 *Grade No. 6*, sometimes referred to as Bunker C, is a high-viscosity oil used mostly in commercial and industrial heating. It requires preheating in the storage tank to permit pumping, and additional preheating at the burner to permit atomizing. The extra equipment and maintenance required to handle this fuel usually preclude its use in small installations.

X1.3.8 Residual fuel oil supplied to meet regulations requiring low sulfur content can differ from the grade previously

supplied. It may be lower in viscosity (and fall into a different grade number). If it must be fluid at a given temperature, Test Method D 97 need not accurately reflect the pour point which can be expected after a period of storage. It is suggested that the purchaser and supplier discuss the proper handling and operating techniques for a given low-sulfur residual fuel oil in the installation where it is to be used.

X1.4 Significance of Test Methods

X1.4.1 The significance of the properties of fuel oil on which limitations are placed by the specification is as follows:

X1.4.1.1 *Flash Point*—The flash point of a fuel oil is an indication of the maximum temperature at which it can be stored and handled without serious fire hazard. The minimum permissible flash point is usually regulated by federal, state, or municipal laws and is based on accepted practice in handling and use.

X1.4.1.2 *Pour Point*—The pour point is an indication of the lowest temperature at which a fuel oil can be stored and still be capable of flowing under very low forces. The pour point is prescribed in accordance with the conditions of storage and use. Higher pour point fuels are permissible where heated storage and adequate piping facilities are provided. An increase in pour point can occur when residual fuel oils are subjected to cyclic temperature variations that can occur in the course of storage or when the fuel is preheated and returned to storage tanks. To predict these properties, Test Method D 3245 may be required.

X1.4.1.3 *Water and Sediment*—Appreciable amounts of water and sediment in a fuel oil tend to cause fouling of facilities for handling it, and to give trouble in burner mechanisms. Sediment may accumulate in storage tanks and on filter screens or burner parts, resulting in obstruction to flow of oil from the tank to the burner. Water in distillate fuels can cause corrosion of tanks and equipment and it can cause emulsions in residual fuels.

X1.4.1.4 *Carbon Residue*—The carbon residue of a fuel is a measure of the carbonaceous material left after all the volatile components are vaporized in the absence of air. It is a rough approximation of the tendency of a fuel to form deposits in vaporizing burners, such as pot-type and sleeve-type burners, where the fuel is vaporized in an air-deficient atmosphere.

X1.4.1.4.1 To obtain measurable values of carbon residue in the lighter distillate fuel oils, it is necessary to distill the oil to remove 90 % of it in accordance with Section 9 of Test Method D 524, and then determine the carbon residue concentrated in the remaining 10 % bottoms.

X1.4.1.5 *Ash*—The amount of ash is the quantity of noncombustible material in an oil. Excessive amounts can indicate the presence of materials that cause high wear of burner pumps and valves, and contribute to deposits on boiler heating surfaces.

X1.4.1.6 *Distillation*—The distillation test shows the volatility of a fuel and the ease with which it can be vaporized. The test is of greater significance for oils that are to be burned in vaporizing type burners than for the atomizing type. For example, the maximum 10 % and 90 % distilled temperatures are specified for grade No. 1 fuel. The limiting 10 % value assures easy starting in vaporizing type burners and the 90 % limit excludes heavier fractions that would be difficult to vaporize.

X1.4.1.6.1 The limits specified for grade No. 2 heating oil define a product that is acceptable for burners of the atomizing type in household heating installations. Distillation limits are not specified for fuel oils of grades Nos. 4, 5, and 6.

X1.4.1.7 *Viscosity Limits for Grades Nos. 1 and 2*—The viscosity of an oil is a measure of its resistance to flow. In fuel oil it is highly significant since it indicates both the relative ease with which the oil will flow or can be pumped, and the ease of atomization.

X1.4.1.7.1 Viscosity limits for No. 1 and No. 2 grades are specified to help maintain uniform fuel flow in appliances with gravity flow, and to provide satisfactory atomization and constant flow rate through the small nozzles of household burners. For the heavier grades of industrial and bunker fuel oils, viscosity is of major importance, so that adequate preheating facilities can be provided to permit them to be pumped to the burner and to provide good atomization. However, it is equally important that the maximum viscosity under the existing conditions be such that the oil can be pumped satisfactorily from the storage tank to the preheater.

X1.4.1.8 *Density*—Density alone is of little significance as an indication of the burning characteristics of fuel oil. However, when used in conjunction with other properties, it is of value in mass-volume relationships and in calculating the specific energy (heating value) of an oil.

X1.4.1.9 *Corrosion*—The corrosion test serves to indicate the presence or absence of materials that could corrode copper, brass, and bronze components of the fuel system. This property is specified only for Nos. 1 and 2 distillate fuel oils.

X1.4.1.10 Limited sulfur content of fuel oil can be required for special uses in connection with heat treatment, nonferrous metal, glass, and ceramic furnaces or to meet federal, state, or local legislation or regulations.

X1.4.1.11 *Nitrogen*—Nitrogen oxide emission regulations have been imposed on certain combustion facilities as a function of fuel nitrogen content. For purposes of these regulations, distillate fuels, low nitrogen residual fuels, and high nitrogen residual fuels have been defined by their nitrogen content. Installations are required to meet different emission standards according to the classification of the fuel being used. When regulations require such a distinction to be made, fuel nitrogen specifications can be needed in the contractual agreement between the purchaser and the supplier.

EXHIBIT 9

Designation: D 1217 – 93 (Reapproved 1998)

An American National Standard

Standard Test Method for Density and Relative Density (Specific Gravity) of Liquids by Bingham Pycnometer[1]

This standard is issued under the fixed designation D 1217; 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.

1. Scope

1.1 This test method covers the measurement of the density of pure hydrocarbons or petroleum distillates boiling between 90 and 110°C that can be handled in a normal fashion as a liquid at the specified test temperatures of 20 and 25°C.

1.2 This test method provides a calculation procedure for conversion of density to relative density (specific gravity).

1.3 The values stated in SI units are to be regarded as the standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Specific precautionary statements are given in Note 1, Note 2, and Note 3.

2. Referenced Documents

2.1 *ASTM Standards:*

E 1 Specification for ASTM Thermometers[2]

3. Terminology

3.1 *Definitions:*

3.1.1 *density*—the weight in vacuo, (that is, the mass) of a unit volume of the material at any given temperature.

3.1.2 *relative density (specific gravity)*—the ratio of the mass (weight in vacuo) of a given volume of material at a temperature, t_1, to the mass of an equal volume of water at a reference temperature, t_2; or it is the ratio of the density of the material at t_1 to the density of water at t_2. When the reference temperature is 4.00°C, the temperature at which the relative density of water is unity, relative density (specific gravity) and density are numerically equal.

4. Summary of Test Method

4.1 The liquid sample is introduced into a pycnometer, equilibrated to the desired temperature, and weighed. The relative density (specific gravity) or density is then calculated from this weight and the previously determined weight of water that is required to fill the pycnometer at the same temperature, both weights being corrected for the buoyancy of air.

5. Significance and Use

5.1 Density is a fundamental physical property which can be used in conjunction with other properties to characterize pure hydrocarbons and their mixtures.

5.2 This test method was originally developed for the determination of the density of the ASTM Knock Test Reference Fuels *n*-heptane and *iso*octane, with an accuracy of 0.00003 g/mL. Although it is no longer employed extensively for this purpose, this test method is useful whenever accurate densities of pure hydrocarbons or petroleum fractions with boiling points between 90 and 110°C are required.

6. Apparatus

6.1 *Pycnometer*, Bingham-type,[3] conforming to the dimensions given in Fig. 1, constructed of borosilicate glass and having a total weight not exceeding 30 g.

6.2 *Constant-Temperature Bath*, provided with suitable pycnometer holders or clips and means for maintaining temperatures constant to ±0.01°C in the desired range.

6.3 *Bath Thermometer*, graduated in 0.1°C subdivisions and standardized for the ice point and the range of use to the nearest 0.01°C. ASTM Saybolt Viscosity Thermometer 17C as prescribed in Specification E 1, designed for tests at 21.1°C and 25°C, is recommended. A standardized platinum resistance thermometer may also be used, and offers the best means for observing minute temperature changes in the bath. Whichever means are available, it must be realized that for most hydrocarbons the density coefficient is about 0.0008 units/°C, and therefore an error of ±0.013°C would cause an error of ±0.00001 in density.

6.4 *Hypodermic Syringe*, 30-mL capacity, of chemically resistant glass, equipped with a 152-mm (6-in.) needle made of stainless steel tubing as shown in Fig. 2.

6.5 *Draw-Off Needle*, made of stainless steel tubing as shown in Fig. 2.

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[1] This test method is under the jurisdiction of ASTM Committee D-2 on Petroleum Products and Lubricantsand is the direct responsibility of Subcommittee D02.04on Hydrocarbon Analysis.

Current edition approved Feb. 15, 1993. Published May 1993. Originally published as D 1217 – 52 T. Last previous edition D 1217 – 91.

[2] *Annual Book of ASTM Standards*, Vol 14.03.

[3] Pycnometer available from Reliance Glass Co., 220 Gateway Rd., Bensenville, IL 60106-0825, has been found satisfactory.

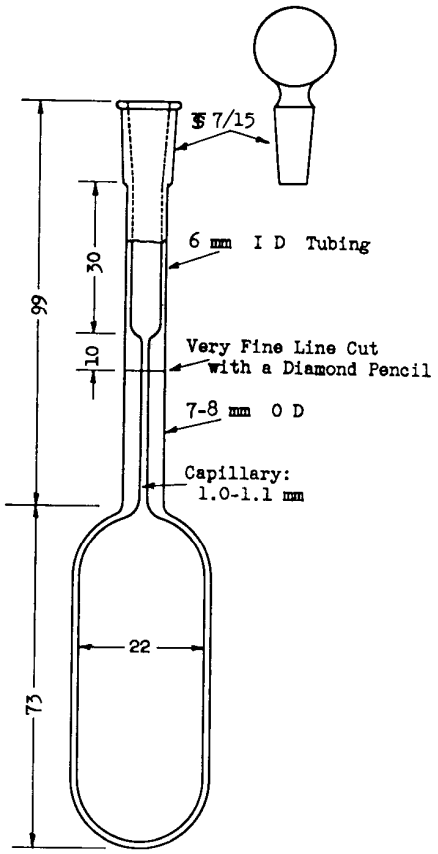


FIG. 1 Bingham-Type Pycnometer, 25 mL

6.6 *Solvent-Cleaning Assembly*, as shown in Fig. 3.

6.7 *Chromic Acid Cleaning Apparatus*, similar to that shown in Fig. 4.

6.8 *Balance*, capable of reproducing weighings within 0.1 mg. Mechanical balances should have sensitivity which causes the pointer to be deflected 2 or 3 scale divisions per 1 mg when carrying a load of 30 g or less on each pan. The balance should be located in a room shielded from drafts and fumes and in which the temperature changes between related weighings (empty and filled pycnometer) do not cause a significant change in the ratio of the balance arms. Otherwise weighings shall be made by the method of substitution, in which the calibrated weights and pycnometer are alternately weighed on the same balance pan. The same balance shall be used for all related weighings.

6.9 *Weights*, whose relative values are known to the nearest 0.05 mg or better. The same set of weights shall be used for the calibration of the pycnometer and the determination of densities.

7. Reagents and Materials

7.1 *Acetone*—(**Warning**—See Note 1).

NOTE 1—**Warning:** Extremely flammable. Use adequate ventilation.

7.2 *Isopentane*—(**Warning**—See Note 2).

NOTE 2—**Warning:** Extremely flammable. Avoid buildup of vapors and remove all sources of ignition, especially non-explosion proof electrical apparatus.

7.3 *Chromic Acid (Potassium Dichromate/Conc. Sulfuric Acid)*—(**Warning**—See Note 3).

NOTE 3—**Warning:** Causes severe burns. A recognized carcinogen. Do not get in eyes, or on skin or clothing.

8. Preparation of Apparatus

8.1 Thoroughly clean the pycnometer with hot chromic acid cleaning solution by means of the assembly shown in Fig. 4 (**Warning**—See Note 3). Chromic acid solution is the most effective cleaning agent. However, surfactant cleaning fluids have also been used successfully. Mount the apparatus firmly and connect the trap to the vacuum. Warm the necessary amount of cleaning acid in the beaker, place the pycnometer on the ground joint, and evacuate by opening the stopcock to vacuum. Fill the pycnometer with acid by turning the stopcock, repeat several times or remove the filled pycnometer, and allow it to stand for several hours at 50 to 60°C. Remove the acid from the pycnometer by evacuation, empty the acid from the trap, and flush the pycnometer with water. Cleaning should be made in this manner whenever the pycnometer is to be calibrated or whenever liquid fails to drain cleanly from the walls of the pycnometer or its capillary. Ordinarily, the pycnometer may be cleaned between determinations by washing with a suitable solvent, rinsing with pure, dry acetone, followed by isopentane, and vacuum drying.

8.2 Transfer the pycnometer to the cleaner assembly shown in Fig. 3, with vacuum line and trap attached to the side tube as indicated. Place the pycnometer on the cleaner with the upper hypodermic needle extending upward into the pycnometer, and press the edge of the ground joint on the rubber stopper until the vacuum holds it in place. Draw out all the liquid or sample. Immerse the lower end of the hypodermic tube in a suitable solvent and draw 20 to 25 mL through the pycnometer. Leaving the pycnometer in place, draw air through it until it is dry. Clean the hypodermic syringe with the same apparatus.

9. Calibration of Pycnometer

9.1 Proceeding as directed in Section 10, determine the weight of freshly-boiled and cooled distilled water (distilled from alkaline permanganate through a tin condenser) held by the pycnometer when equilibrated to volume at the bath temperature to be used in the determination. Repeat until at least three values agree to ±0.2 mg.

10. Procedure

10.1 Using another 25-mL pycnometer as a tare (Note 4), weigh the clean, dry pycnometer to 0.1 mg and record the weight.

NOTE 4—It is convenient to use the lightest of a set of pycnometers as a tare. For best results the treatment and environment of both pycnometer and tare should be identical for some time prior to weighing.

10.2 Cool the sample to 5 to 10°C below the test temperature, and fill the clean 30-mL hypodermic syringe. Transfer the sample to the pycnometer through the filling needle; avoid trapping air bubbles (Note 2) in the bulb or capillary of the pycnometer. If any are present, draw them into the syringe where possible. Also remove with the syringe or draw-off

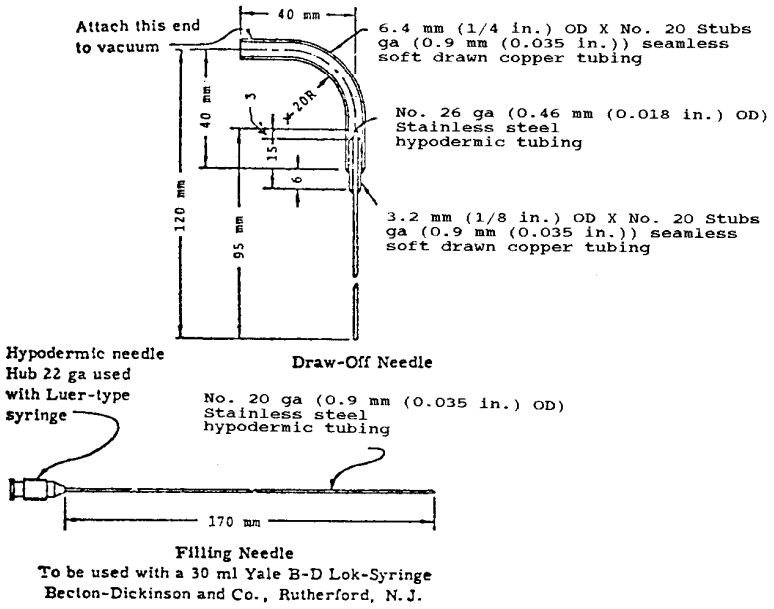


FIG. 2 Accessories for Bingham-Type Pycnometer

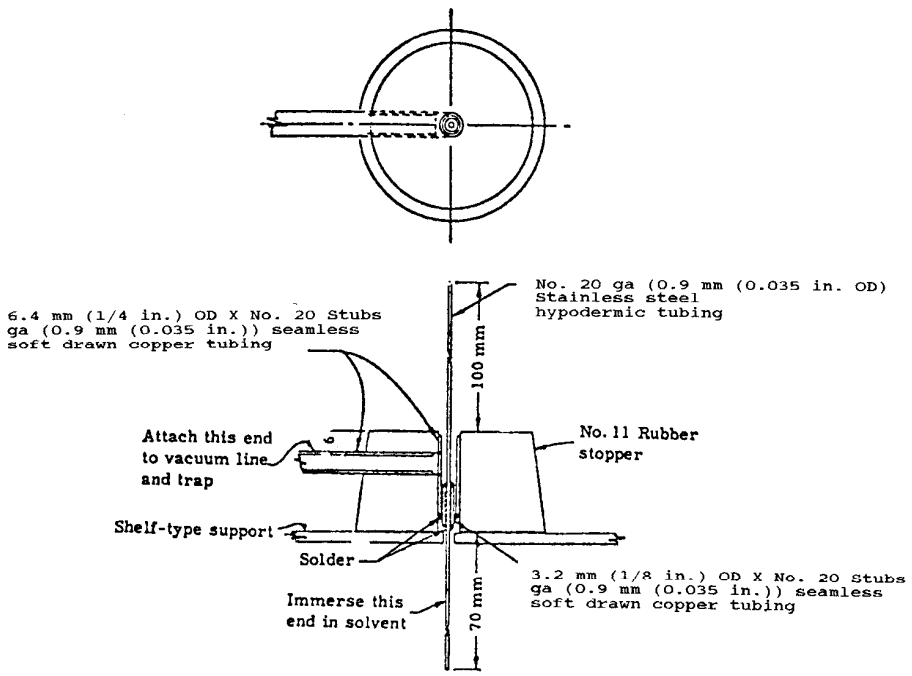


FIG. 3 Cleaner Assembly for Bingham-Type Pycnometer

needle any liquid above the calibration mark in the capillary or overflow reservoir. Dry the remainder with a cotton fiber pipe cleaner or cotton swab which has been dampened slightly with acetone.

NOTE 5—For work of highest accuracy on pure compounds, dissolved air may be removed from the sample by repeated freezing and remelting of the sample under vacuum in the pycnometer.

10.3 Close the pycnometer with the glass stopper and immerse it to a point above the calibration mark in the constant-temperature bath adjusted to a constancy of ±0.01°C at the desired temperature. Periodically, or before the liquid expands into the overflow chamber, remove the stopper, raise the pycnometer sufficiently to expose the calibration mark to view, and readjust the liquid level to the mark by withdrawing liquid through the steel draw-off needle until expansion has stopped, indicating that the liquid has reached the temperature of the thermostat. Do not allow the liquid to expand more than 10 mm above the calibration mark at any time, to minimize errors caused by faulty drainage. Allow the contents to equilibrate an additional 10 min and draw the level down exactly to

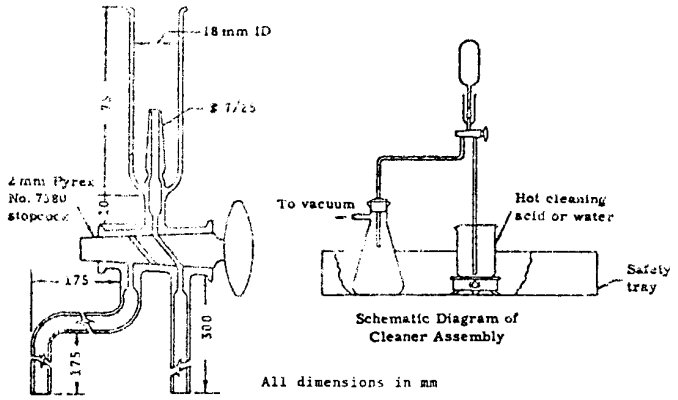


FIG. 4 All-Glass Pycnometer Cleaner Assembly for Use with Hot Chromic Acid Cleaning Solution

the calibration line, avoiding parallax and using a magnifier, if necessary, to obtain good visibility. Remove any liquid adhering to the walls above the calibration mark, with the draw-off needle or pipe cleaner, depending upon the volatility of the sample. Portions in the overflow bulb may be removed with a cotton swab moistened with acetone.

10.4 Replace the glass stopper, remove the pycnometer from the bath, wash the outside surface with acetone, and dry thoroughly with a chemically clean, lint-free, slightly damp cloth. Place the pycnometer in or near the balance case for 20 min and weigh to the nearest 0.1 mg. In atmospheres of low humidity (60 % or lower), drying the pycnometer by rubbing with a dry cotton cloth will induce static charges equivalent to a loss of about 1 mg in the weight of the pycnometer. This charge need not be completely dissipated in less than 30 min. The use of about 0.1-mg radium bromide- or polonium-coated foil in the balance case, or maintaining the relative humidity at 60 % or higher, aids in reducing weighing difficulties due to static charges.

10.5 Record temperature of the balance, barometric pressure, and relative humidity.

11. Calculation

11.1 Calculate the true density of the sample as follows:

$$\text{Density, g/mL at °C} = W_s(1 + (d_a/d_s) - (d_a/d_{wt}))d_w/W_w(1 + (d_a/d_w) - (d_a/d_{wt})) \quad (1)$$

where:

W_s = weight in air of sample contained in the pycnometer at the test temperature, g,
W_w = weight in air of the water contained in the pycnometer at the calibration temperature, g,
d_w = density of water at the calibration temperature, as obtained from Table 1,
d_a = density of air in balance case at the time of weighing, as calculated from 10.3,
d_{wt} = density of weights used in weighing the sample and water (brass = 10.4 g/mL, stainless steel = 7.75 g/mL), and
d_s = approximate density of sample or

$$(W_s \times d)/W_w \quad (2)$$

TABLE 1 Density of Water[A]

Temperature,° C	Density, g/mL	Temperature, °C	Density, g/mL	Temperature, °C	Density, g/mL
0	0.999840	21	0.997991	40	0.992212
3	0.999964	22	0.997769	45	0.990208
4	0.999972	23	0.997537	50	0.988030
5	0.999964	24	0.997295	55	0.985688
10	0.999699	25	0.997043	60	0.983191
15	0.999099	26	0.996782	65	0.980546
15.56	0.999012	27	0.996511	70	0.977759
16	0.998943	28	0.996231	75	0.974837
17	0.998774	29	0.995943	80	0.971785
18	0.998595	30	0.995645	85	0.968606
19	0.998404	35	0.994029	90	0.965305
20	0.998203	37.78	0.993042	100	0.958345

[A] Densities conforming to the International Temperature Scale 1990 (ITS 90) were extracted from Appendix G, *Standard Methods for Analysis of Petroleum and Related Products 1991*, Institute of Petroleum, London.

11.2 The equation assumes that the weighings of the pycnometer empty and filled are made in such a short time interval that the air density has not changed. If significant change should occur, the calculated apparent weight of the sample, W_s, in this equation, must be corrected for the difference in air buoyancy exerted on the pycnometer as follows:

$$W_s = W^2_{PS} - W'_p(1 + (d'_a/2.2) - (d'_a/d_{wt}))/(1 + (d_a^2/2.2) - (d_a^2/d_{wt})) \quad (3)$$

where:

W^2_{PS} = weight of pycnometer and contained sample under second or final air density,
W'_P = weight of pycnometer in air of first density,
d'_a = density of air when weighing empty pycnometer,
d_a^2 = density of air when weighing filled pycnometer, and
d_{wt} and 2.2 = density of weights and borosilicate glass, respectively.

Likewise, if the pycnometer, empty and filled with water for calibration, is weighed under different air densities a similar correction for different air buoyancies shall be applied.

11.3 Calculate the relative density (specific gravity) of the sample by dividing the density as obtained in 11.1 by the relative density of water at the reference temperature obtained from Table 1.

11.4 Calculate the density of air in the balance room as follows:

$$\text{Air density } (d_a),\ \text{g/mL} = [(B - 0.3783\,Hp)(0.000465)]/(273 + t) \quad (4)$$

where:

B = barometric pressure, mm Hg, corrected to 0°C,
H = relative humidity, decimal fraction,
p = vapor pressure of water at temperature t, mm Hg, and
t = room temperature, °C.

NOTE 6—If this test method is to be used frequently, a considerable amount of calculation can be avoided by use of a gas density balance to determine the air density. Weigh a sealed 250-mL glass bulb at several different air densities and plot the weight against the air density. To determine the air density at some later time, weigh the bulb and read the air density from the point on the curve corresponding to the weight.

11.5 To calculate the density or relative density (specific gravity) at any test temperature, t, other than the calibration temperature, t_c (to correct for the cubical coefficient of thermal expansion of borosilicate glass), divide the value obtained in 10.1 or 10.2 by the following expression:

$$1 + 9.6 \times 10^{-6}\,(t - t_c) \quad (5)$$

12. Report

12.1 In reporting density, give the test temperature and the units (for example, density, 20°C = x.xxxxx g/mL). In reporting relative density (specific gravity), give both the test temperature and the reference temperature, but no units (for example, relative density (specific gravity), 20/4°C = x.xxxxx). Carry all calculations to one digit beyond the last significant figure, but report the final result to the fifth decimal place (0.00001).

13. Precision and Bias

13.1 *Precision*—Results, using the 25-mL Bingham-type pycnometer, should not differ from the mean by more than the following amounts:

Repeatability One Operator and Apparatus	Reproducibility Different Operators and Apparatus
0.00002	0.00003

NOTE 7—The precision for this method was not obtained in accordance with RR:D02-1007.

13.2 *Bias*—The difference of results from the established values when compared to pure reference materials is not expected to be more than ±0.00003 g/mL. Specific bias has not been established by cooperative testing.

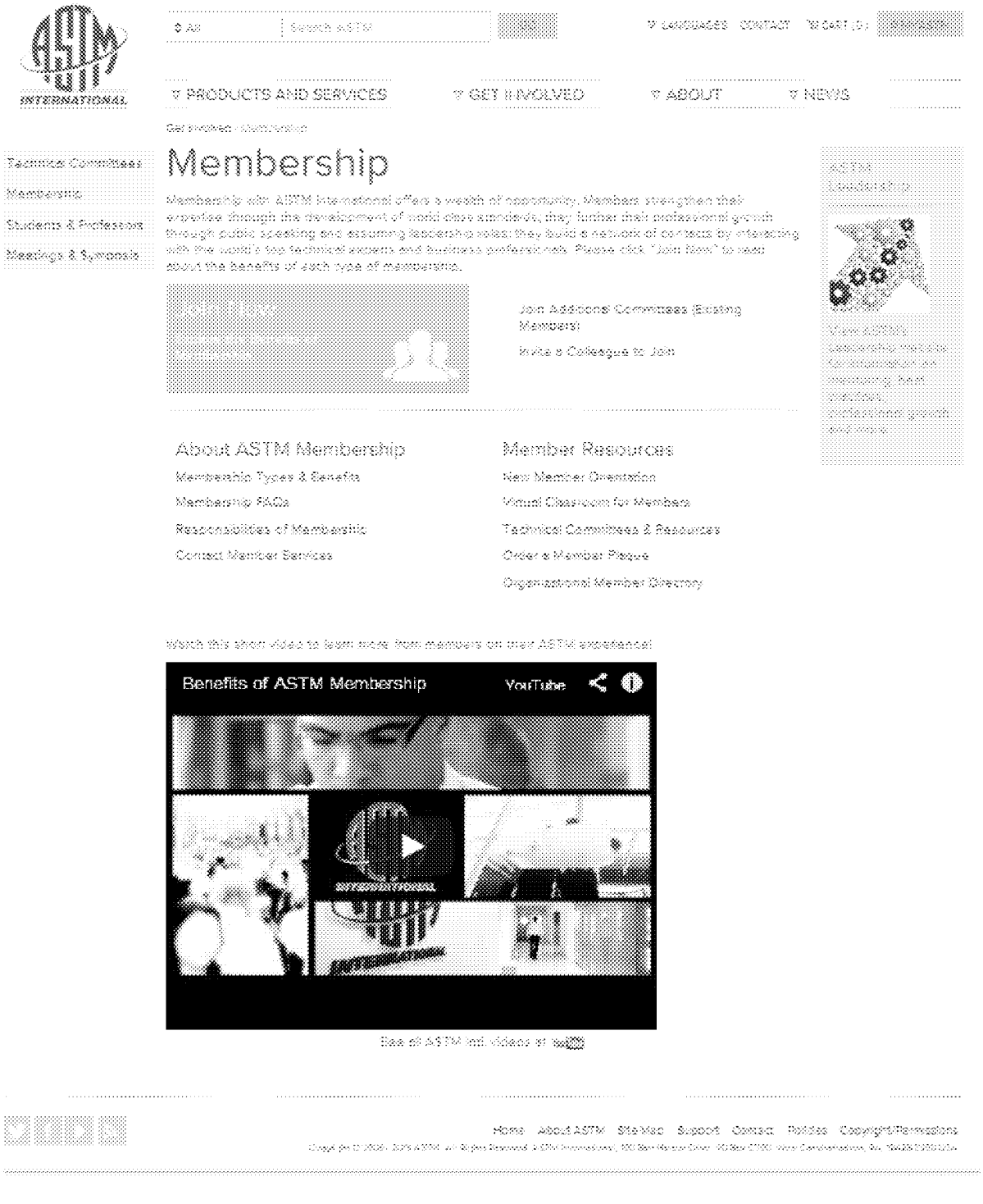
14. Keywords

14.1 Density; pycnometer; relative density; specific gravity

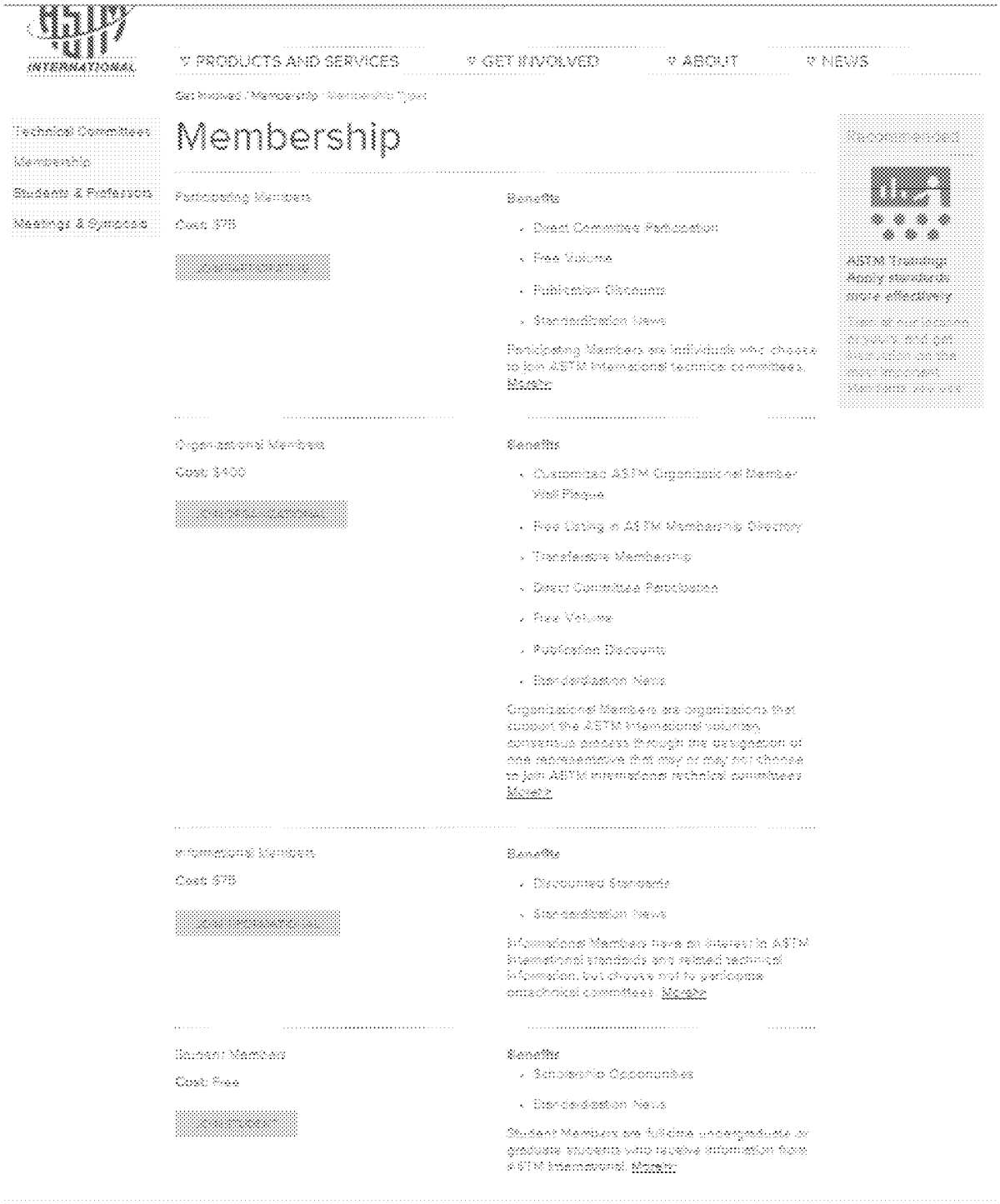
EXHIBIT 10

New Memberships

http://www.astm.org/MEMBERSHIP/index.html



http://www.astm.org/MEMBERSHIP/MemTypes.htm



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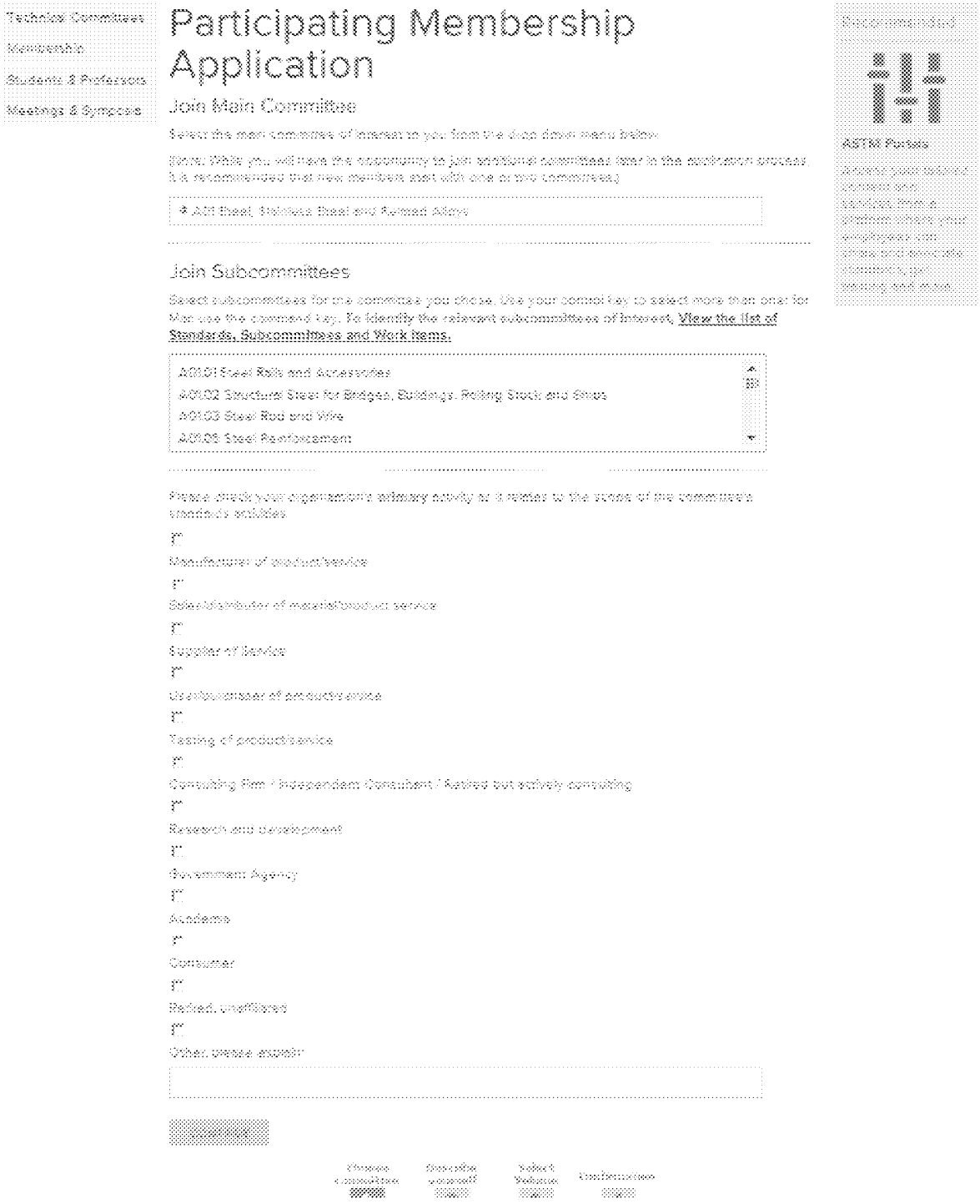
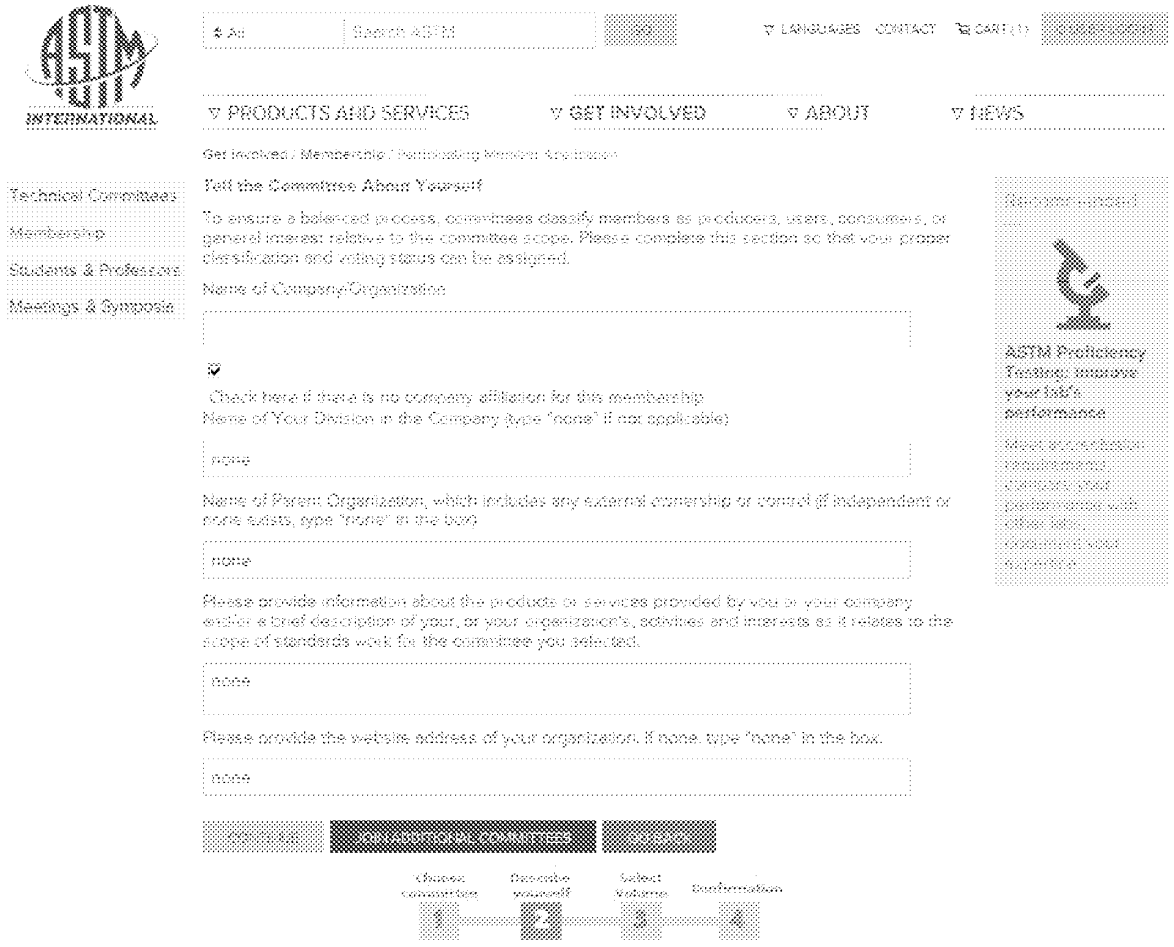
http://www.astm.org/MEMBERSHIP/participatingapp.html

1. Choose committees

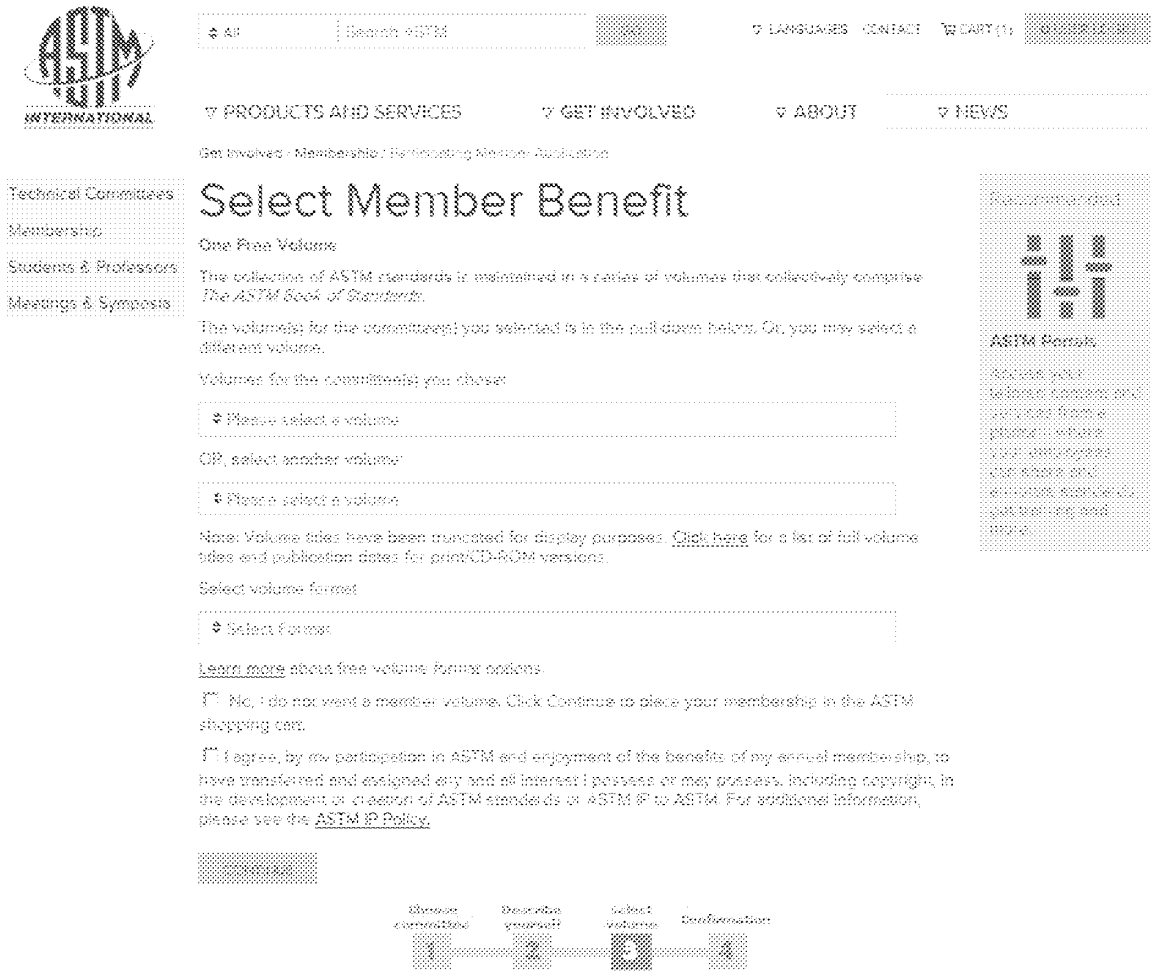


Selection of a main committee as well as a primary activity is required to move on.

2. Describe yourself

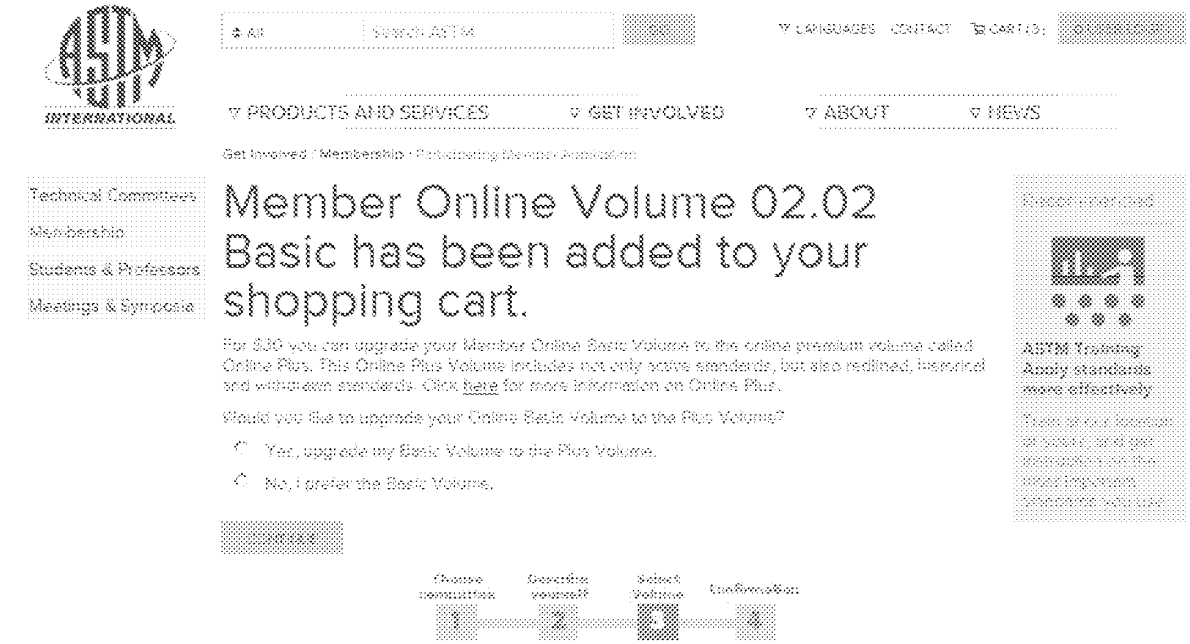


3. Select Volume



Volumes are refined based on committee choice in first dropdown, with the option to select a different volume in the second dropdown. Select volume format maintains its blank status so that users must view all options equally before selecting. If a basic volume is chosen, the following 'upgrade to plus' prompt will appear.

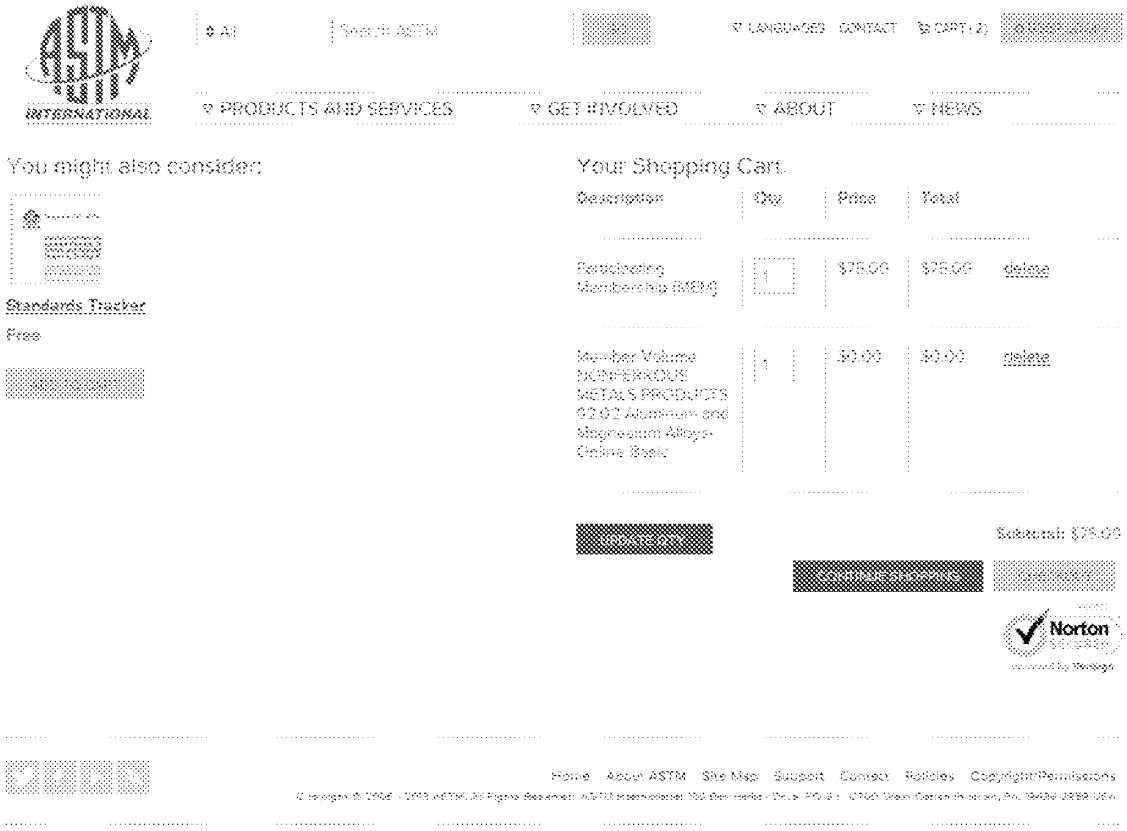
Selecting "No" will forward the user to checkout (#5).



4. Confirmation

Title format appears as: 'Volume' 'XX.XX' 'basic/plus'. Change your selection takes the user back to the previous screen for upgrading to plus. (Currently at this point you cannot adjust the member volume, just the basic/plus option)

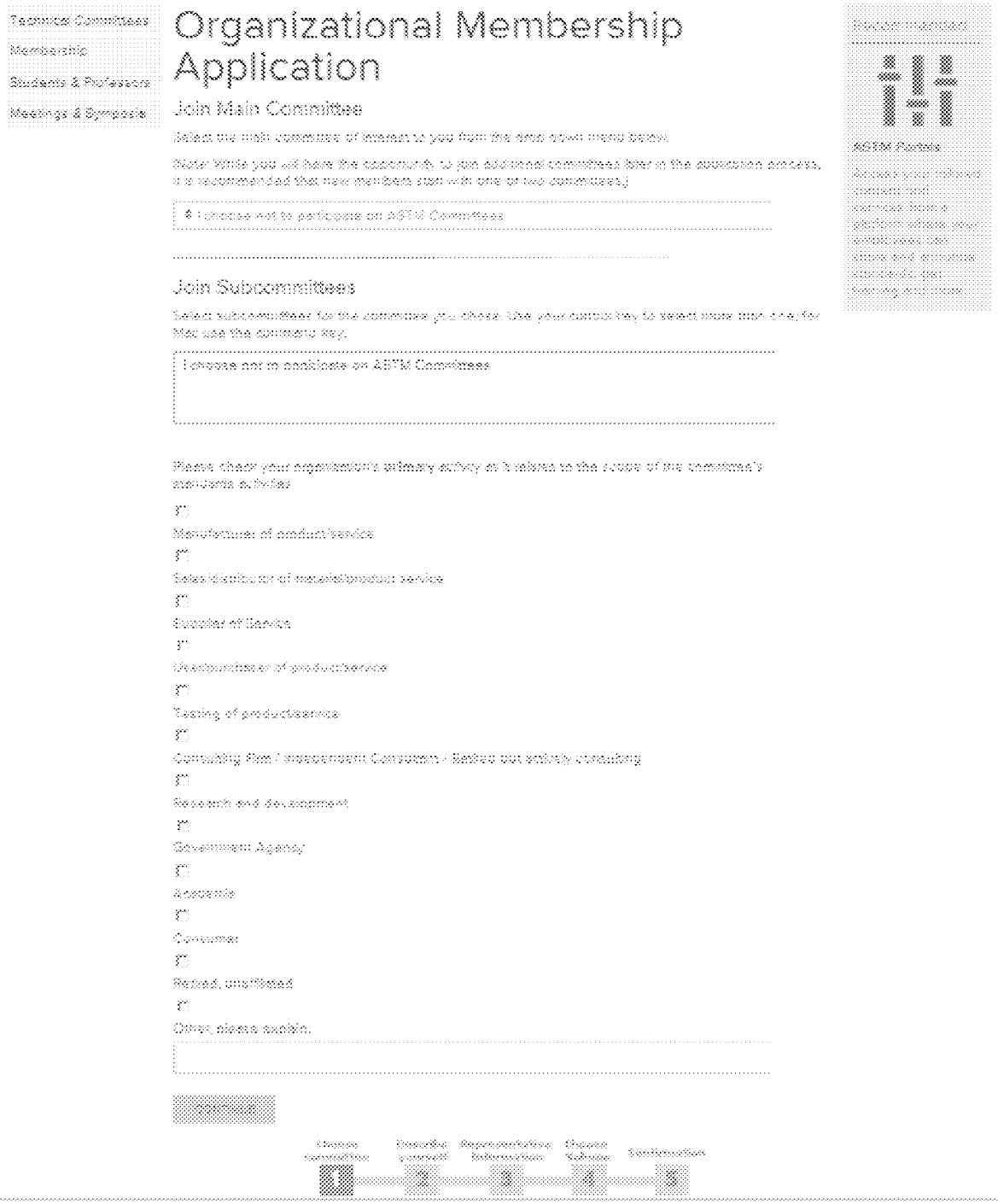
5. Checkout



Continue will pass the user to checkout where they will see the cost of the membership as well as the free volume (along with any other items they've added to the cart).

ORGANIZATIONAL MEMBER:
http://www.astm.org/MEMBERSHIP/orgapp.htm

1. Choose Committee



Org accounts can choose not to be part of a committee, which is the default option, or they can choose a committee and/or subcommittee. A primary activity is required to move on. Opting out of committee participation will forward the user to Representative Information (#3)

2. Describe yourself (if a committee has been selected. If the option to join a committee was not chosen, the user will bounce to Representative Information)

3. Representative Information

All | Search ASTM

LANGUAGES CONTACT CART (0)

Organizational Representative Application

Please nominate your organization's representative. Your representative will be the contact for your Membership and can join committees, participate, and vote

Please provide the information below and click Continue.

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Last Name:

Organization:

Address:

City:

Country:
Please Select a Country

State/Province:
Select State

Zip:

Phone:

Please do not include country code, extensions, or "/"

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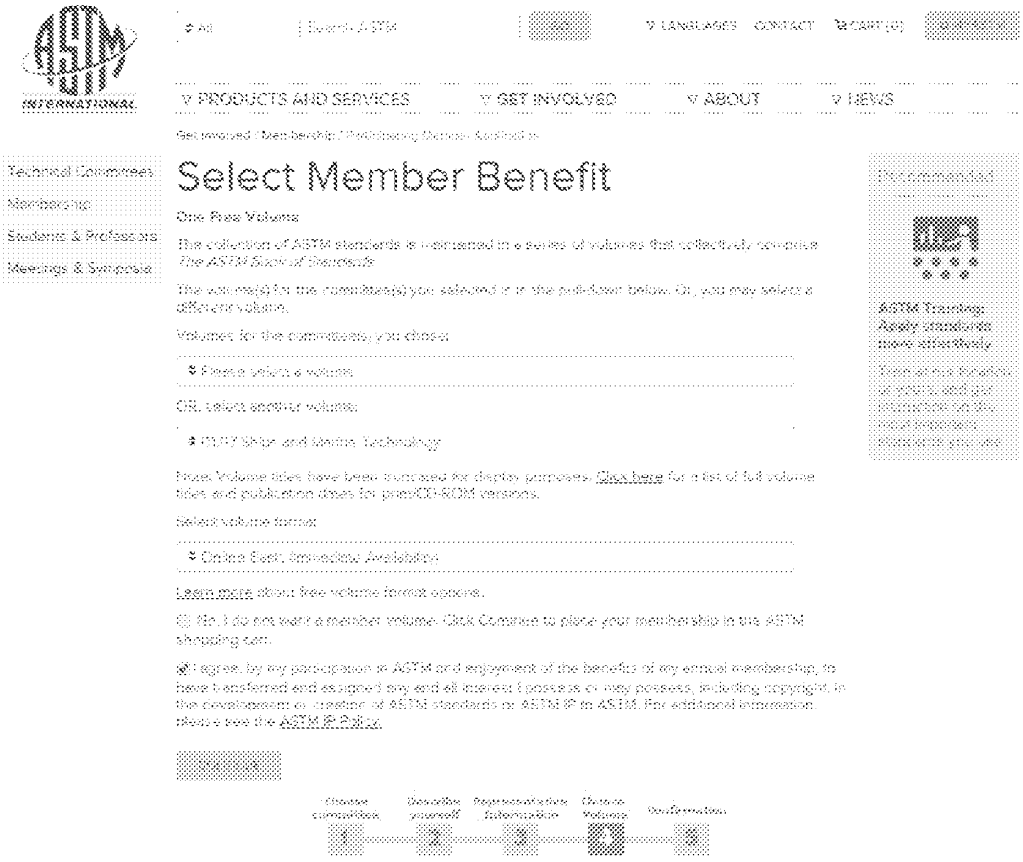
Required for Order Confirmation and Support

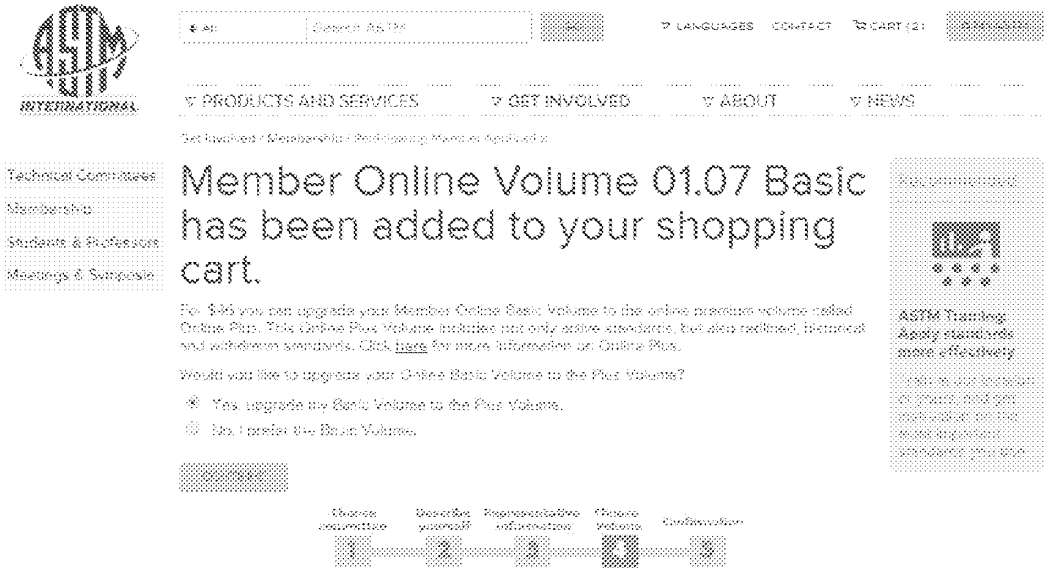
Continue

1 Choose Committee — 2 Describe yourself — 3 Representative Information — 4 Choose Volume — 5 Confirmation

4. Choose Volume



5. Confirmation



INFORMATIONAL MEMBER

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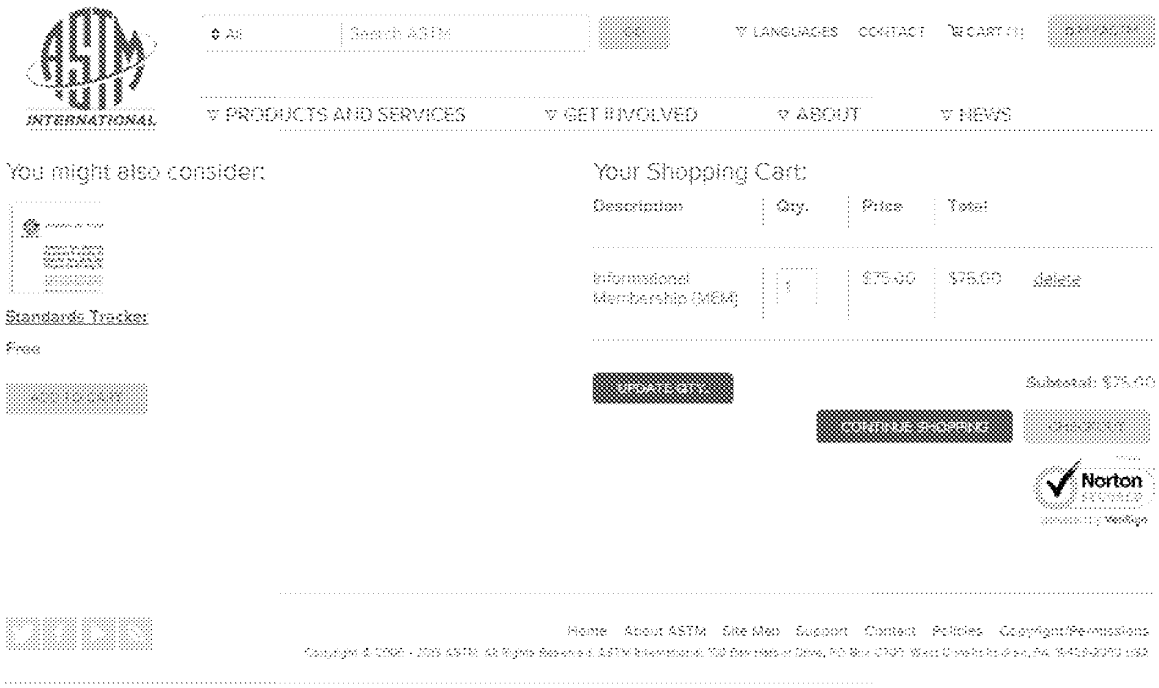

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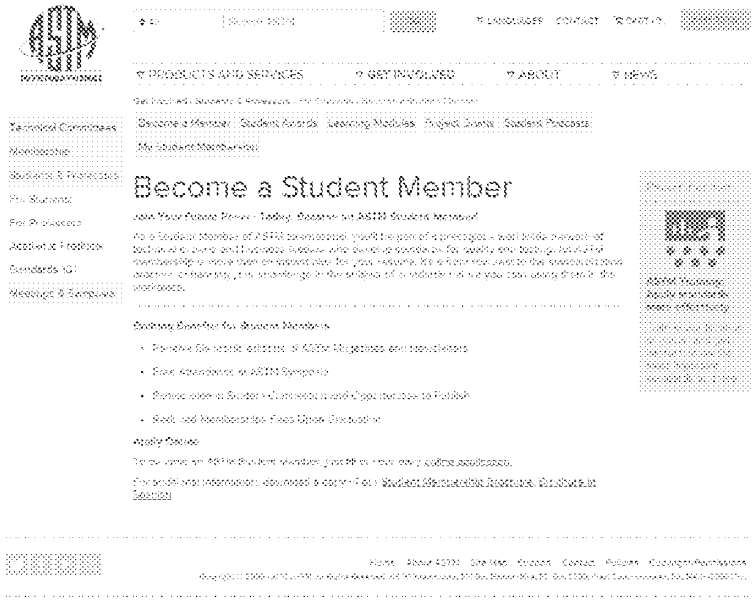
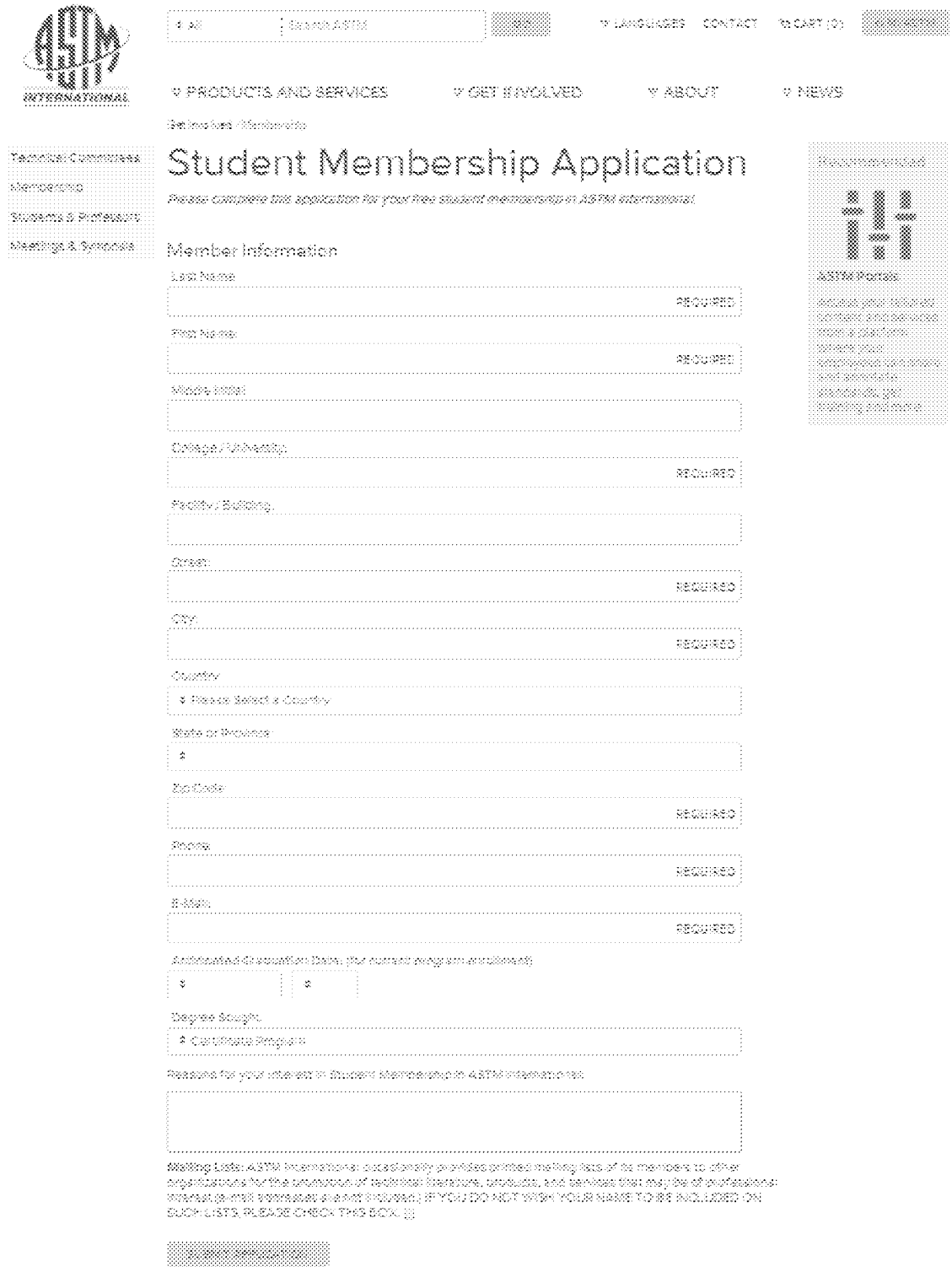


Click through to the online application: http://www.astm.org/COMMIT/MEMBERAPP/filtrexx40.cgi?+-P+MEMBER_TYPE+New+-P+MemberProduct+MEMBER-STUDM+membership_studentapp.frm



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Middle Initial:

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Country:
Please Select a Country

State or Province:

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Phone:
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E-Mail:
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Anticipated Graduation Date: (for current program enrollment)

Degree Sought:
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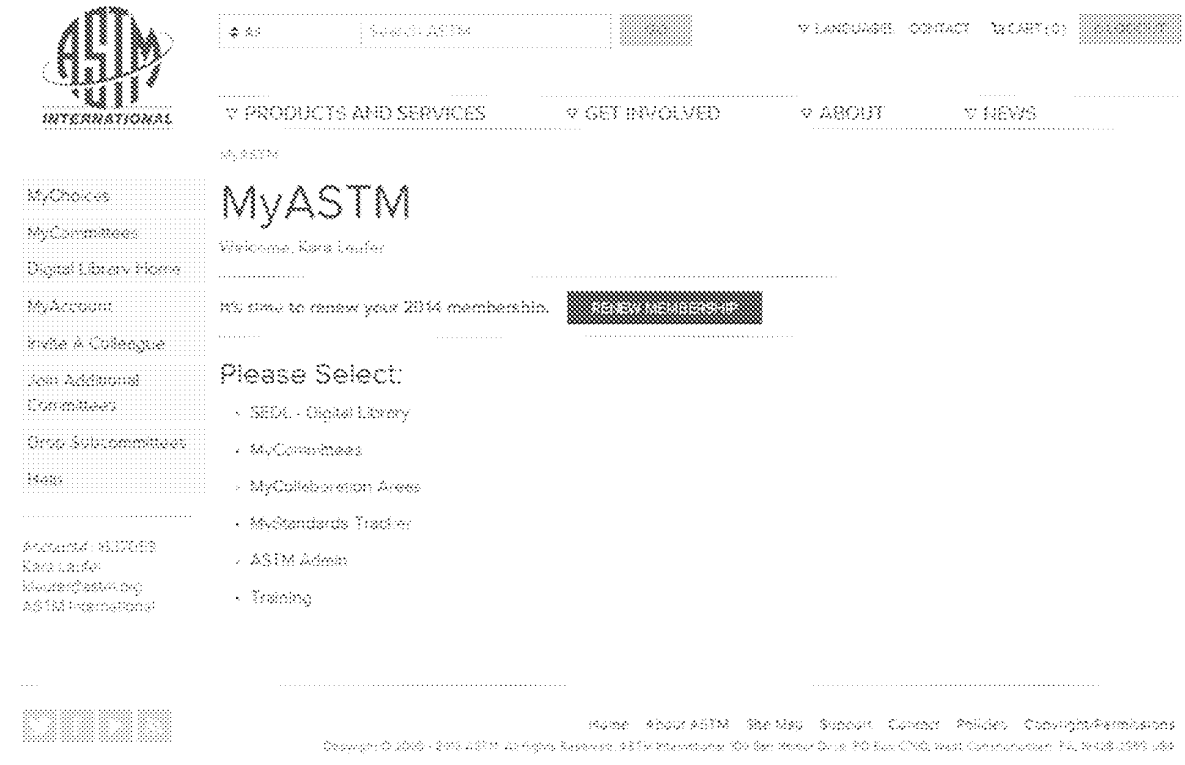
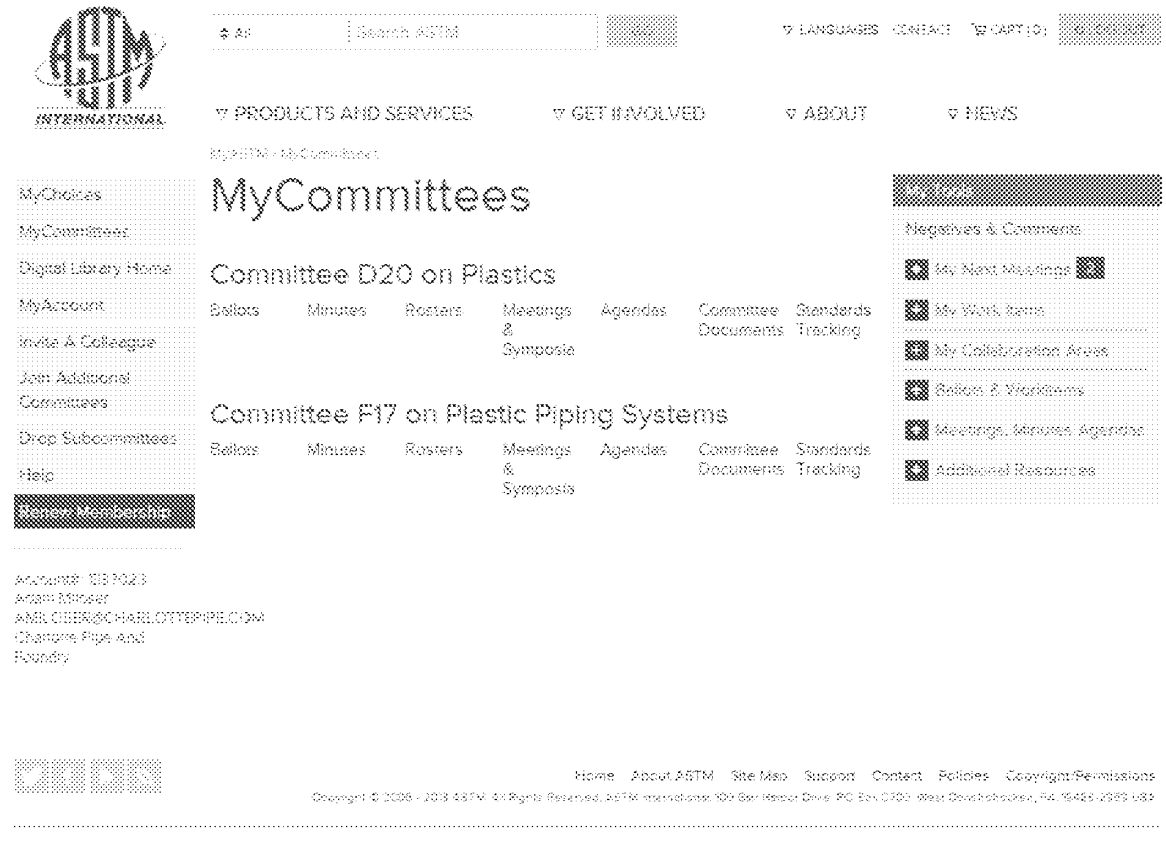
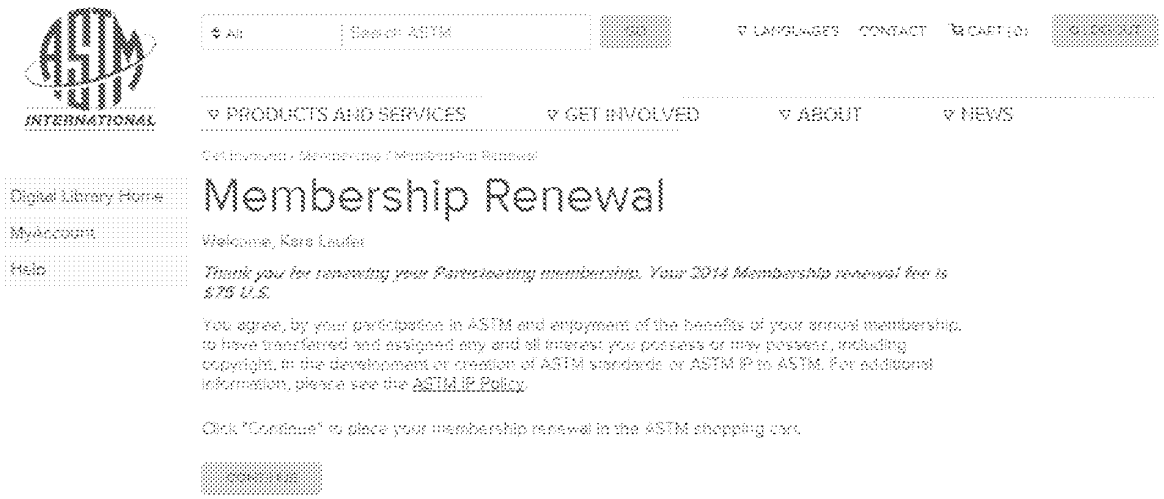
EXHIBIT 11

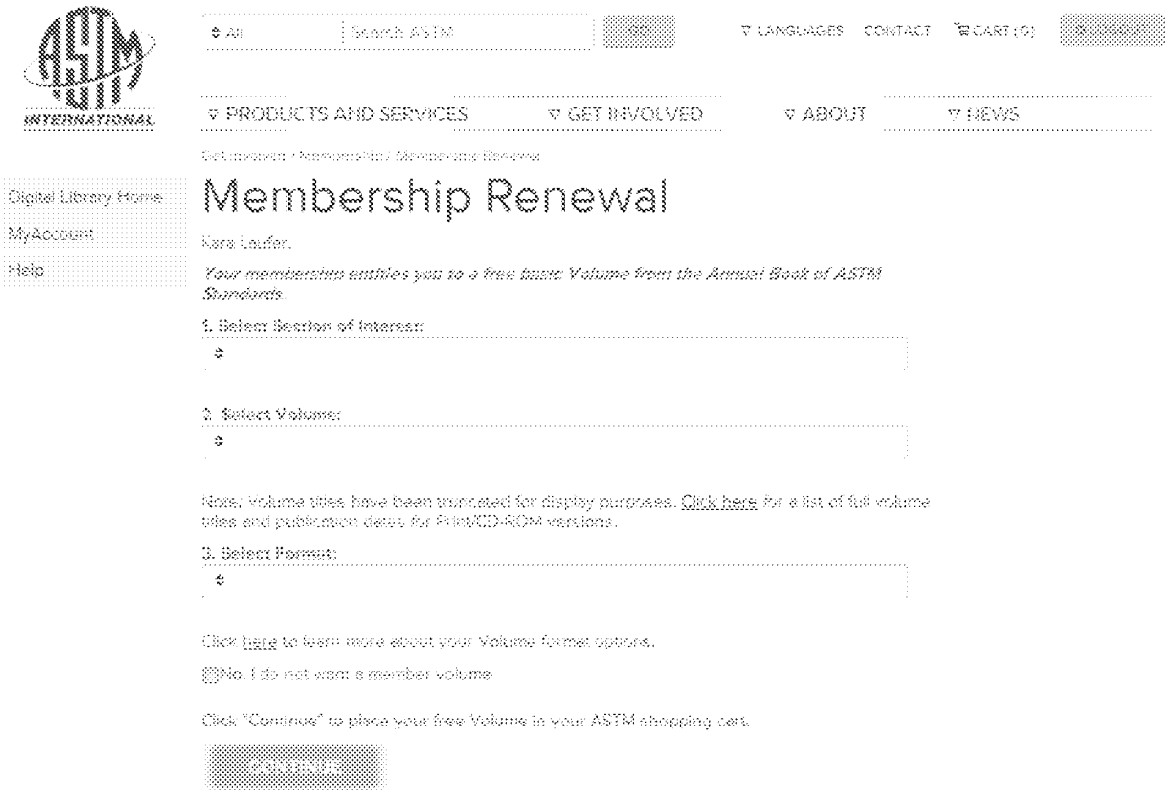
Membership Renewal



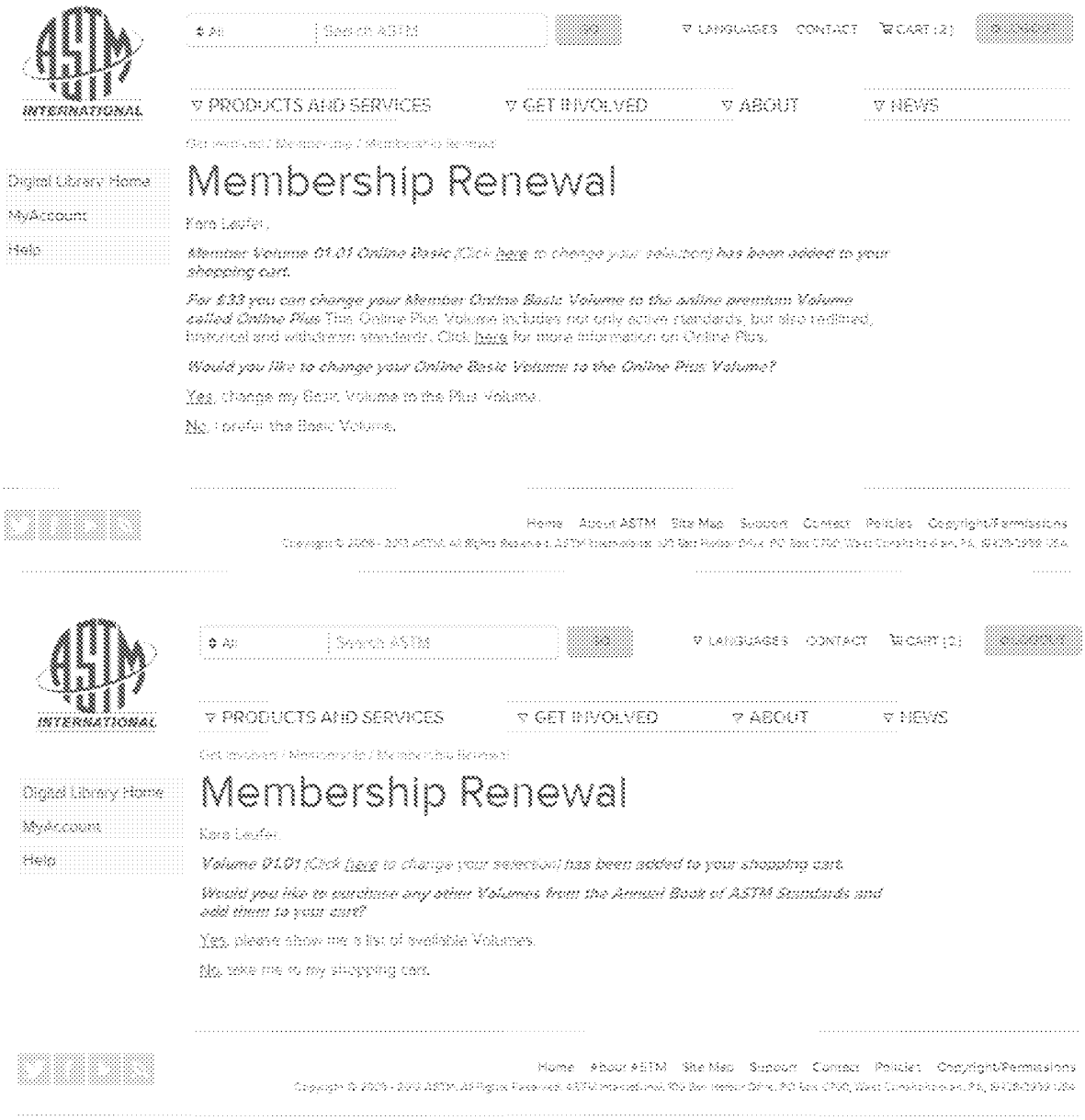


PARTICIPATING MEMBER





Note: Items will be added to the shopping cart after this screen.



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❑	❑	❑	❑	Volume 15.11 Consumer Products; Light Sport Aircraft; Unmanned Aircraft Systems; Normal and Utility Category Airplane Electrical Wiring Systems; Unmanned Maritime Vehicle Systems (UMVS); Language Services and Products	Nov	$275	$321	$229	$28
❑	❑	❑	❑	Volume 15.12 Livestock, Meat and Poultry Evaluation Systems; Food Service Equipment	Nov	$212	$248	$177	$21
❑	❑	❑	❑	**Special Price for Section 15**—*Must be Prepaid*		**$2,425**	**$2,829**	**$2,021**	
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P	C								
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Complete and return this form to:
ASTM Customer Service 100 Barr Harbor Drive, PO Box C700,
West Conshohocken, PA 19428-2959 • USA

For Faster Service: Call: +1 610 832 9585
Fax: +1 610 834 3636
Email: service@astm.org • Web site: www.astm.org

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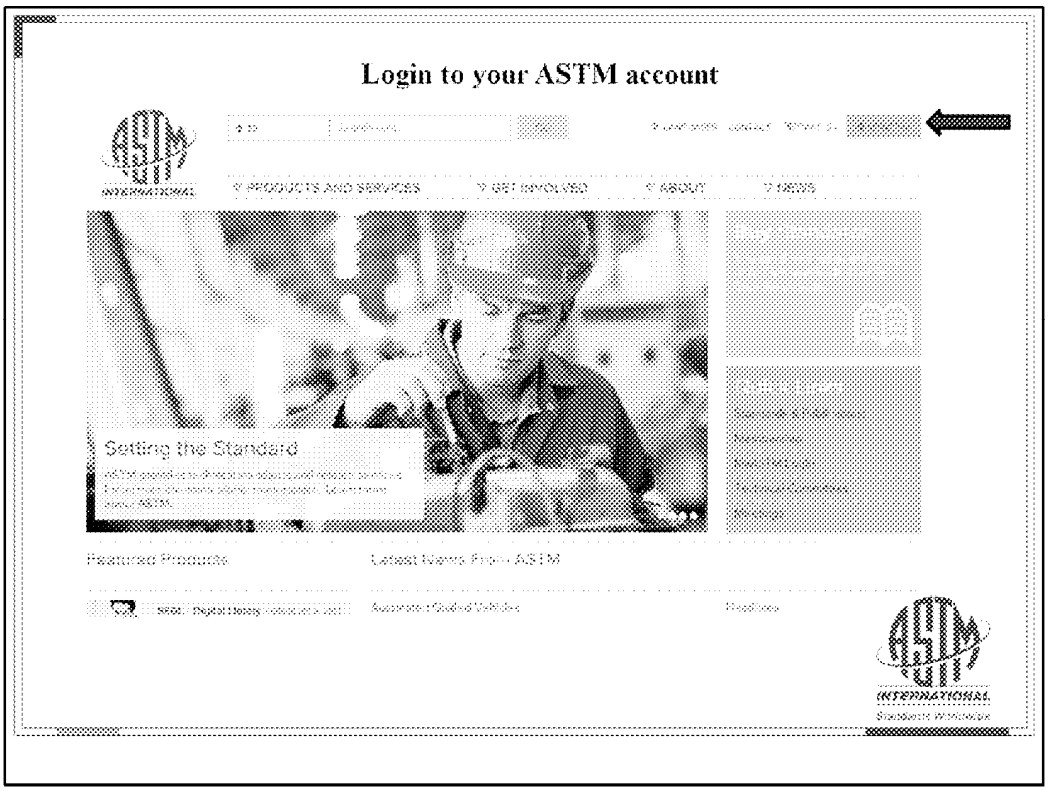
MSFM12

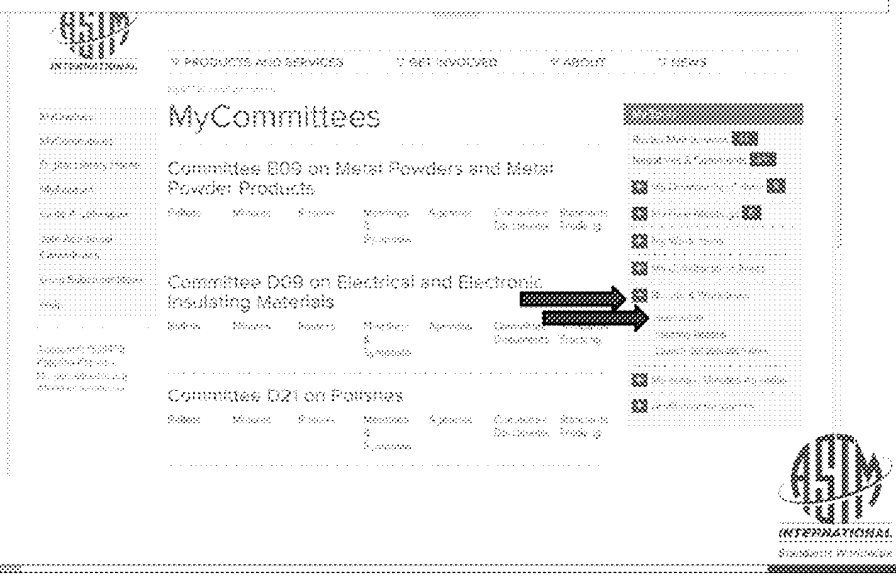
EXHIBIT 13

How to register a work item

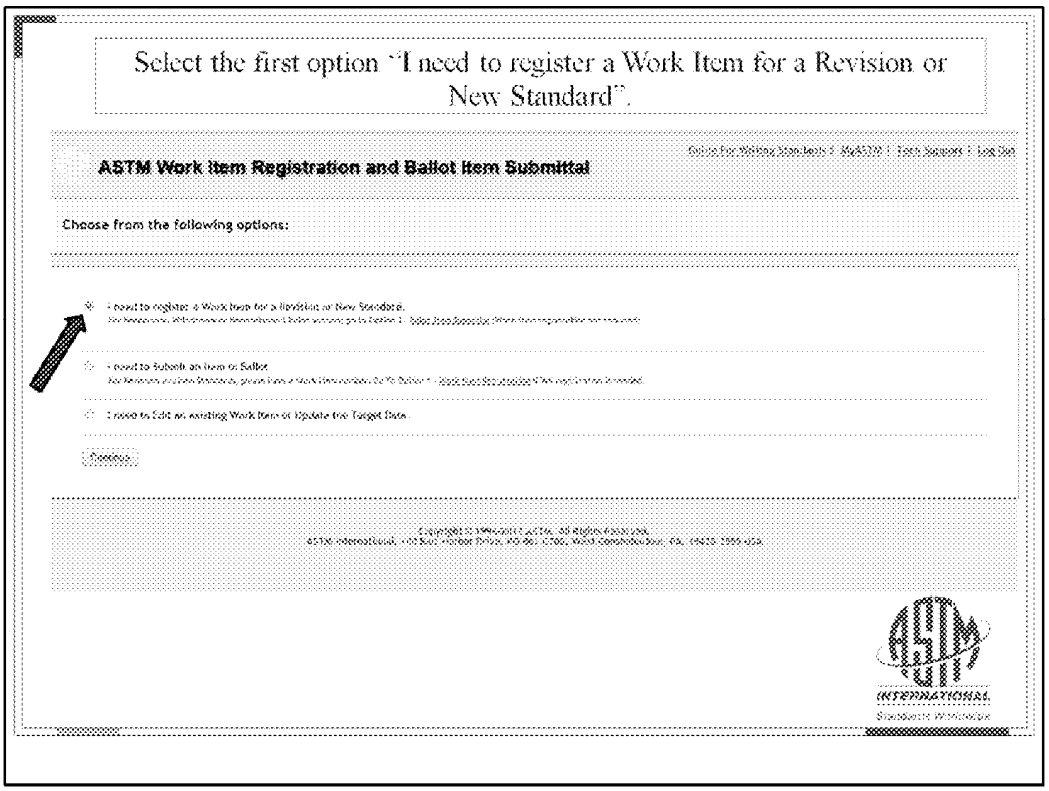
Please follow this step by step guide to register a work item.
A work item is a tracking number that ASTM
uses to follow each standard through the process.

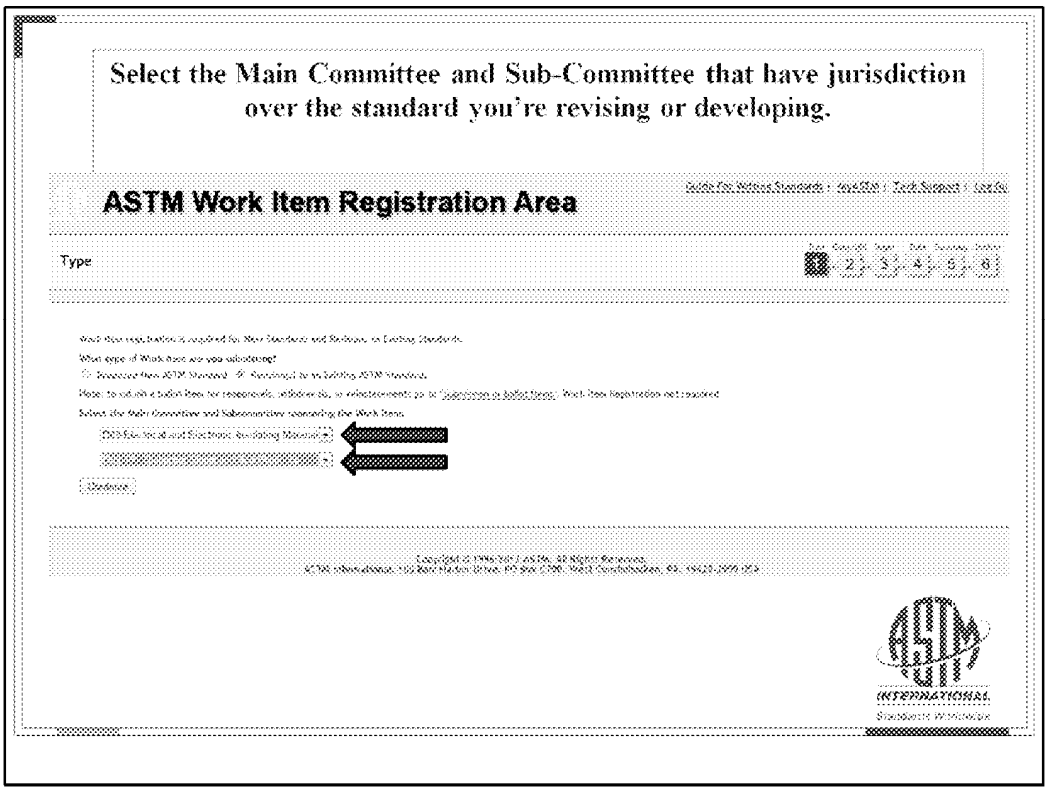


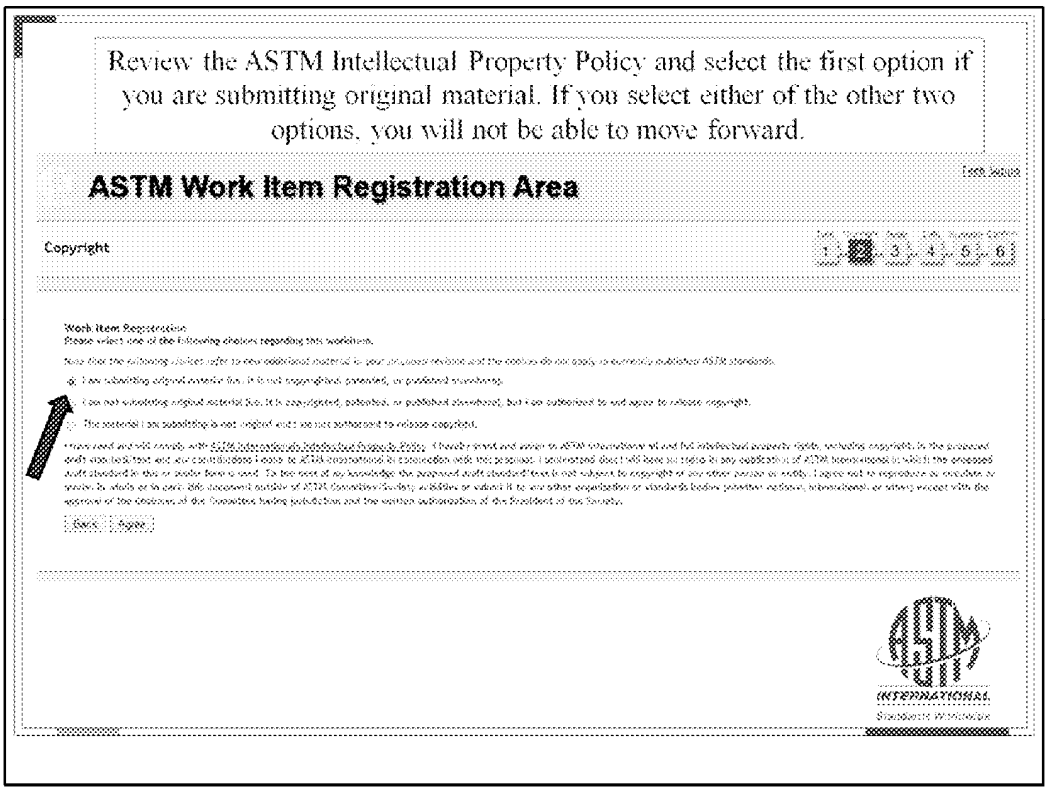
From the right side toolbar, select Ballots & Work Items and then click Submit/Edit.

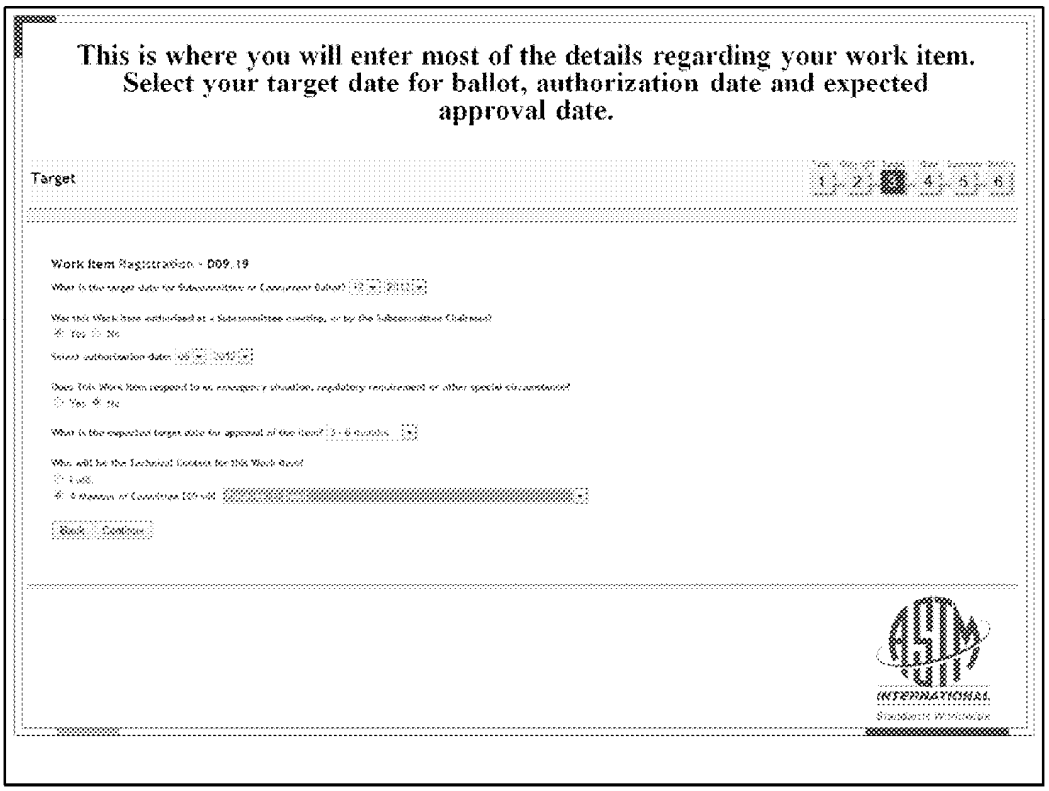


Select the first option "I need to register a Work Item for a Revision or New Standard".

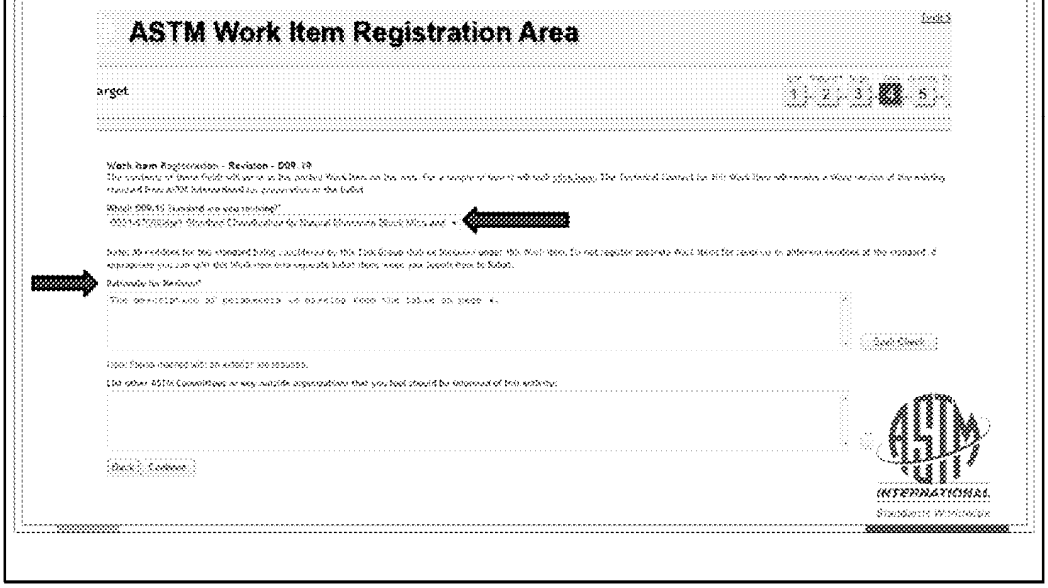




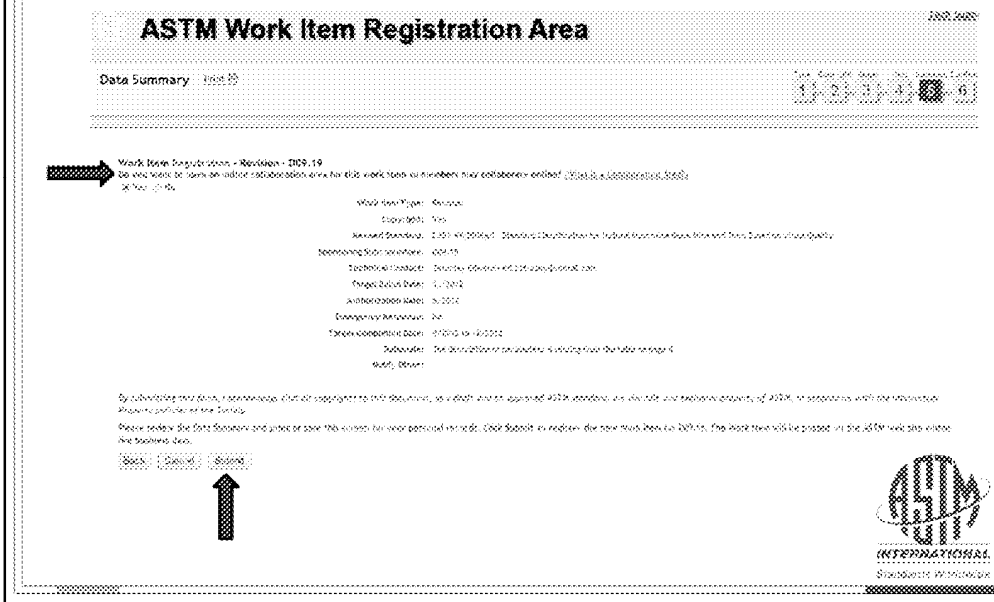




Select the standard that you are revising and give a detailed rationale for your activity. If it is a new standard, give as much detail in the rationale as possible.



This is the final screen where you want to review the information you entered and submit it for official registration.



After you click submit, the next screen that appears, will include your work item number. Please take a moment to make a note of this number for future reference.

Thank You!

For additional questions, please contact your Staff Manager.

EXHIBIT 14

Int. Cls.: 16, 35, 41 and 42

Prior U.S. Cls.: 2, 5, 22, 23, 29, 37, 38, 50, 100, 101, 102 and 107

Reg. No. 2,679,320

United States Patent and Trademark Office

Registered Jan. 28, 2003

TRADEMARK
SERVICE MARK
PRINCIPAL REGISTER

ASTM

AMERICAN SOCIETY FOR TESTING AND MATERIALS (PENNSYLVANIA CORPORATION)

100 BARR HARBOR DRIVE

WEST CONSHOHOCKEN, PA 19428

FOR: BOOKS FEATURING INFORMATION ON STANDARDIZATION OF SPECIFICATIONS AND THE METHODS OF TESTING FOR CEMENT AND CONCRETE MATERIALS, CEMENT, CHEMICAL-RESISTANT NONMETALLIC MATERIALS, LIME, CONCRETE AND CONCRETE AGGREGATES, MORTARS AND GROUTS FOR UNIT MASONRY, CONCRETE PIPE, MANUFACTURED MASONRY UNITS, FIBER-REINFORCED CEMENT PRODUCTS, PRECAST CONCRETE PRODUCTS; CERAMICS MATERIALS, REFRACTORIES, GLASS AND GLASS PRODUCTS, CERAMIC WHITEWARES AND RELATED PRODUCTS, ADVANCED CERAMICS, COMPOSITE MATERIALS; CHEMICALS, ENGINE COOLANTS, AROMATIC HYDROCARBONS AND RELATED CHEMICALS, HALOGENATED ORGANIC SOLVENTS AND FIRE EXTINGUISHING AGENTS, INDUSTRIAL AND SPECIALTY CHEMICALS; CONSTRUCTION MATERIALS INCLUDING BUT NOT LIMITED TO ENGINEERING, VITRIFIED CLAY PIPE, GYPSUM AND RELATED BUILDING MATERIALS AND SYSTEMS, THERMAL INSULATION, DIMENSION STONE, BUILDING SEALS AND SEALANTS, ROAD AND PAVING MATERIALS, WOOD, ROOFING, WATERPROOFING, BITUMINOUS MATERIALS, SOIL AND ROCK, GEOSYNTHETICS, VEHICLE-PAVEMENT SYSTEMS, RESILIENT FLOOR COVERINGS, PLASTIC PIPING SYSTEMS; ELECTRONICS AND ELECTRICAL INSULATION, ELECTRICAL AND ELECTRONIC INSULATING MATERIALS, ELECTRICAL INSULATING LIQUIDS AND GASES, ELECTRONICS; END USE PRODUCTS, SOAPS AND OTHER DETERGENTS, POLISHES, LEATHER, SPORTS EQUIPMENT, VACUUM CLEANERS, FENCES, AMUSEMENT RIDES AND DEVICES, FOOD SERVICE EQUIPMENT; ENERGY - NUCLEAR FUEL CYCLE, SOLAR, GEOTHERMAL, AND OTHER ALTERNATIVE ENERGY SOURCES; ENVIRONMENT, WASTE MANAGEMENT, PESTICIDES, HAZARDOUS SUBSTANCES; GENERAL PRODUCTS - ADHESIVES, ACTIVATED CARBON; HEALTH CARE, MEDICAL AND SURGICAL MATERIALS AND DEVICES, ANESTHETIC AND RESPIRATORY EQUIPMENT; METAL PRODUCTS, STEEL, STAINLESS STEEL AND RELATED ALLOYS, IRON CASTINGS, METALLIC-COATED IRON AND STEEL PRODUCTS, MAGNETIC PROPERTIES, ELECTRICAL CONDUCTORS, NONFERROUS METALS AND ALLOYS, COPPER AND COPPER ALLOYS, LIGHT METALS AND ALLOYS, METAL POWDERS AND METAL POWDER PRODUCTS, REACTIVE AND REFRACTORY METALS AND ALLOYS, FASTENERS; PAINTS AND COATINGS, METALLIC AND INORGANIC COATINGS, PAINT AND RELATED COATINGS, MATERIALS AND APPLICATIONS, PROTECTIVE COATING AND LINING WORK FOR POWER GENERATION FACILITIES; PAPER AND PACKAGING, PAPER AND PAPER PRODUCTS, PACKAGING, FLEXIBLE BARRIER MATERIALS; PETROLEUM PRODUCTS, LUBRICANTS, AND FOSSIL FUELS - PETROLEUM PRODUCTS AND LUBRICANTS, GASEOUS FUELS, COAL AND COKE, CATALYSTS; PLASTICS, PLASTIC PIPING SYSTEMS; RUBBER, CARBON BLACK, GASKETS, TIRES; SAFETY, ELECTRICAL PROTECTIVE EQUIPMENT FOR WORKERS, PROTECTIVE CLOTHING, IN CLASS 16 (U.S. CLS. 2, 5, 22, 23, 29, 37, 38 AND 50).

FIRST USE 3-15-1962; IN COMMERCE 3-15-1962.

FOR: PROMOTING PUBLIC AWARENESS OF THE NEED FOR STANDARDS FOR RELIABLE MATERIALS, PRODUCTS, SYSTEMS AND SERVICES TO IMPROVE PUBLIC HEALTH AND SAFETY

AND THE OVERALL QUALITY OF LIFE, IN CLASS 35 (U.S. CLS. 100, 101 AND 102).

FIRST USE 3-15-1962; IN COMMERCE 3-15-1962.

FOR: EDUCATIONAL SERVICES, NAMELY, CONDUCTING SYMPOSIA AND COMMITTEE MEETINGS IN THE FIELD OF STANDARDIZATION OF SPECIFICATIONS AND METHODS OF TESTING FOR CEMENT AND CONCRETE MATERIALS, CEMENT, CHEMICAL-RESISTANT NONMETALLIC MATERIALS, LIME, CONCRETE AND CONCRETE AGGREGATES, MORTARS AND GROUTS FOR UNIT MASONRY, CONCRETE PIPE, MANUFACTURED MASONRY UNITS, FIBER-REINFORCED CEMENT PRODUCTS, PRECAST CONCRETE PRODUCTS; CERAMICS MATERIALS - REFRACTORIES, GLASS AND GLASS PRODUCTS, CERAMIC WHITEWARES AND RELATED PRODUCTS, ADVANCED CERAMICS, COMPOSITE MATERIALS; CHEMICALS, ENGINE COOLANTS, AROMATIC HYDROCARBONS AND RELATED CHEMICALS, HALOGENATED ORGANIC SOLVENTS AND FIRE EXTINGUISHING AGENTS, INDUSTRIAL AND SPECIALTY CHEMICALS; CONSTRUCTION MATERIALS INCLUDING BUT NOT LIMITED TO ENGINEERING, VITRIFIED CLAY PIPE, GYPSUM AND RELATED BUILDING MATERIALS AND SYSTEMS, THERMAL INSULATION, DIMENSION STONE, BUILDING SEALS AND SEALANTS, ROAD AND PAVING MATERIALS, WOOD, ROOFING, WATERPROOFING, BITUMINOUS MATERIALS, SOIL AND ROCK, GEOSYNTHETICS, VEHICLE-PAVEMENT SYSTEMS, RESILIENT FLOOR COVERINGS, PLASTIC PIPING SYSTEMS; ELECTRONICS AND ELECTRICAL INSULATION, ELECTRICAL AND ELECTRONIC INSULATING MATERIALS, ELECTRICAL INSULATING LIQUIDS AND GASES, ELECTRONICS; END USE PRODUCTS, SOAPS AND OTHER DETERGENTS, POLISHES, LEATHER, SPORTS EQUIPMENT, VACUUM CLEANERS, FENCES, AMUSEMENT RIDES AND DEVICES, FOOD SERVICE EQUIPMENT; ENERGY, NUCLEAR FUEL CYCLE, SOLAR, GEOTHERMAL, AND OTHER ALTERNATIVE ENERGY SOURCES; ENVIRONMENT, WASTE MANAGEMENT, PESTICIDES, HAZARDOUS SUBSTANCES; GENERAL PRODUCTS - ADHESIVES, ACTIVATED CARBON; HEALTH CARE, MEDICAL AND SURGICAL MATERIALS AND DEVICES, ANESTHETIC AND RESPIRATORY EQUIPMENT; METAL PRODUCTS, STEEL, STAINLESS STEEL AND RELATED ALLOYS, IRON CASTINGS, METALLIC-COATED IRON AND STEEL PRODUCTS, MAGNETIC PROPERTIES, ELECTRICAL CONDUCTORS, NONFERROUS METALS AND ALLOYS, COPPER AND COPPER ALLOYS, LIGHT METALS AND ALLOYS, METAL POWDERS AND METAL POWDER PRODUCTS, REACTIVE AND REFRACTORY METALS AND ALLOYS, FASTENERS; PAINTS AND COATINGS - METALLIC AND INORGANIC COATINGS, PAINT AND RELATED COATINGS, MATERIALS AND APPLICATIONS, PROTECTIVE COATING AND LINING WORK FOR POWER GENERATION FACILITIES; PAPER AND PACKAGING, PAPER AND PAPER PRODUCTS, PACKAGING, FLEXIBLE BARRIER MATERIALS; PETROLEUM PRODUCTS, LUBRICANTS, AND FOSSIL FUELS, PETROLEUM PRODUCTS AND LUBRICANTS, GASEOUS FUELS, COAL AND COKE, CATALYSTS; PLASTICS, PLASTIC PIPING SYSTEMS; RUBBER, CARBON BLACK, GASKETS, TIRES; SAFETY, ELECTRICAL PROTECTIVE EQUIPMENT FOR WORKERS, PROTECTIVE CLOTHING, IN CLASS 41 (U.S. CLS. 100, 101 AND 107).

FIRST USE 3-15-1962; IN COMMERCE 3-15-1962.

FOR: PROVIDING A WEBSITE ON GLOBAL COMPUTER NETWORKS FEATURING INFORMATION IN THE FIELD OF SPECIFICATIONS AND METHODS OF TESTING FOR CEMENT AND CONCRETE MATERIALS, CEMENT, CHEMICAL-RESISTANT NONMETALLIC MATERIALS, LIME, CONCRETE AND CONCRETE AGGREGATES, MORTARS AND GROUTS FOR UNIT MASONRY, CONCRETE PIPE, MANUFACTURED MASONRY UNITS, FIBER-REINFORCED CEMENT PRODUCTS, PRECAST CONCRETE PRODUCTS; CERAMICS MATERIALS, REFRACTORIES, GLASS AND GLASS PRODUCTS, CERAMIC WHITEWARES AND RELATED PRODUCTS, ADVANCED CERAMICS, COMPOSITE MATERIALS; CHEMICALS - ENGINE COOLANTS, AROMATIC HYDROCARBONS AND RELATED CHEMICALS, HALOGENATED ORGANIC SOLVENTS AND FIRE EXTINGUISHING AGENTS, INDUSTRIAL AND SPECIALTY CHEMICALS; CONSTRUCTION MATERIALS INCLUDING BUT NOT LIMITED TO ENGINEERING - VITRIFIED CLAY PIPE, GYPSUM AND RELATED BUILDING MATERIALS AND SYSTEMS, THERMAL INSULATION, DIMENSION STONE, BUILDING SEALS AND SEALANTS, ROAD AND PAVING MATERIALS, WOOD, ROOFING, WATERPROOFING, BITUMINOUS MATERIALS, SOIL AND ROCK, GEOSYNTHETICS, VEHICLE-PAVEMENT SYSTEMS, RESILIENT FLOOR COVERINGS, PLASTIC PIPING SYSTEMS; ELECTRONICS AND ELECTRICAL INSULATION, ELECTRICAL AND ELECTRONIC INSULATING MATERIALS, ELECTRICAL INSULATING LIQUIDS AND GASES, ELECTRONICS; END USE PRODUCTS, SOAPS AND OTHER DETERGENTS, POLISHES, LEATHER, SPORTS EQUIPMENT, VACUUM CLEANERS, FENCES, AMUSEMENT RIDES AND DEVICES, FOOD SERVICE EQUIPMENT; ENERGY, NUCLEAR FUEL CYCLE, SOLAR, GEOTHERMAL, AND OTHER ALTERNATIVE ENERGY SOURCES; ENVIRONMENT, WASTE MANAGEMENT, PESTICIDES, HAZARDOUS SUBSTANCES; GENERAL PRODUCTS - ADHESIVES, ACTIVATED CARBON; HEALTH CARE, MEDICAL AND SURGICAL MATERIALS AND DEVICES, ANESTHETIC AND RESPIRATORY EQUIPMENT; METAL PRODUCTS, STEEL, STAINLESS STEEL AND RELATED ALLOYS, IRON CASTINGS, METALLIC-COATED IRON AND STEEL PRODUCTS, MAGNETIC PROPERTIES, ELECTRICAL CONDUCTORS, NONFERROUS METALS AND ALLOYS, COPPER AND COPPER ALLOYS, LIGHT METALS AND ALLOYS, METAL POWDERS AND METAL POWDER PRODUCTS, REACTIVE AND REFRACTORY METALS AND ALLOYS, FASTENERS;

PAINTS AND COATINGS, METALLIC AND INORGANIC COATINGS, PAINT AND RELATED COATINGS, MATERIALS AND APPLICATIONS, PROTECTIVE COATING AND LINING WORK FOR POWER GENERATION FACILITIES; PAPER AND PACKAGING, PAPER AND PAPER PRODUCTS, PACKAGING, FLEXIBLE BARRIER MATERIALS; PETROLEUM PRODUCTS, LUBRICANTS, AND FOSSIL FUELS, PETROLEUM PRODUCTS AND LUBRICANTS, GASEOUS FUELS, COAL AND COKE, CATALYSTS; PLASTICS, PLASTIC PIPING SYSTEMS; RUBBER, CARBON BLACK, GASKETS, TIRES; SAFETY, ELECTRICAL PROTECTIVE EQUIPMENT FOR WORKERS, PROTECTIVE CLOTHING, IN CLASS 42 (U.S. CLS. 100 AND 101).

FIRST USE 3-15-1962; IN COMMERCE 3-15-1962.

OWNER OF U.S. REG. NOS. 901,227 AND 993,094.

SER. NO. 75-638,698, FILED 2-11-1999.

LESLIE RICHARDS, EXAMINING ATTORNEY

PTO Form 1583 (Rev 5/2006)
OMB No. 0651-0055 (Exp 12/31/2011)

Combined Declaration of Use and Incontestability under Sections 8 & 15

The table below presents the data as entered.

Input Field	Entered
REGISTRATION NUMBER	2679320
REGISTRATION DATE	01/28/2003
SERIAL NUMBER	75638698
MARK SECTION	
MARK	ASTM
OWNER SECTION (current)	
NAME	American Society for Testing and Materials
STREET	100 Barr Harbor Drive
CITY	West Conshohocken
STATE	Pennsylvania
ZIP/POSTAL CODE	19428
COUNTRY	US
ATTORNEY SECTION (current)	
NAME	DENISE ADAMUCCI
FIRM NAME	KLETT ROONEY LIEBER & SCHORLING PC
STREET	2 LOGAN SQ 12TH FL
CITY	PHILADELPHIA
STATE	Pennsylvania
POSTAL CODE	19103-2756
COUNTRY	United States
ATTORNEY SECTION (proposed)	
NAME	Carole R. Klein
FIRM NAME	Morgan, Lewis & Bockius LLP

STREET	1111 Pennsylvania Avenue, NW
CITY	Washington
STATE	District of Columbia
POSTAL CODE	20004
COUNTRY	United States
PHONE	202-739-5517
FAX	202-739-3001
EMAIL	trademarks@morganlewis.com
AUTHORIZED TO COMMUNICATE VIA E-MAIL	Yes
ATTORNEY DOCKET NUMBER	035186.0007
OTHER APPOINTED ATTORNEY	the firm of Morgan, Lewis & Bockius LLP, MICHAEL F. CLAYTON, JAMES R. SIMS III, RON N. DREBEN, KAREN A. BUTCHER, BRETT I. MILLER, ANITA B. POLOTT, CAROLE R. KLEIN, JOSEPH E. WASHINGTON, KRISTIN H. ALTOFF, GENE K. PARK, MEGAN K. BOWEN, BRIAN P. OÂ'DONNELL, DANA S. GROSS, NATALIE A. WARD, HENRY SHINN, and SETH I. SHAIFER, members of the District of Columbia Bar, MERRY BIGGERSTAFF, member of the New York Bar, and DAN MARKS, member of the California Bar, all located at 1111 Pennsylvania Ave., NW, Washington, D.C. 20004, ROCHELLE D. ALPERT, CARLA B. OAKLEY, SHARON R. SMITH, and LEIGHA E. WILBUR, members of the California Bar, all located at One Market, Spear Street Tower, San Francisco, California 94105, and ANDREW J. GRAY IV, member of the California Bar, located at 2 Palo Alto Square, Suite 700, 3000 El Camino Real, Palo Alto, California 94306, all of whom should receive correspondence and documents related to this application through the offices
GOODS AND/OR SERVICES SECTION	
INTERNATIONAL CLASS	016
GOODS OR SERVICES	KEEP ALL LISTED
SPECIMEN FILE NAME(S)	\\TICRS\EXPORT5\IMAGEOUT5 \756\386\75638698\xml1\81 50002.JPG
SPECIMEN DESCRIPTION	photograph of manual
INTERNATIONAL CLASS	035

GOODS OR SERVICES	KEEP ALL LISTED
SPECIMEN FILE NAME(S)	\\TICRS\EXPORT5\IMAGEOUT5 \756\386\75638698\xml1\81 50003.JPG
SPECIMEN DESCRIPTION	page from website
INTERNATIONAL CLASS	041
GOODS OR SERVICES	KEEP ALL LISTED
SPECIMEN FILE NAME(S)	\\TICRS\EXPORT5\IMAGEOUT5 \756\386\75638698\xml1\81 50004.JPG
SPECIMEN DESCRIPTION	page from website
INTERNATIONAL CLASS	042
GOODS OR SERVICES	KEEP ALL LISTED
SPECIMEN FILE NAME(S)	\\TICRS\EXPORT5\IMAGEOUT5 \756\386\75638698\xml1\81 50005.JPG
SPECIMEN DESCRIPTION	page from website
PAYMENT SECTION	
NUMBER OF CLASSES	4
NUMBER OF CLASSES PAID	4
SUBTOTAL AMOUNT	1200
TOTAL FEE PAID	1200
SIGNATURE SECTION	
SIGNATURE	/Thomas B. O'Brien, Jr./
SIGNATORY'S NAME	Thomas B. O'Brien Jr.
SIGNATORY'S POSITION	Vice President & General Counsel
DATE SIGNED	01/26/2009
PAYMENT METHOD	DA
FILING INFORMATION	
SUBMIT DATE	Mon Jan 26 13:26:39 EST 2009
TEAS STAMP	USPTO/S08N15-96.241.29.24 6-20090126132639117396-26 79320-44042b9939fe160f1de 789964cb9b619f7d-DA-10343 -20090126131432563889

PTO Form 1583 (Rev 5/2006)
OMB No. 0651-0055 (Exp 12/31/2011)

Combined Declaration of Use and Incontestability under Sections 8 & 15
To the Commissioner for Trademarks:

REGISTRATION NUMBER: 2679320
REGISTRATION DATE: 01/28/2003

MARK: ASTM

The owner, American Society for Testing and Materials, having an address of
100 Barr Harbor Drive
West Conshohocken, Pennsylvania 19428
US
is filing a Combined Declaration of Use and Incontestability under Sections 8 & 15.

For International Class 016, the mark is in use in commerce on or in connection with **all** of the goods or services listed in the existing registration for this specific class; **and** the mark has been continuously used in commerce for five (5) consecutive years after the date of registration, or the date of publication under Section 12(c), and is still in use in commerce on or in connection with **all** goods or services listed in the existing registration for this class. Also, no final decision adverse to the owner's claim of ownership of such mark for those goods or services exists, or to the owner's right to register the same or to keep the same on the register; and, no proceeding involving said rights pending and not disposed of in either the U.S. Patent and Trademark Office or the courts exists.

The owner is submitting one specimen for this class showing the mark as used in commerce on or in connection with any item in this class, consisting of a(n) photograph of manual.
Specimen File1

For International Class 035, the mark is in use in commerce on or in connection with **all** of the goods or services listed in the existing registration for this specific class; **and** the mark has been continuously used in commerce for five (5) consecutive years after the date of registration, or the date of publication under Section 12(c), and is still in use in commerce on or in connection with **all** goods or services listed in the existing registration for this class. Also, no final decision adverse to the owner's claim of ownership of such mark for those goods or services exists, or to the owner's right to register the same or to keep the same on the register; and, no proceeding involving said rights pending and not disposed of in either the U.S. Patent and Trademark Office or the courts exists.

The owner is submitting one specimen for this class showing the mark as used in commerce on or in connection with any item in this class, consisting of a(n) page from website.
Specimen File1

For International Class 041, the mark is in use in commerce on or in connection with **all** of the goods or services listed in the existing registration for this specific class; **and** the mark has been continuously used in commerce for five (5) consecutive years after the date of registration, or the date of publication under Section 12(c), and is still in use in commerce on or in connection with **all** goods or services listed in the

existing registration for this class. Also, no final decision adverse to the owner's claim of ownership of such mark for those goods or services exists, or to the owner's right to register the same or to keep the same on the register; and, no proceeding involving said rights pending and not disposed of in either the U.S. Patent and Trademark Office or the courts exists.

The owner is submitting one specimen for this class showing the mark as used in commerce on or in connection with any item in this class, consisting of a(n) page from website.
Specimen File1

For International Class 042, the mark is in use in commerce on or in connection with **all** of the goods or services listed in the existing registration for this specific class; **and** the mark has been continuously used in commerce for five (5) consecutive years after the date of registration, or the date of publication under Section 12(c), and is still in use in commerce on or in connection with **all** goods or services listed in the existing registration for this class. Also, no final decision adverse to the owner's claim of ownership of such mark for those goods or services exists, or to the owner's right to register the same or to keep the same on the register; and, no proceeding involving said rights pending and not disposed of in either the U.S. Patent and Trademark Office or the courts exists.

The owner is submitting one specimen for this class showing the mark as used in commerce on or in connection with any item in this class, consisting of a(n) page from website.
Specimen File1

The registrant hereby appoints Carole R. Klein and the firm of Morgan, Lewis & Bockius LLP, MICHAEL F. CLAYTON, JAMES R. SIMS III, RON N. DREBEN, KAREN A. BUTCHER, BRETT I. MILLER, ANITA B. POLOTT, CAROLE R. KLEIN, JOSEPH E. WASHINGTON, KRISTIN H. ALTOFF, GENE K. PARK, MEGAN K. BOWEN, BRIAN P. OÂ'DONNELL, DANA S. GROSS, NATALIE A. WARD, HENRY SHINN, and SETH I. SHAIFER, members of the District of Columbia Bar, MERRY BIGGERSTAFF, member of the New York Bar, and DAN MARKS, member of the California Bar, all located at 1111 Pennsylvania Ave., NW, Washington, D.C. 20004, ROCHELLE D. ALPERT, CARLA B. OAKLEY, SHARON R. SMITH, and LEIGHA E. WILBUR, members of the California Bar, all located at One Market, Spear Street Tower, San Francisco, California 94105, and ANDREW J. GRAY IV, member of the California Bar, located at 2 Palo Alto Square, Suite 700, 3000 El Camino Real, Palo Alto, California 94306, all of whom should receive correspondence and documents related to this application through the offices of Morgan, Lewis & Bockius LLP

1111 Pennsylvania Avenue, NW
Washington, District of Columbia 20004
United States

to file this Combined Declaration of Use and Incontestability under Sections 8 & 15 on behalf of the registrant. The attorney docket/reference number is 035186.0007.

A fee payment in the amount of $1200 will be submitted with the form, representing payment for 4 class(es), plus any additional grace period fee, if necessary.

Declaration

The mark is in use in commerce on or in connection with the goods and/or services identified above, as evidenced by the attached specimen(s) showing the mark as used in commerce. The mark has been in continuous use in commerce for five (5) consecutive years after the date of registration, or the date of publication under Section 12(c), and is still in use in commerce. There has been no final decision adverse

to the owner's claim of ownership of such mark, or to the owner's right to register the same or to keep the same on the register; and there is no proceeding involving said rights pending and not disposed of either in the U.S. Patent and Trademark Office or in the courts.

The undersigned being hereby warned that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 U.S.C. Section 1001, and that such willful false statements and the like may jeopardize the validity of this document, declares that he/she is properly authorized to execute this document on behalf of the Owner; and all statements made of his/her own knowledge are true and that all statements made on information and belief are believed to be true.

Signature: /Thomas B. O'Brien, Jr./ Date: 01/26/2009
Signatory's Name: Thomas B. O'Brien Jr.
Signatory's Position: Vice President & General Counsel

Mailing Address **(current):**
KLETT ROONEY LIEBER & SCHORLING PC
2 LOGAN SQ 12TH FL
PHILADELPHIA, Pennsylvania 19103-2756

Mailing Address **(proposed):**
Morgan, Lewis & Bockius LLP
1111 Pennsylvania Avenue, NW
Washington, District of Columbia 20004

Serial Number: 75638698
Internet Transmission Date: Mon Jan 26 13:26:39 EST 2009
TEAS Stamp: USPTO/S08N15-96.241.29.246-2009012613263
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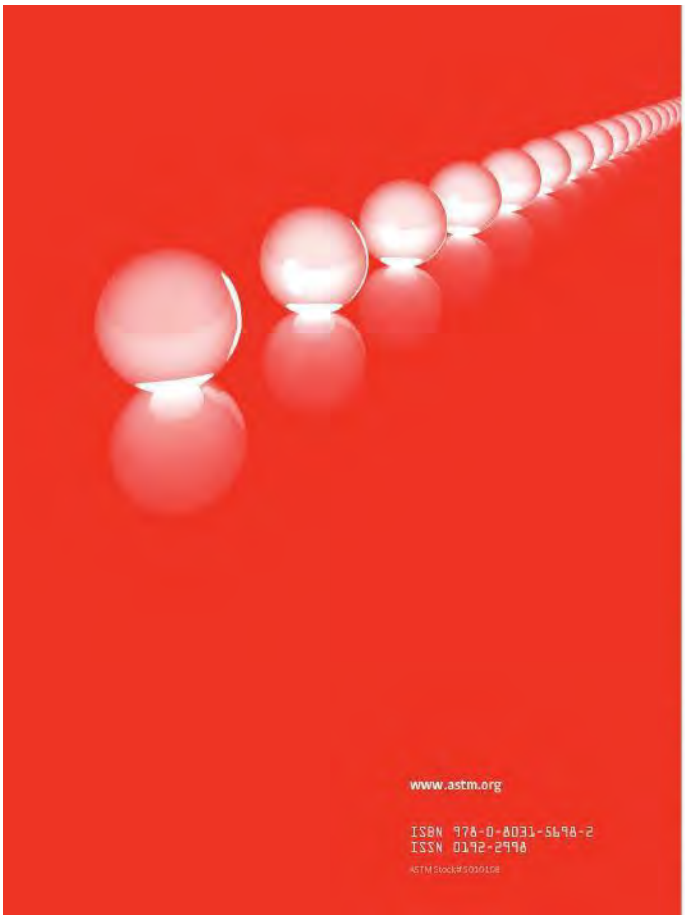

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2008 ANNUAL BOOK OF ASTM STANDARDS

Steel — Piping, Tubing, Fittings

SECTION 1
VOLUME 01.01
JAN

2008
ANNUAL BOOK OF ASTM STANDARDS

SECTION ONE
IRON AND STEEL PRODUCTS

VOLUME 01.01

Steel — Piping, Tubing, Fittings

Revision Issued Annually

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Serial Number: 75638698

RAM Sale Number: 10343

RAM Accounting Date: 20090126

Total Fees: $1200

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In TICRS (AM-FLG-IN-TICRS): True

Transaction Date: 20090126

EXHIBIT 15

Int. Cls.: 16, 35, 41 and 42

Prior U.S. Cls.: 2, 5, 22, 23, 29, 37, 38, 50, 100, 101, 102 and 107

United States Patent and Trademark Office

Reg. No. 2,685,857

Registered Feb. 11, 2003

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ASTM INTERNATIONAL

AMERICAN SOCIETY FOR TESTING AND MATERIALS (PENNSYLVANIA NON-PROFIT CORPORATION)
100 BARR HARBOR DRIVE
WEST CONSHOHOCKEN, PA 19428

FOR: BOOKS FEATURING INFORMATION AND STANDARDIZATION OF SPECIFICATIONS AND THE METHODS OF TESTING FOR THE ENGINEERING, INDUSTRIAL AND ALLIED FIELDS, IN CLASS 16 (U.S. CLS. 2, 5, 22, 23, 29, 37, 38 AND 50).

FIRST USE 11-1-2001; IN COMMERCE 11-1-2001.

FOR: PROMOTING PUBLIC AWARENESS AND KNOWLEDGE OF AND THE NEED FOR TESTING METHODS, SPECIFICATIONS AND STANDARDS FOR THE ENGINEERING, INDUSTRIAL AND ALLIED FIELDS, IN CLASS 35 (U.S. CLS. 100, 101 AND 102).

FIRST USE 10-1-2001; IN COMMERCE 10-1-2001.

FOR: EDUCATIONAL SERVICES, NAMELY, CONDUCTING SYMPOSIA AND COMMITTEE MEETINGS IN THE FIELD OF STANDARDIZATION OF SPECIFICATIONS AND METHODS OF TESTING FOR THE ENGINEERING, INDUSTRIAL AND ALLIED FIELDS, IN CLASS 41 (U.S. CLS. 100, 101 AND 107).

FIRST USE 10-1-2001; IN COMMERCE 10-1-2001.

FOR: TESTING OF THE GOODS AND SERVICES OF OTHERS FOR THE PURPOSE OF CERTIFICATION AND THE ESTABLISHMENT OF STANDARDS AND SPECIFICATIONS, AND PROVIDING A WEBSITE FEATURING INFORMATION IN THE FIELD OF METHODS OF TESTING, SPECIFICATIONS AND STANDARDS, IN THE ENGINEERING, INDUSTRIAL AND ALLIED FIELDS, IN CLASS 42 (U.S. CLS. 100 AND 101).

FIRST USE 10-1-2001; IN COMMERCE 10-1-2001.

NO CLAIM IS MADE TO THE EXCLUSIVE RIGHT TO USE INTERNATIONAL, APART FROM THE MARK AS SHOWN.

SER. NO. 76-343,236, FILED 11-30-2001.

LESLIE RICHARDS, EXAMINING ATTORNEY

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Combined Declaration of Use and Incontestability under Sections 8 & 15

The table below presents the data as entered.

Input Field	Entered
REGISTRATION NUMBER	2685857
REGISTRATION DATE	02/11/2003
SERIAL NUMBER	76343236
MARK SECTION	
MARK	ASTM INTERNATIONAL
OWNER SECTION (current)	
NAME	American Society for Testing and Materials
STREET	100 Barr Harbor Drive
CITY	West Conshohocken
STATE	Pennsylvania
ZIP/POSTAL CODE	19428
COUNTRY	US
PHONE	610-832-9500
FAX	610-832-9555
ATTORNEY SECTION (current)	
NAME	Denise Adamucci
FIRM NAME	KLETT ROONEY LIEBER & SCHORLING
STREET	TWO LOGAN SQUARE, 12TH FLOOR
CITY	PHILADELPHIA
STATE	Pennsylvania
POSTAL CODE	19103-2756
COUNTRY	United States
PHONE	(215) 567-7658

FAX	(215) 567-2737
EMAIL	dadamucci@klettrooney.com
ATTORNEY SECTION (proposed)	
NAME	Carole R. Klein
FIRM NAME	Morgan, Lewis & Bockius LLP
STREET	1111 Pennsylvania Avenue, NW
CITY	Washington
STATE	District of Columbia
POSTAL CODE	20004
COUNTRY	United States
PHONE	202-739-5517
FAX	202-739-3001
EMAIL	trademarks@morganlewis.com
AUTHORIZED TO COMMUNICATE VIA E-MAIL	Yes
ATTORNEY DOCKET NUMBER	035186.0007.0160
OTHER APPOINTED ATTORNEY	the firm of Morgan, Lewis & Bockius LLP, MICHAEL F. CLAYTON, JAMES R. SIMS III, RON N. DREBEN, KAREN A. BUTCHER, BRETT I. MILLER, ANITA B. POLOTT, CAROLE R. KLEIN, JOSEPH E. WASHINGTON, KRISTIN H. ALTOFF, GENE K. PARK, MEGAN K. BOWEN, BRIAN P. OÂ'DONNELL, DANA S. GROSS, NATALIE A. WARD, HENRY SHINN, and SETH I. SHAIFER, members of the District of Columbia Bar, MERRY BIGGERSTAFF, member of the New York Bar, and DAN MARKS, member of the California Bar, all located at 1111 Pennsylvania Ave., NW, Washington, D.C. 20004, ROCHELLE D. ALPERT, CARLA B. OAKLEY, SHARON R. SMITH, and LEIGHA E. WILBUR, members of the California Bar, all located at One Market, Spear Street Tower, San Francisco, California 94105, and ANDREW J. GRAY IV, member of the California Bar, located at 2 Palo Alto Square, Suite 700, 3000 El Camino Real, Palo Alto, California 94306, all of whom should receive correspondence and documents related to this application through the offices
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INTERNATIONAL CLASS	016
GOODS OR SERVICES	KEEP ALL LISTED
SPECIMEN FILE NAME(S)	\\TICRS\EXPORT5\IMAGEOUT5 \763\432\76343236\xml1\81 50002.JPG
SPECIMEN DESCRIPTION	photograph of book cover
INTERNATIONAL CLASS	035
GOODS OR SERVICES	KEEP ALL LISTED
SPECIMEN FILE NAME(S)	\\TICRS\EXPORT5\IMAGEOUT5 \763\432\76343236\xml1\81 50003.JPG
SPECIMEN DESCRIPTION	page from website
INTERNATIONAL CLASS	041
GOODS OR SERVICES	KEEP ALL LISTED
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SPECIMEN DESCRIPTION	page from website
INTERNATIONAL CLASS	042
GOODS OR SERVICES	KEEP ALL LISTED
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SPECIMEN DESCRIPTION	page from website
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NUMBER OF CLASSES	4
NUMBER OF CLASSES PAID	4
SUBTOTAL AMOUNT	1200
TOTAL FEE PAID	1200
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SIGNATURE	/Thomas B. O'Brien, Jr./
SIGNATORY'S NAME	Thomas B. O'Brien Jr.
SIGNATORY'S POSITION	Vice President & General Cousel
DATE SIGNED	01/26/2009
PAYMENT METHOD	DA
FILING INFORMATION	

SUBMIT DATE	Mon Jan 26 13:32:46 EST 2009
TEAS STAMP	USPTO/S08N15-96.241.29.246-20090126133246540365-2685857-4402f99ac79415168febc61ba63e8b68dc-DA-10424-20090126132142673988

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Combined Declaration of Use and Incontestability under Sections 8 & 15
To the Commissioner for Trademarks:

REGISTRATION NUMBER: 2685857
REGISTRATION DATE: 02/11/2003

MARK: ASTM INTERNATIONAL

The owner, American Society for Testing and Materials, having an address of
100 Barr Harbor Drive
West Conshohocken, Pennsylvania 19428
US
is filing a Combined Declaration of Use and Incontestability under Sections 8 & 15.

For International Class 016, the mark is in use in commerce on or in connection with **all** of the goods or services listed in the existing registration for this specific class; **and** the mark has been continuously used in commerce for five (5) consecutive years after the date of registration, or the date of publication under Section 12(c), and is still in use in commerce on or in connection with **all** goods or services listed in the existing registration for this class. Also, no final decision adverse to the owner's claim of ownership of such mark for those goods or services exists, or to the owner's right to register the same or to keep the same on the register; and, no proceeding involving said rights pending and not disposed of in either the U.S. Patent and Trademark Office or the courts exists.

The owner is submitting one specimen for this class showing the mark as used in commerce on or in connection with any item in this class, consisting of a(n) photograph of book cover.
Specimen File1

For International Class 035, the mark is in use in commerce on or in connection with **all** of the goods or services listed in the existing registration for this specific class; **and** the mark has been continuously used in commerce for five (5) consecutive years after the date of registration, or the date of publication under Section 12(c), and is still in use in commerce on or in connection with **all** goods or services listed in the existing registration for this class. Also, no final decision adverse to the owner's claim of ownership of such mark for those goods or services exists, or to the owner's right to register the same or to keep the same on the register; and, no proceeding involving said rights pending and not disposed of in either the U.S. Patent and Trademark Office or the courts exists.

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The owner is submitting one specimen for this class showing the mark as used in commerce on or in connection with any item in this class, consisting of a(n) page from website.
Specimen File1

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The owner is submitting one specimen for this class showing the mark as used in commerce on or in connection with any item in this class, consisting of a(n) page from website.
Specimen File1

The registrant hereby appoints Carole R. Klein and the firm of Morgan, Lewis & Bockius LLP, MICHAEL F. CLAYTON, JAMES R. SIMS III, RON N. DREBEN, KAREN A. BUTCHER, BRETT I. MILLER, ANITA B. POLOTT, CAROLE R. KLEIN, JOSEPH E. WASHINGTON, KRISTIN H. ALTOFF, GENE K. PARK, MEGAN K. BOWEN, BRIAN P. OÂ'DONNELL, DANA S. GROSS, NATALIE A. WARD, HENRY SHINN, and SETH I. SHAIFER, members of the District of Columbia Bar, MERRY BIGGERSTAFF, member of the New York Bar, and DAN MARKS, member of the California Bar, all located at 1111 Pennsylvania Ave., NW, Washington, D.C. 20004, ROCHELLE D. ALPERT, CARLA B. OAKLEY, SHARON R. SMITH, and LEIGHA E. WILBUR, members of the California Bar, all located at One Market, Spear Street Tower, San Francisco, California 94105, and ANDREW J. GRAY IV, member of the California Bar, located at 2 Palo Alto Square, Suite 700, 3000 El Camino Real, Palo Alto, California 94306, all of whom should receive correspondence and documents related to this application through the offices of Morgan, Lewis & Bockius LLP

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to file this Combined Declaration of Use and Incontestability under Sections 8 & 15 on behalf of the registrant. The attorney docket/reference number is 035186.0007.0160.

A fee payment in the amount of $1200 will be submitted with the form, representing payment for 4 class(es), plus any additional grace period fee, if necessary.

Declaration

The mark is in use in commerce on or in connection with the goods and/or services identified above, as evidenced by the attached specimen(s) showing the mark as used in commerce. The mark has been in continuous use in commerce for five (5) consecutive years after the date of registration, or the date of publication under Section 12(c), and is still in use in commerce. There has been no final decision adverse

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Signature: /Thomas B. O'Brien, Jr./ Date: 01/26/2009
Signatory's Name: Thomas B. O'Brien Jr.
Signatory's Position: Vice President & General Cousel

Mailing Address **(current):**
KLETT ROONEY LIEBER & SCHORLING
TWO LOGAN SQUARE, 12TH FLOOR
PHILADELPHIA, Pennsylvania 19103-2756

Mailing Address **(proposed):**
Morgan, Lewis & Bockius LLP
1111 Pennsylvania Avenue, NW
Washington, District of Columbia 20004

Serial Number: 76343236
Internet Transmission Date: Mon Jan 26 13:32:46 EST 2009
TEAS Stamp: USPTO/S08N15-96.241.29.246-2009012613324
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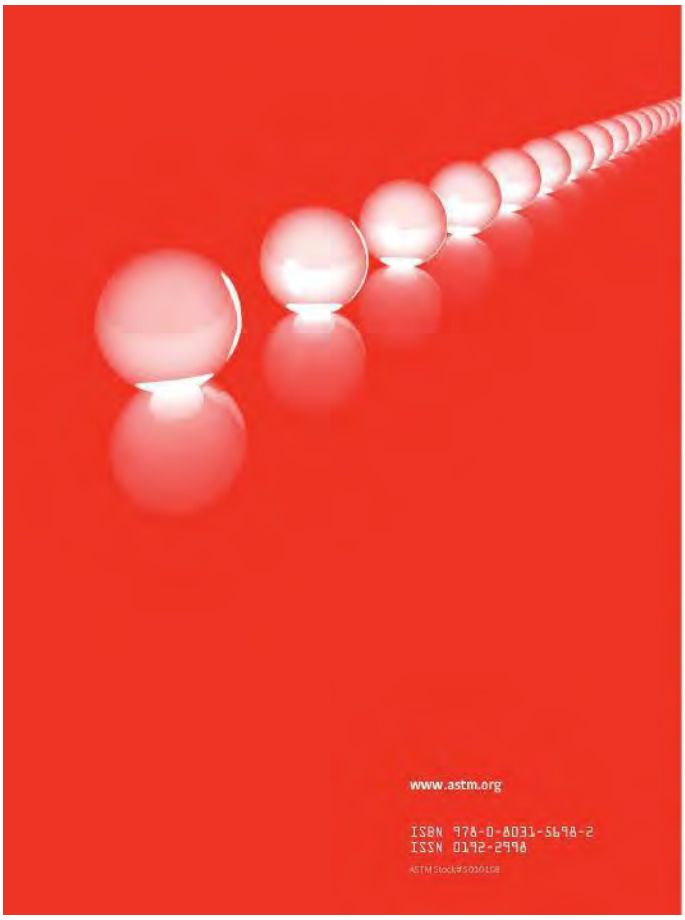

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In TICRS (AM-FLG-IN-TICRS): True

Transaction Date: 20090126

Int. Cl.: 16

Prior U.S. Cls.: 2, 5, 22, 23, 29, 37, 38 and 50

United States Patent and Trademark Office

Reg. No. 2,651,796

Registered Nov. 19, 2002

TRADEMARK
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AMERICAN SOCIETY FOR TESTING AND MATERIALS (PENNSYLVANIA NON-PROFIT CORPORATION)
100 BARR HARBOR DRIVE
WEST CONSHOHOCKEN, PA 19428

FOR: PUBLICATIONS PUBLISHED FROM TIME TO TIME, NAMELY, MAGAZINES, BOOKS, PAMPHLETS, BROCHURES, NEWSLETTERS, AND JOURNALS RELATING TO TESTING METHODS, SPECIFICATIONS AND STANDARDS IN THE ENGINEERING, INDUSTRIAL AND ALLIED FIELDS, IN CLASS 16 (U.S. CLS. 2, 5, 22, 23, 29, 37, 38 AND 50).

FIRST USE 11-1-2001; IN COMMERCE 11-1-2001.

OWNER OF U.S. REG. NOS. 901,227 AND 993,094.

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SER. NO. 76-343,235, FILED 11-30-2001.

LESLIE RICHARDS, EXAMINING ATTORNEY

PTO Form 1583 (Rev 5/2006)
OMB No. 0651-0055 (Exp 12/31/2011)

Combined Declaration of Use and Incontestability under Sections 8 & 15

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SERIAL NUMBER	76343235
MARK SECTION	
MARK	ASTM INTERNATIONAL (stylized and/or with design)
OWNER SECTION (current)	
NAME	American Society for Testing and Materials
STREET	100 Barr Harbor Drive
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STATE	Pennsylvania
ZIP/POSTAL CODE	19428
COUNTRY	United States
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AUTHORIZED TO COMMUNICATE VIA E-MAIL	Yes
ATTORNEY DOCKET NUMBER	035186.0007.0151
OTHER APPOINTED ATTORNEY	the firm of Morgan, Lewis & Bockius LLP, MICHAEL F. CLAYTON, JAMES R. SIMS III, RON N. DREBEN, KAREN A. BUTCHER, BRETT I. MILLER, ANITA B. POLOTT, CAROLE R. KLEIN, JOSEPH E. WASHINGTON, KRISTIN H. ALTOFF, GENE K. PARK, MEGAN K. BOWEN, BRIAN P. OÂ'DONNELL, NATALIE A. WARD, HENRY SHINN, and SETH I. SHAIFER, members of the District of Columbia Bar, and DANA S. GROSS and MERRY BIGGERSTAFF members of the New York Bar, all located at 1111 Pennsylvania Ave., NW, Washington, D.C. 20004, ROCHELLE D. ALPERT, CARLA B. OAKLEY, SHARON R. SMITH, DIANE J. MASON, and LEIGHA E. WILBUR, members of the California Bar, all located at One Market, Spear Street Tower, San Francisco, California 94105, and ANDREW J. GRAY IV, member of the California Bar, located at 2 Palo Alto Square, Suite 700, 3000 El Camino Real, Palo Alto, California 94306, all of whom should receive correspondence and documents related to this application through the offices
GOODS AND/OR SERVICES SECTION	

INTERNATIONAL CLASS	016
GOODS OR SERVICES	KEEP ALL LISTED
SPECIMEN FILE NAME(S)	\\TICRS\EXPORT4\IMAGEOUT4\763\432\76343235\xml1\81 50002.JPG
SPECIMEN DESCRIPTION	cover of publication
PAYMENT SECTION	
NUMBER OF CLASSES	1
NUMBER OF CLASSES PAID	1
SUBTOTAL AMOUNT	300
TOTAL FEE PAID	300
SIGNATURE SECTION	
SIGNATURE	/Thomas B. O'Brien Jr./
SIGNATORY'S NAME	Thomas B. O'Brien Jr.
SIGNATORY'S POSITION	Vice President & General Counsel
DATE SIGNED	11/19/2008
PAYMENT METHOD	DA
FILING INFORMATION	
SUBMIT DATE	Wed Nov 19 21:06:20 EST 2008
TEAS STAMP	USPTO/S08N15-72.73.50.2-20081119210620238721-26517 96-4006213692268b8ad7c14b1d10351d8a60-DA-4608-20081119114901182352

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Combined Declaration of Use and Incontestability under Sections 8 & 15
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REGISTRATION NUMBER: 2651796
REGISTRATION DATE: 11/19/2002

MARK: ASTM INTERNATIONAL (stylized and/or with design)

The owner, American Society for Testing and Materials, having an address of
100 Barr Harbor Drive
West Conshohocken, Pennsylvania 19428
United States
is filing a Combined Declaration of Use and Incontestability under Sections 8 & 15.

For International Class 016, the mark is in use in commerce on or in connection with **all** of the goods or services listed in the existing registration for this specific class; **and** the mark has been continuously used in commerce for five (5) consecutive years after the date of registration, or the date of publication under Section 12(c), and is still in use in commerce on or in connection with **all** goods or services listed in the existing registration for this class. Also, no final decision adverse to the owner's claim of ownership of such mark for those goods or services exists, or to the owner's right to register the same or to keep the same on the register; and, no proceeding involving said rights pending and not disposed of in either the U.S. Patent and Trademark Office or the courts exists.

The owner is submitting one specimen for this class showing the mark as used in commerce on or in connection with any item in this class, consisting of a(n) cover of publication.
Specimen File1

The registrant hereby appoints Carole R. Klein and the firm of Morgan, Lewis & Bockius LLP, MICHAEL F. CLAYTON, JAMES R. SIMS III, RON N. DREBEN, KAREN A. BUTCHER, BRETT I. MILLER, ANITA B. POLOTT, CAROLE R. KLEIN, JOSEPH E. WASHINGTON, KRISTIN H. ALTOFF, GENE K. PARK, MEGAN K. BOWEN, BRIAN P. OÂ'DONNELL, NATALIE A. WARD, HENRY SHINN, and SETH I. SHAIFER, members of the District of Columbia Bar, and DANA S. GROSS and MERRY BIGGERSTAFF members of the New York Bar, all located at 1111 Pennsylvania Ave., NW, Washington, D.C. 20004, ROCHELLE D. ALPERT, CARLA B. OAKLEY, SHARON R. SMITH, DIANE J. MASON, and LEIGHA E. WILBUR, members of the California Bar, all located at One Market, Spear Street Tower, San Francisco, California 94105, and ANDREW J. GRAY IV, member of the California Bar, located at 2 Palo Alto Square, Suite 700, 3000 El Camino Real, Palo Alto, California 94306, all of whom should receive correspondence and documents related to this application through the offices of Morgan, Lewis & Bockius LLP
1111 Pennsylvania Avenue, NW
Washington, District of Columbia 20004
United States
to file this Combined Declaration of Use and Incontestability under Sections 8 & 15 on behalf of the registrant. The attorney docket/reference number is 035186.0007.0151.

A fee payment in the amount of $300 will be submitted with the form, representing payment for 1 class(es), plus any additional grace period fee, if necessary.

Declaration

The owner, or its related company, is using the mark in commerce on or in connection with the goods and/or services identified above, as evidenced by the attached specimen(s) showing the mark as used in commerce. The owner, or its related company, has continuously used the mark in commerce on or in connection with the goods and/or services identified above, for five (5) consecutive years after the date of registration, or the date of publication under Section 12(c), and is still using the mark in commerce on or in connection with the identified goods and/or services. There has been no final decision adverse to the owner's claim of ownership of such mark for such goods and/or services, or to the owner's right to register the same or to keep the same on the register; and there is no proceeding involving said rights pending and not disposed of either in the U.S. Patent and Trademark Office or in the courts.

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Signature: /Thomas B. O'Brien Jr./ Date: 11/19/2008
Signatory's Name: Thomas B. O'Brien Jr.
Signatory's Position: Vice President & General Counsel

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KLETT ROONEY LIEBER & SCHORLING
2 LOGAN SQ 12TH FL
PHILADELPHIA, Pennsylvania 19103-2756

Mailing Address **(proposed):**
Morgan, Lewis & Bockius LLP
1111 Pennsylvania Avenue, NW
Washington, District of Columbia 20004

Serial Number: 76343235
Internet Transmission Date: Wed Nov 19 21:06:20 EST 2008
TEAS Stamp: USPTO/S08N15-72.73.50.2-2008111921062023
8721-2651796-4006213692268b8ad7c14b1d103
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Total Fees: $300

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Transaction	Fee Code	Transaction Date	Fee per Class	Number of Classes	Number of Classes Paid	Total Fee
§8 affidavit	7205	20081119	$100	1	1	$100
§15 affidavit	7208	20081119	$200	1	1	$200

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United States of America
United States Patent and Trademark Office

Reg. No. 4,079,772

Registered Jan. 3, 2012

Int. Cl.: 16

TRADEMARK

PRINCIPAL REGISTER

AMERICAN SOCIETY FOR TESTING AND MATERIALS (PENNSYLVANIA CORPORATION)
100 BARR HARBOR DRIVE
WEST CONSHOHOCKEN, PA 194282959

FOR: PUBLICATIONS, NAMELY, MAGAZINES, BOOKS, PAMPHLETS, BROCHURES, NEWSLETTERS AND JOURNALS, RELATING TO TESTING METHODS, SPECIFICATIONS AND STANDARDS IN ENGINEERING, INDUSTRIAL AND ALLIED FIELDS, PUBLISHED FROM TIME TO TIME, IN CLASS 16 (U.S. CLS. 2, 5, 22, 23, 29, 37, 38 AND 50).

FIRST USE 3-15-1965; IN COMMERCE 3-15-1965.

OWNER OF U.S. REG. NOS. 993,094, 2,679,320 AND OTHERS.

THE MARK CONSISTS OF THE LETTERS "ASTM" IN CIRCULAR FORMAT.

SER. NO. 85-317,229, FILED 5-10-2011.

REBECCA GILBERT, EXAMINING ATTORNEY

David J. Kappos

Director of the United States Patent and Trademark Office

REQUIREMENTS TO MAINTAIN YOUR FEDERAL TRADEMARK REGISTRATION

WARNING: YOUR REGISTRATION WILL BE CANCELLED IF YOU DO NOT FILE THE DOCUMENTS BELOW DURING THE SPECIFIED TIME PERIODS.

Requirements in the First Ten Years*
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First Filing Deadline: You must file a Declaration of Use (or Excusable Nonuse) between the 5th and 6th years after the registration date. *See* 15 U.S.C. §§1058, 1141k. If the declaration is accepted, the registration will continue in force for the remainder of the ten-year period, calculated from the registration date, unless cancelled by an order of the Commissioner for Trademarks or a federal court.

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Requirements in Successive Ten-Year Periods*
What and When to File:

You must file a Declaration of Use (or Excusable Nonuse) **and** an Application for Renewal between every 9th and 10th-year period, calculated from the registration date.*

Grace Period Filings*

The above documents will be accepted as timely if filed within six months after the deadlines listed above with the payment of an additional fee.

The United States Patent and Trademark Office (USPTO) will NOT send you any future notice or reminder of these filing requirements.

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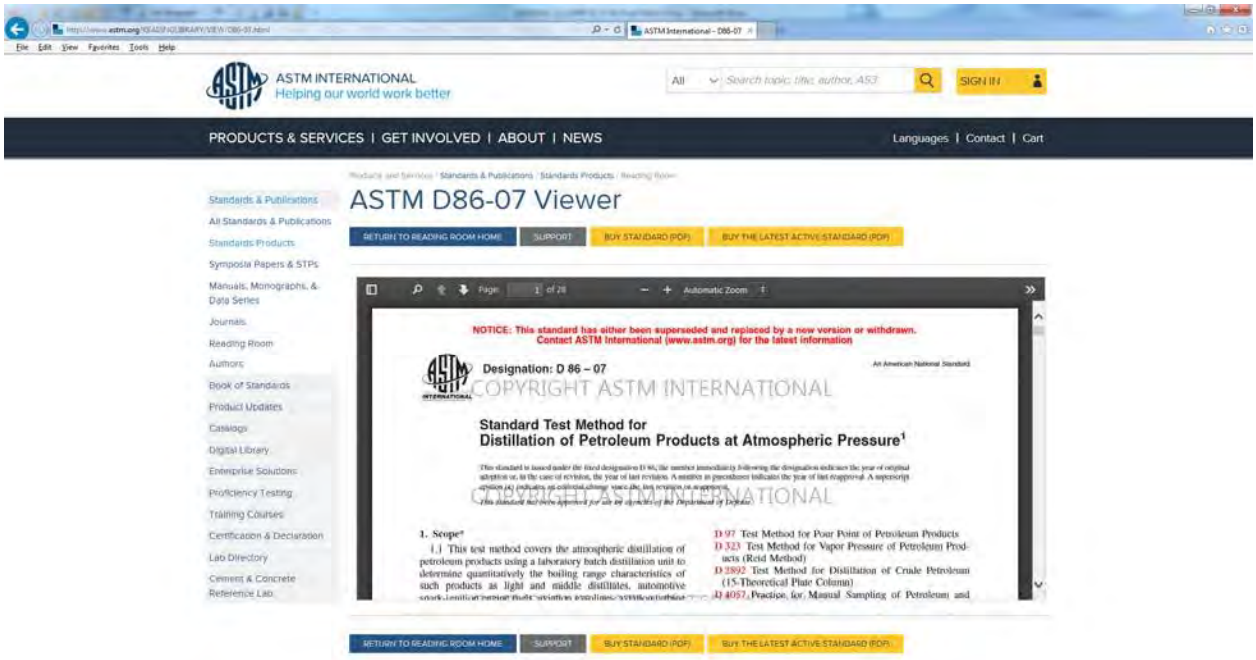
NOTE: Fees and requirements for maintaining registrations are subject to change. Please check the USPTO website for further information. With the exception of renewal applications for registered extensions of protection, you can file the registration maintenance documents referenced above online at http://www.uspto.gov.

EXHIBIT 17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Standard Test Method for
Distillation of Petroleum Products at Atmospheric Pressure[1]
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1. Scope*
D 97 Test Method for Pour Point of Petroleum Products
D 323 Test Method for Vapor Pressure of Petroleum Products (Reid Method)
D 2892 Test Method for Distillation of Crude Petroleum (15-Theoretical Plate Column)
D 4057 Practice for Manual Sampling of Petroleum and
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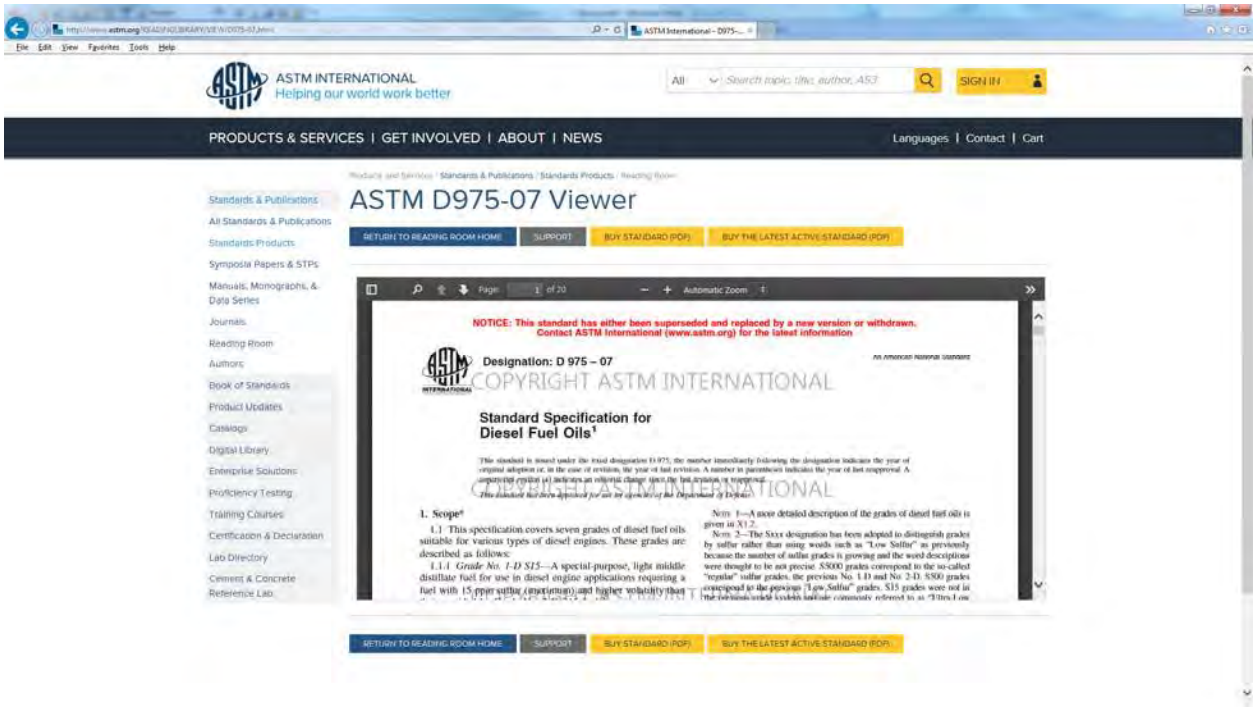
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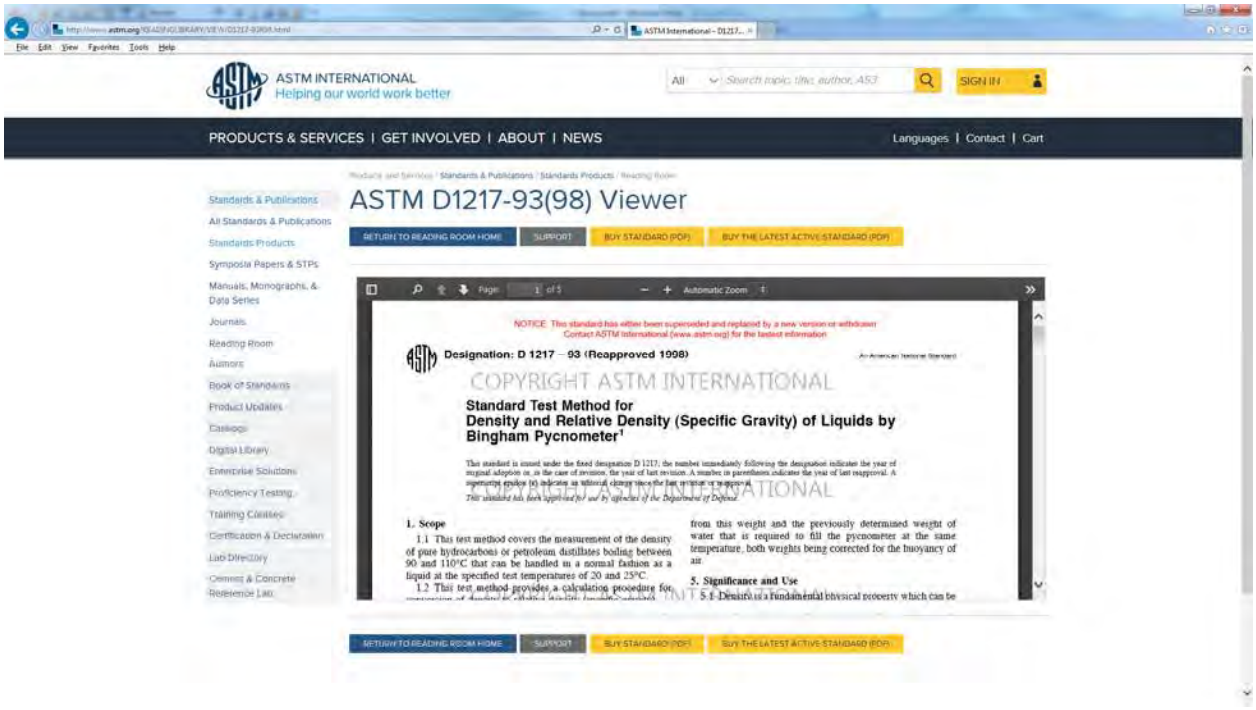
Standard Specification for
Diesel Fuel Oils1
1. Scope2
1.1 This specification covers seven grades of diesel fuel oils suitable for various types of diesel engines. These grades are described as follows:
1.1.1 Grade No. 1-D S15—A special-purpose, light middle distillate fuel for use in diesel engine applications requiring a fuel with 15 ppm sulfur (maximum) and higher volatility than
Note 1—A more detailed description of the grades of diesel fuel oils is given in X1.2.
Note 2—The SULFUR designation has been adopted to distinguish grades by sulfur rather than using words such as "Low Sulfur" as previously because the number of sulfur grades is growing and the word descriptions were thought to be not precise. S5000 grades correspond to the so-called "regular" sulfur grades, the previous No. 1-D and No. 2-D. S500 grades correspond to the previous "Low Sulfur" grades. S15 grades were not in the previous widely known and/or commonly referred to as "Ultra Low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Designation: D 1217 – 93 (Reapproved 1998)
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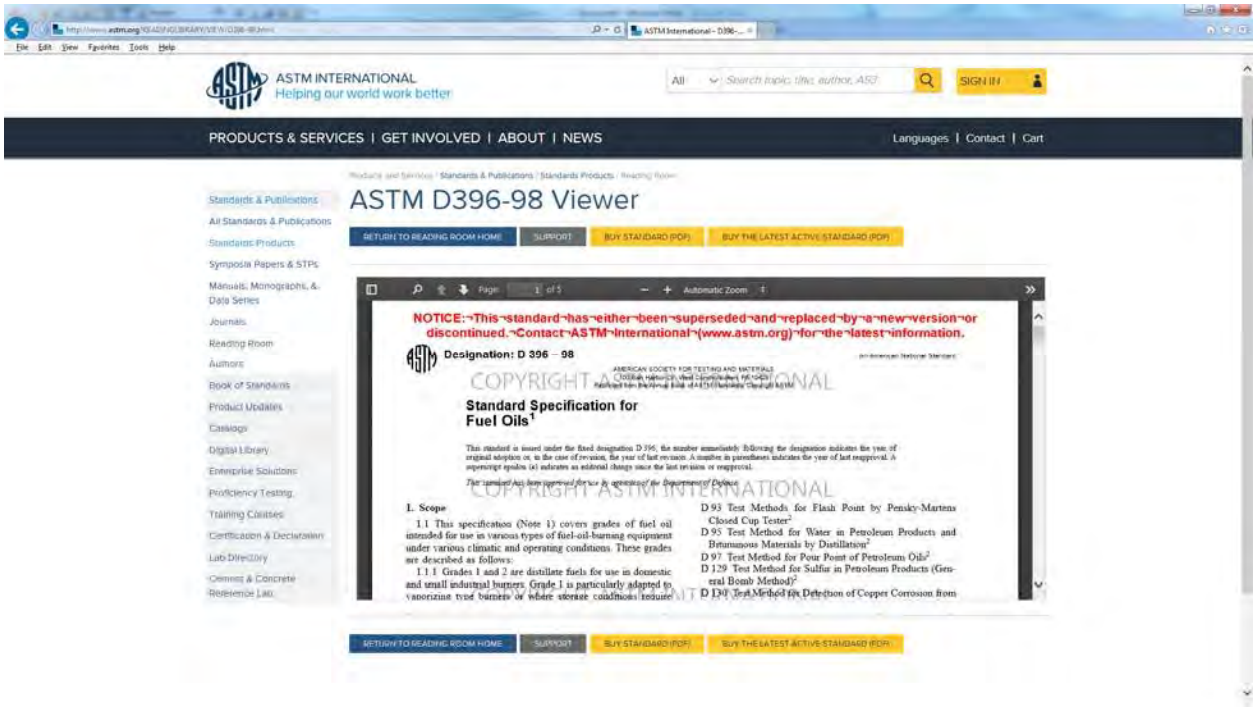
Standard Test Method for
Density and Relative Density (Specific Gravity) of Liquids by Bingham Pycnometer1
1. Scope
5. Significance and Use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Designation: D 396 – 98
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Standard Specification for
Fuel Oils
1. Scope
1.1 This specification (Note 1) covers grades of fuel oil intended for use in various types of fuel-oil-burning equipment under various climatic and operating conditions. These grades are described as follows:
D 93 Test Methods for Flash Point by Pensky-Martens Closed Cup Tester
D 95 Test Method for Water in Petroleum Products and Bituminous Materials by Distillation
D 97 Test Method for Pour Point of Petroleum Oils
D 129 Test Method for Sulfur in Petroleum Products (General Bomb Method)
D 130 Test Method for Detection of Copper Corrosion from

EXHIBIT 18

⇒ PREAMBLE—NOT PART OF THE SPECIFICATION ⇐

In order to promote public education and public safety, equal justice for all, a better informed citizenry, the rule of law, world trade and world peace, this legal document is hereby made available on a noncommercial basis, as it is the right of all humans to know and speak the laws that govern them.

The reader is advised:

- In this file, Public.Resource.Org has transformed this specification into the Hypertext Markup Language (HTML) for the purpose of informing citizens of their rights and obligations by making these provisions more accessible and more usable.
- This specification has been incorporated by reference into federal law by the Consumer Product Safety Commission as part of the Safety Standard for Infant Walkers (16 CFR 1216).
- Public.Resource.Org has made no changes to this specification. Any errors in the transformation of this specification should be reported to Public.Resource.Org.
- All hyperlinks to named standards are to versions that have been incorporated by reference into law and may not be the latest version.
- This file is based on the HTML 5, MathML, SVG, and CSS specifications and may not be compatible with some older browsers.
- Users may wish to modify this file. In particular, the header section calls the MathJax library and users may wish to use native MathML instead. There are also two calls to Google Fonts and one to our own external style sheet.
- Internal IDs have been assigned to each clause and section (e.g., s3.1), figure ("f1"), table ("t1"), and equation ("eq1").
- Public.Resource.org is not affiliated in any way with any of the organizations named herein.

⇒ END OF PREAMBLE—NOT PART OF THE SPECIFICATION ⇐

Designation: F977 – 12

Standard Consumer Safety Specification for Infant Walkers[1]

This standard is issued under the fixed designation F977; 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.

[1] This consumer safety specification is under the jurisdiction of ASTM Committee F15 on Consumer Products and is the direct responsibility of Subcommittee F15.17 on Carriages, Strollers, Walkers and Stationary Activity Centers.

Current edition approved May 1, 2012. Published May 2012. Originally approved in 1986. Last previous edition approved in 2011 as F977 – 11b. DOI: 10.1520/F0977-12.

Table of Contents

INTRODUCTION

This consumer safety specification addresses walker incidents that were identified by the U.S. Consumer Product Safety Commission (CPSC).

Based on data collected by the CPSC, the majority of incidents involved children falling down stairs or steps in walkers. Other incidents involved children tipping over in walkers or accessing hot surfaces or liquids. The injuries associated with these incidents ranged from cuts and bruises to burns, skull fractures, and deaths. Most of the children injured were under 15 months old.

In response to the incident data provided by the CPSC, this consumer safety specification attempts to minimize the risk of injury or death associated with children in walkers falling down stairs or between levels, or tipping over. It also contains provisions to address the risk of injury associated with walker seating systems and folding mechanisms.

1. Scope

1.1 This consumer safety specification covers performance requirements, test methods, and marking requirements to promote safe use of the infant walker (see 3.1).

1.2 This consumer safety specification is intended to minimize accidents to children resulting from normal use and reasonably foreseeable misuse or abuse of walkers.

1.3 No walker produced after the approval date of this consumer safety specification shall, either by label or other means, indicate compliance with this specification unless it conforms to all requirements contained herein.

1.4 This consumer safety specification is not intended to address accidents and injuries resulting from the interaction of other persons with the child in the walker or the accidents resulting from abuse and misuse by children able to walk.

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

1.6 The following precautionary caveat pertains only to the test method portion, Section 7, of this consumer safety specification: *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:[2]

- D3359 Test Methods for Measuring Adhesion by Tape Test
- F963 Consumer Safety Specification for Toy Safety

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

2.2 *Federal Regulations:*[3]

- 16 CFR 1303 Ban of Lead-Containing Paint and Certain Consumer Products Bearing Lead-Containing Paint
- 16 CFR 1500 Hazardous Substances Act Regulations Including Sections:
  - 1500.48 Technical Requirements for Determining a Sharp Point in Toys or Other Articles Intended for Use by Children Under Eight Years of Age
  - 1500.49 Technical Requirements for Determining a Sharp Metal or Glass Edge in Toys or Other Articles Intended for Use by Children Under Eight Years of Age
  - 1500.50-.52 Test Methods for Simulating Use and Abuse of Toys and Other Articles Intended for Use by Children
- 16 CFR 1501 Method for Identifying Toys and Other Articles Intended for Use by Children Under Three Years of Age Which Present Choking, Aspiration, or Ingestion Hazards Because of Small Parts

[3] Available from U.S. Government Printing Office, N. Capital and H Streets, NW, Washington, DC 20401.

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *conspicuous, adj*— a label that is visible, when the unit is in a manufacturer's recommended use position, to a person standing near the unit at any one position around the unit but not necessarily visible from all positions.

3.1.2 *dynamic load*, *n*— application of impulsive force through free fall of a weight.

3.1.3 *manufacturer's recommended use position*, *n*— any position that is presented as a normal, allowable, or acceptable configuration for the use of the product by the manufacturer in any descriptive or instructional literature. This specifically excludes positions that the manufacturer shows in a like manner in its literature to be unacceptable, unsafe, or not recommended.

3.1.4 *non-paper label*, *n*— any label material (such as plastic or metal) which either will not tear without the aid of tools or tears leaving a sharply defined edge.

3.1.5 *occupant*, *n*— that individual who is in a product that is set up in one of the manufacturer's recommended use positions.

3.1.6 *paper label*, *n*— any label material which tears without the aid of tools and leaves a fibrous edge.

3.1.7 *static load*, *n*— a vertically downward force applied by a calibrated force gauge or by dead weights.

3.1.8 *walker*, *n*— a mobile unit that enables a child to move on a horizontal surface when propelled by the child sitting or standing within the walker, and that is in the manufacturer's recommended use position. Examples of different style walkers can be seen in Fig. 1.

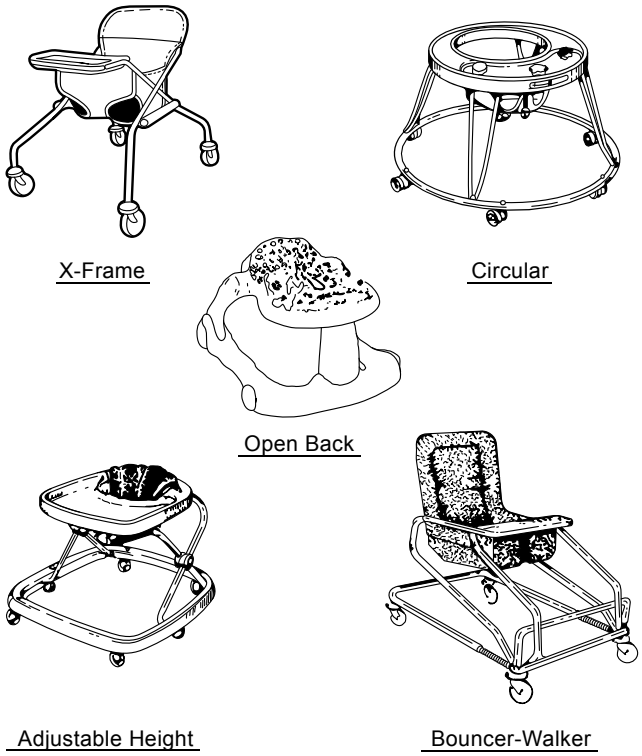


FIG. 1 Illustrations of Five Types of Baby Walkers

4. Calibration and Standardization

4.1 All testing shall be conducted on a concrete floor that may be covered with ⅛ in. (3 mm) thick vinyl floor cover, unless test instructs differently.

4.2 The walker shall be completely assembled, unless otherwise noted, in accordance with the manufacturer's instructions.

4.3 No testing shall be conducted within 48 h of manufacturing.

4.4 The product to be tested shall be in a room with ambient temperature of 73 ± 9°F (23 ± 5°C) for at least 1 h prior to testing. Testing then shall be conducted within this temperature range.

4.5 All testing required by this specification shall be conducted on the same unit.

4.6 The following guidelines shall apply to force gauges used for testing:

4.6.1 *Equipment*— Force gauge with a range of 0 to 25 lbf (111 N) and a tolerance of 60.25 lbf (1.1 N). A calibration interval shall be maintained for the force gauge which will ensure that the accuracy does not drift beyond the stated tolerance.

4.6.2 *Equipment*— Force gauge with a range 0 to 100 lbf (445 N) and a tolerance of 61 lbf (4.4 N). A calibration interval shall be maintained for the force gauge which will ensure that the accuracy does not drift beyond the stated tolerance.

5. General Requirements

5.1 The walker shall conform to the regulations specified in Section 2 of this specification before and after all testing.

5.2 Prior to testing, any exposed wood parts shall be smooth and free from splinters.

5.3 *Latching or Locking Mechanisms*— Any unit that folds shall have a latching or locking device or other provision in the design that will prevent the unit from unintentionally folding when properly placed in the manufacturer's recommended use position. The unit shall remain in its manufacturer's recommended use position during and upon completion of the test, in accordance with 7.2. If a unit is designed with a latching or locking device, that device shall remain engaged and operative after testing.

5.4 *Openings*— Holes or slots that extend entirely through a wall section of any rigid material less than 0.375 in. (9.53 mm) thick and admit a 0.210 in. (5.33 mm) diameter rod shall also admit a 0.375 in. (9.53 mm) diameter rod. Holes or slots that are between 0.210 in. (5.33 mm) and 0.375 in. (9.53 mm) and have a wall thickness less than 0.375 in. (9.53 mm), but are limited in depth to 0.375 in. (9.53 mm) maximum by another rigid surface shall be permissible (see Fig. 2). The product shall be evaluated in all manufacturer's recommended use positions.

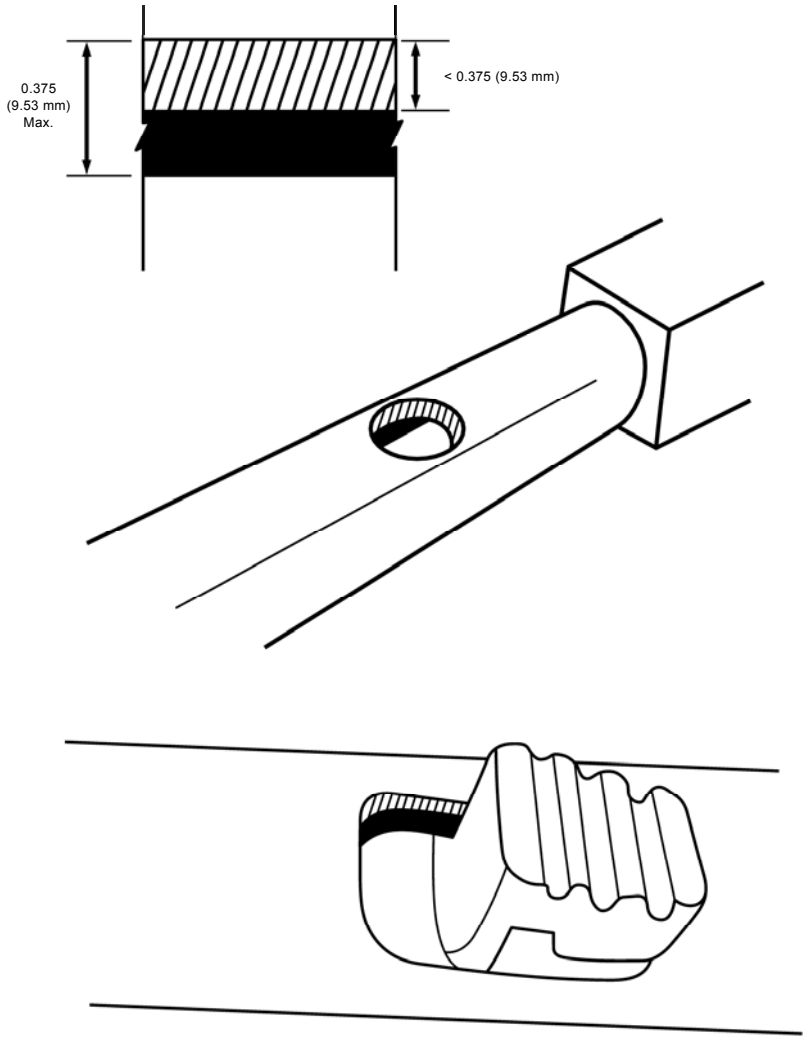


FIG. 2 Opening Examples

5.5 *Scissoring, Shearing, Pinching*— A product, when in a manufacturer's recommended use position, shall be designed and constructed so as to prevent injury to the occupant from any scissoring, shearing, or pinching when members or components rotate about a common axis or fastening point, slide, pivot, fold or otherwise move relative to one another. Scissoring, shearing, or pinching that may cause injury shall not be

permissible when the edges of any rigid parts admit a probe greater than 0.210 in. (5.33 mm) and less than 0.375 in. (9.53 mm) diameter at any accessible point throughout the range of motion of such parts.

5.6 *Exposed Coil Springs*— Any exposed coil spring which is accessible to the occupant, having or capable of generating a space between coils of 0.210 in. (5.33 mm) or greater during static load testing in accordance with 7.1.2 shall be covered or otherwise designed to prevent injury from entrapment.

5.7 Labeling

5.7.1 Warning labels, whether paper or non-paper, shall be permanent when tested per 7.4.1-7.4.3.

5.7.2 Warning statements applied directly onto the surface of the product by hot stamping, heat transfer, printing, wood burning, etc. shall be permanent when tested per 7.4.4.

5.7.3 Non-paper labels shall not liberate small parts when tested in accordance with 7.4.5.

5.8 *Protective Components*— If a child can grasp components between the thumb and forefinger, or teeth (such as caps, sleeves, or plugs used for protection from sharp edges, points, or entrapment of fingers or toes), or if there is at least 0.040 in. (1.00 mm) gap between the component and its adjacent parent component, such component shall not be removed when tested in accordance with 7.5.

5.9 *Toys*— Toy accessories attached to, removable from, or sold with an infant walker, as well as their means of attachment, must meet applicable requirements of Consumer Safety Specification F963.

6. Performance Requirements

NOTE 1 — The forces that are to be applied to the sample in the tests described in Section 7 of this specification are readily applied by means of a calibrated force gauge, or in the case of static load and dynamic load tests, by fixed masses.

6.1 Stability

6.1.1 *Tipping Resistance Against an Immovable Object*— A minimum stability index of 18 shall be required to tip over a walker either forwards or backwards when tested in accordance with 7.3.

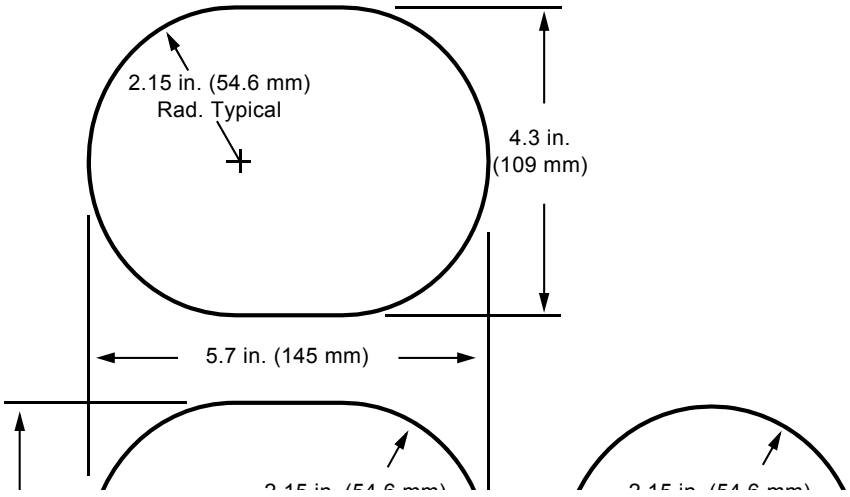
6.1.2 *Occupant Leaning Over Edge*— A walker shall remain upright (not tip over) when forces are applied forward, and sideward, in accordance with 7.3.4.

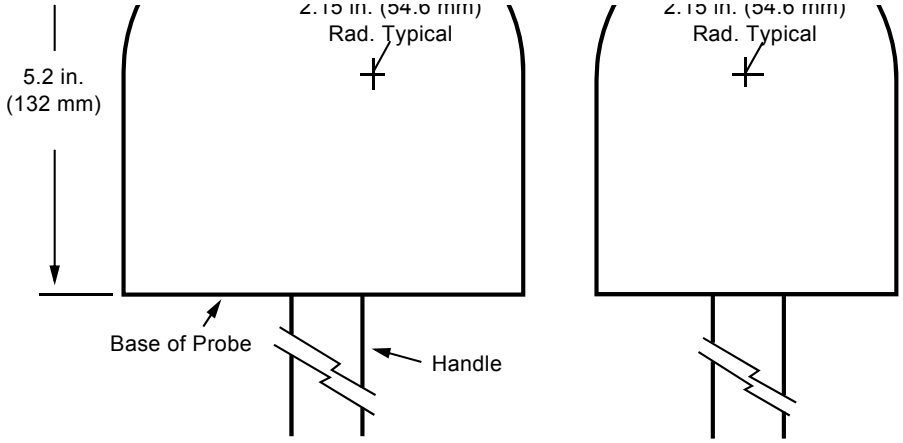
6.2 *Structural Integrity*— All tests that cover static and dynamic loading, and support of the occupant, are to be performed on the same product, sequentially and without refurbishing or repositioning of adjustment, if any. At test conclusion, there shall be no failure of seams, breakage of materials, or changes in adjustments that could cause the unit not to fully support the child or create a hazardous condition as defined in Section 5. Maximum slippage of adjustable features, if any, is 1 in. (25 mm).

6.2.1 *Dynamic Load*— The occupant support member (seat) shall support a dynamic load when tested in accordance with 7.1.1.

6.2.2 *Static Load*— The walker shall not create a hazardous condition as defined in 5.4 when tested in accordance with 7.1.2.

6.2.3 *Leg Openings*— The seat of the walker shall be designed so that the leg openings will not permit passage of the test probe (see Fig. 3) when tested in accordance with 7.1.3.





NOTE — Dimensions are based on a 5th percentile 6-month-old child. Gauge may be modified to facilitate testing to allow for pulling of the gauge.

FIG. 3 Small Head Test Probe

6.3 *Prevention of Falls Down Step(s)*— The walker shall maintain contact with and be supported only by the test platform at the conclusion of the tests in 7.6.

6.4 *Parking Device (applicable to walkers equipped with parking brakes)*— The walker shall have a maximum displacement of 1.97 in. (50 mm) for each test in each direction (forward, rearward, and sideward) when tested in accordance with 7.7.

7. Test Methods

NOTE 2 — Except for the structural integrity tests (see 7.1), that shall be performed first, the tests can be performed in any sequence.

7.1 Structural Integrity (see 6.2)

NOTE 3 — All wood blocks are fabricated from 1 in. nominal thickness lumber having a finish thickness of ¾ in. (19 mm) unless otherwise stated.

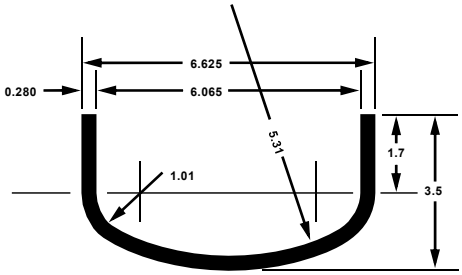
7.1.1 *Dynamic Load (see 6.2.1)*:

7.1.1.1 Position the walker in the manufacturer's recommended use position with all wheels on the floor. If adjustable, adjust to the highest and most upright position.

7.1.1.2 Affix to the walker seat a 6 by 6 in. (150 by 150 mm) wood block. If the unit has a hammock type seat, use a standard 6 in. weld cap, as identified in Fig. 4. Attach the weld cap to the bottom of the test weight with the convex surface down.

7.1.1.3 Drop a test weight of 33 lb (15.0 kg), with the weight of the weld cap included, onto the seat at least a distance of 1 in. (25 mm) 100 times at a rate of 4 ± 1 s per cycle.

7.1.1.4 When testing a spring supported adjustable bouncer walker, test with the unit in the highest adjustment position and support the frame so that the dropping of the 33 lb (15.0 kg) weight does not cause the frame to bottom out artificially.



NOTE — Caps furnished to ANSI standards unless otherwise specified. Welding caps are formed from steel plate and are ellipsoidal in shape. The minor axis being equal to one half the major axis radii "R" and "r" closely approximate the actual semi-ellipsoidal shape. All dimensions in inches and are in accordance with ANSI B16.9.

FIG. 4 Nominal 6 in. Weld Cap Weight (Approximately) 6.4 lb

7.1.2 *Static Load (see 6.2.2)*:

7.1.2.1 Position the walker as in 7.1.1.1.

7.1.2.2 Center a weight of 90 lb (40.8 kg) for a period of 1 min on a 6 by 6 in. (150 by 150 mm) wood block affixed to the walker seat. If the unit has a hammock type seat, use a standard 6 in. (150 mm) weld cap, convex surface down, as identified in Fig. 4 instead of the specified wood block. Include the weight of the weld cap in the 90 lb (40.8 kg) weight. If the natural action of a bouncer type walker will not allow the full application of 90 lb (40.8 kg) static load, then restrict the bouncer mechanism by any means possible so that the full static load can be applied to the seat or section of the walker occupied by the child.

7.1.2.3 Position the walker in the manufacturer's recommended use position with all wheels on the floor. If adjustable, adjust to the lowest use position.

7.1.2.4 Center a weight of 50 lb (22.7 kg) for a period of 1 minute on a 6 by 6 in. (150 by 150 mm) wood block affixed to the walker seat. If the unit has a hammock type seat, use a standard 6 in. (150 mm) weld cap convex surface face down, as identified in Fig. 4 instead of the specified wood block. Include the weight of the weld cap in the 50 lb (22.7 kg) weight. In this test DO NOT restrict the bouncer mechanism from folding or bottoming out. Observe visually the action of all supporting, locking, and adjusting components to make sure that they do not create a hazardous condition as defined in 5.4.

7.1.3 *Leg Openings Test (see 6.2.3)*:

7.1.3.1 If the seat is adjustable, adjust the seat to obtain the largest leg opening.

7.1.3.2 Rotate the test probe shown in Fig. 3 to the orientation most likely to fail and gradually apply a force of 25 lbf (111 N). Apply the force perpendicular to the base of the probe within a period of 5 s and maintain it for an additional 10 s.

7.2 Latching or Locking Mechanisms (see 5.3)

7.2.1 Erect the walker in accordance with the manufacturer's instructions and adjust to the highest and most upright recommended use position.

7.2.2 Position the walker so that the normal folding motion is not impeded.

7.2.3 Apply a force of 10 lbf (44 N) in the direction normally associated with folding the walker in accordance with manufacturer's instructions. Apply the force gradually over a 5-s period and maintain for an additional 10 s before releasing the force.

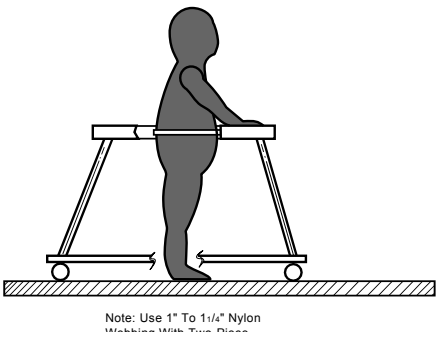
7.2.4 Perform this procedure for a total of five times within a 2 min period.

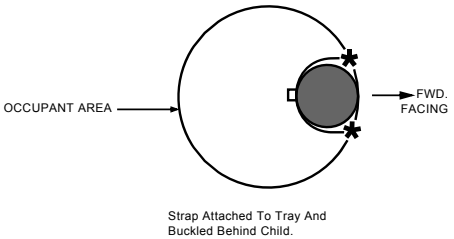
7.3 Stability Test (see 6.1)

7.3.1 *Tipping Resistance Against An Immovable Object (see 6.1.1)*— Establish a horizontal test plane with a piece of ½ in. (13 mm) high by ¾ in. (19 mm) wide aluminum angle stop affixed thereto. Its length shall be a minimum of 6 in. (150 mm) wider than the width of the walker being tested.

7.3.2 *Forward Tip Resistance*:

7.3.2.1 Place the walker on the horizontal test plane and adjust it to the manufacturers highest recommended use position. If the walker has a reclinable seat, place it in its most upright position. Place a six month old CAMI Infant Dummy Mark II4 in the walker and affix it in a position so that its feet just touch the test plane and its abdomen is positioned firmly against the forward edge of the occupant area (see Fig. 5). If the Dummy's feet do not touch the test plane when the walker is in its highest use position, lower the walker until the Dummy's feet just touch the test plane.





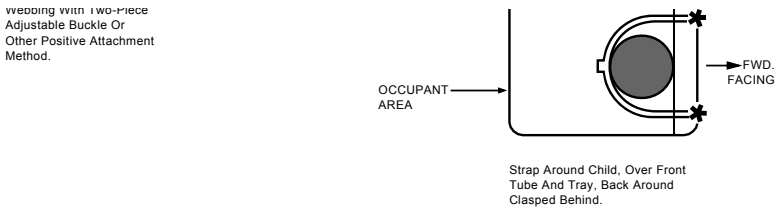


FIG. 5 Placement of CAMI Infant Dummy

7.3.2.2 Position the walker so that its two most forward wheels are touching and perpendicular to the aluminum stop. For walkers that have offset wheels, place the wheels in the most disadvantageous position.

7.3.2.3 Pretension by gradually applying 3 lbf (13 N) forward horizontal force at a level just below the CAMI Dummy's4 armpits in a direction perpendicular to the axis connecting the two most forward wheels and centered halfway between the wheels (see Fig. 6). Then increase the horizontal force until the walker tips over forward.

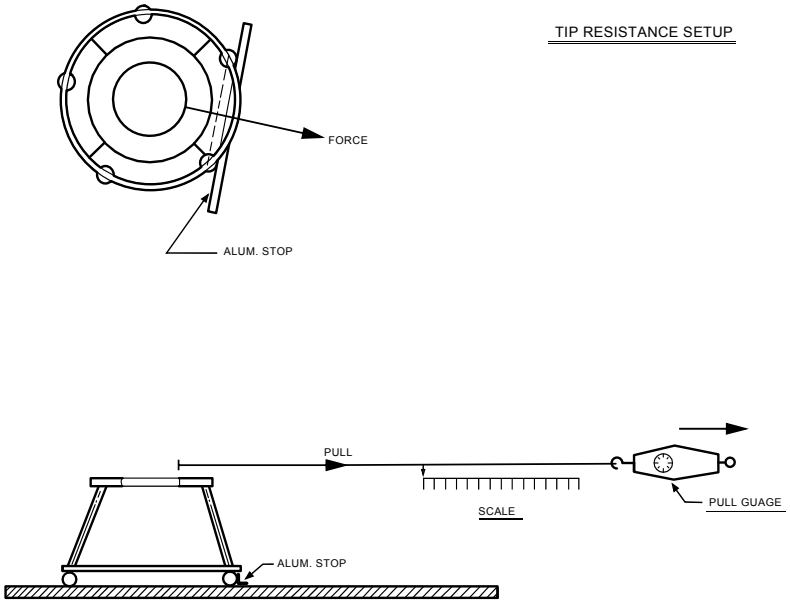


FIG. 6 Tip Resistance Setup

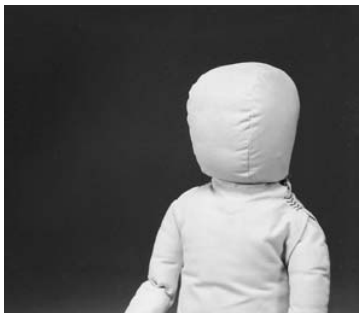
7.3.2.4 If during the application of the force the front edge of the walker contacts the test plane and the wheels contacting the aluminum stop begin to lift upward, release the force allowing the walker to rest upon the test plane, remove the stop from the wheels and position a suitable stop against the front edge of the walker. Then reapply the force as specified in 7.3.2.3 until the walker tips over forward.

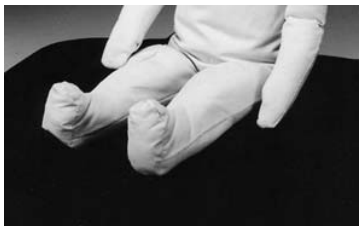
7.3.2.5 Record the distance pulled in inches after pretensioning and the maximum force exerted in pounds (including pre-tensioning). The sum of the distance pulled and maximum force exerted shall be considered the stability index.

7.3.3 *Rear Tip Resistance:*

7.3.3.1 Without adjusting the seat height or the height of the CAMI Dummy4 relative to the horizontal test plane, position the Dummy so that its back is firmly against the rear of the occupant area.

[4] CAMI Infant Dummy (Mark II), Department of Transportation, Memorandum Report AAC-119-74-14, Revision II, Drawing No. SA-1101 (see Fig. 7).





NOTE — This CAMI Infant Dummy was constructed in accordance with the Department of Transportation Specification dated April 29, 1975.

FIG. 7 CAMI Infant Dummy—Mark II

7.3.3.2 Position the walker so that its two most rearward wheels are touching and perpendicular to the aluminum stop. For walkers that have offset wheels, place wheels in the most disadvantageous position.

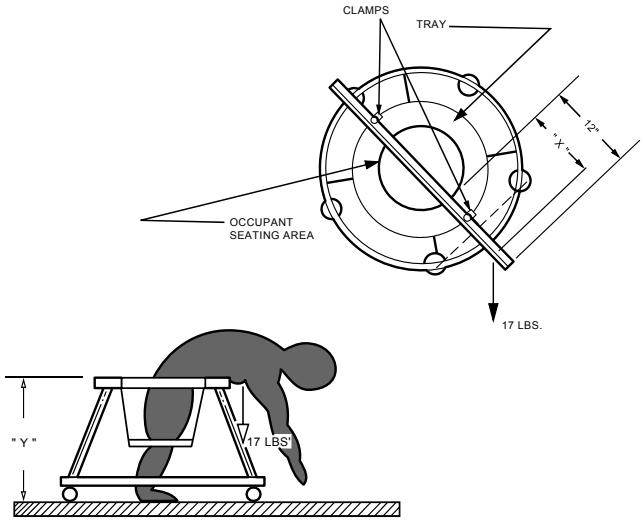
7.3.3.3 Pretension by gradually applying a 3 lbf (13 N) horizontal force in a rearward direction perpendicular to the axis connecting the two most rear wheels and centered between the wheels. Apply the force at a level just below the CAMI Dummy's4 armpits. Then increase the force until the walker tips over. If the walker has a seat pad whose back is higher than the Dummy's armpits, apply the horizontal force at the same height as that of the Dummy's armpits.

7.3.3.4 Record the distance pulled in inches after pretensioning and the maximum force exerted in pounds including pre-tensioning. The sum of the distance pulled and the maximum force exerted shall be considered the stability index.

7.3.4 *Occupant Leaning Outward Over Edge of Walker (see 6.1.2):*

7.3.4.1 Position walker in the manufacturer's recommended use position with all wheels on the floor (flat horizontal plane). For walkers that have offset wheels, place wheels in the most disadvantageous position. If the walker is adjustable, adjust to its highest use position.

7.3.4.2 Clamp a 1 by 1 in. (25 by 25 mm) rigid aluminum angle to the uppermost front and rear horizontal frame members of the walker in a direction perpendicular to the axis of the two most forward wheels and centered between the wheels. The length of the aluminum angle should be such that it extends forward at least 12 in. (300 mm) beyond the front edge of the occupant seating area (see Fig. 8).



NOTE — *X* inches depends on height of walker, *Y* = height of walker tray or uppermost frame member.

FIG. 8 Leaning Over Setup

7.3.4.3 Locate the point on the aluminum angle that is 1 in. (25 mm) less than one half the difference between 32 in. (810 mm), and the height of the walker at the top edge of the tray adjacent to the seating area (see Fig. 8). Over a period of 5 s, gradually apply a vertically downward force of 17 lb to this point and maintain it for an additional 10 s.

NOTE 4 — 32 in. is the maximum height of the user.

7.3.4.4 Repeat the steps in 7.3.4.1, 7.3.4.2, and 7.3.4.3, except position the aluminum angle in a sideward direction perpendicular to the axis connecting the two most sideward wheels and centered halfway between the wheels. Be sure the aluminum angle extends at least 12 in. (300 mm) beyond the inside edge of the tray or horizontal frame member. Placement of the 17 lb (7.7 kg) weight to the side shall not cause the walker to tip over.

7.4 Permanency of Labels and Warnings (see 5.7)

7.4.1 A paper label (excluding labels attached by a seam) shall be considered permanent if, during an attempt to remove it without the aid of tools or solvents, it cannot be removed, it tears into pieces upon removal, or such action damages the surface to which it is attached.

7.4.2 A non-paper label (excluding labels attached by a seam) shall be considered permanent if, during an attempt to remove it without the aid of tools or solvents, it cannot be removed or such action damages the surface to which it is attached.

7.4.3 A warning label attached by a seam shall be considered permanent if it does not detach when subjected to a 15 lb pull force applied in any direction most likely to cause failure using a ¾ in. diameter clamp surface. Apply the force evenly over 5 s and maintain for an additional 10 s.

7.4.4 *Adhesion Test for Warnings Applied Directly onto the Surface of the Product:*

7.4.4.1 Apply the tape test defined in Test Method B-Cross-Cut Tape Test of Test Methods D3359 eliminating parallel cuts.

7.4.4.2 Perform this test once in each different location where warnings are applied.

7.4.4.3 The warning statements will be considered permanent if the printing in the area tested is still legible and attached after being subjected to this test.

7.4.5 A non-paper label, during an attempt to remove it without the aid of tools or solvents, shall not be removed or shall not fit entirely within the small parts cylinder defined in 16 CFR 1501 if it can be removed.

7.5 Removal of Components (see 5.8)

7.5.1 Test components in accordance with each of the following methods in the sequence listed.

7.5.2 Secure the walker so that it cannot move during the performance of the following tests.

7.5.3 *Torque Test*— A torque of 3 lbf·in. (0.3 N·m) shall be applied evenly within a period of 5 s in a clockwise direction until a rotation of 180° from the original position has been attained or 3 lbf·in. (0.3 N·m) has been exceeded. The torque or maximum rotation shall be maintained for an additional 10 s. The torque shall then be removed and the test components permitted to return to a relaxed condition. This procedure shall then be repeated in a counter-clockwise direction.

7.5.4 *Tension Test*:

7.5.4.1 Attach a force gauge to the cap, sleeve or plug by means of any suitable device. For components that cannot reasonably be expected to be grasped between thumb and forefinger, or teeth, on their outer diameter but have a gap of at least 0.040 in. (1.00 mm) between the rear surface of the component and the structural member of the walker to which they are attached, a clamp such as the one shown in Fig. 9 may be a suitable device.

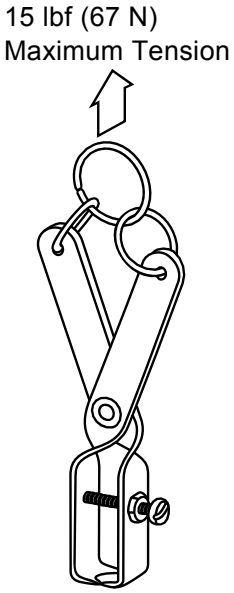


FIG. 9 Tension Test Adaptor/Clamp

7.5.4.2 Be sure that the attachment device does not compress or expand the component so that it hinders any possible removal.

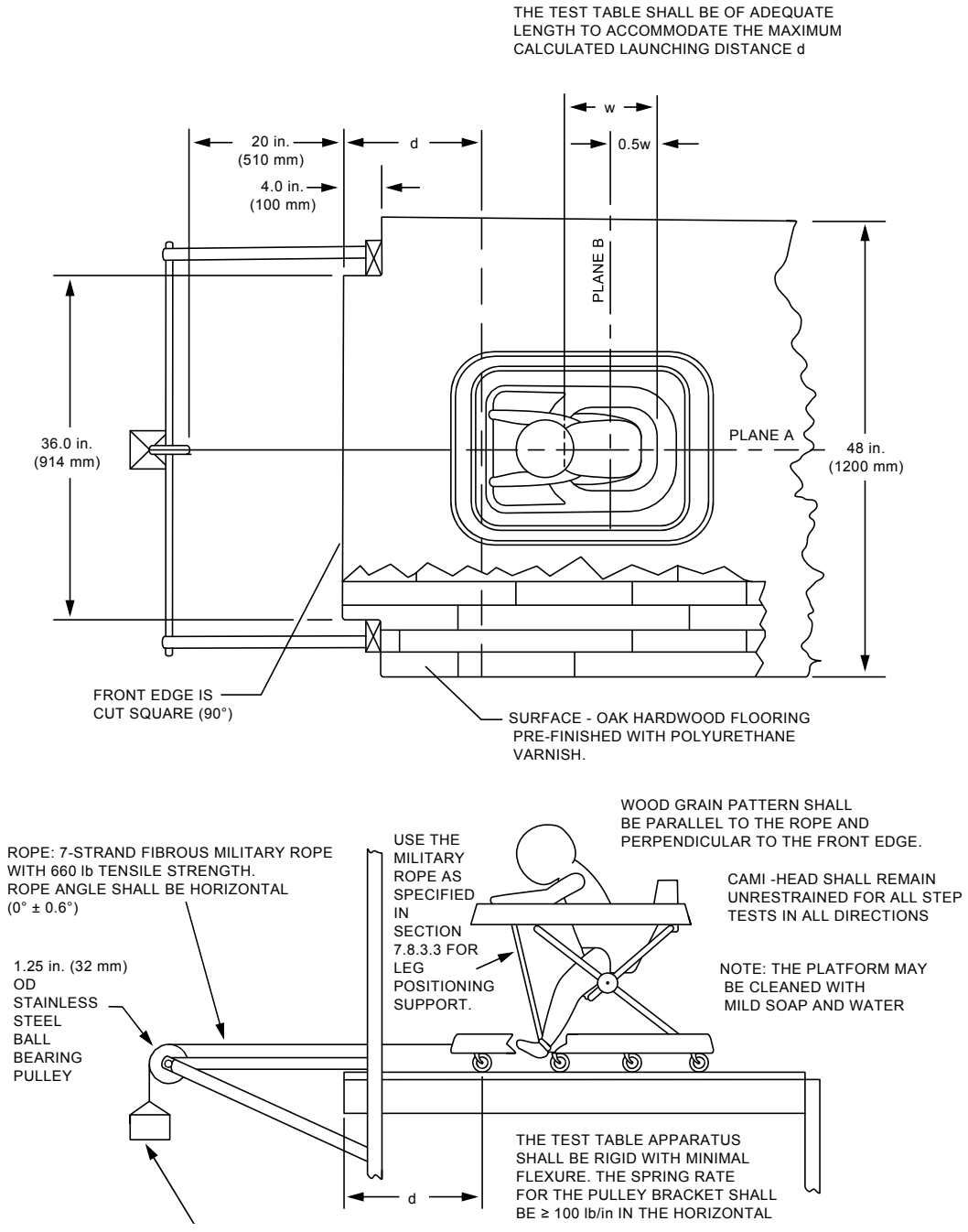
7.5.4.3 Gradually apply a 15 lbf (67 N) force in the direction that would normally be associated with the removal of the component over a 5 s period and hold for an additional 10 s.

7.6 Step(s) Tests (see 6.3) (Refer to Table 1 and Fig. 10)

7.6.1 *Walker and Dummy Positioning for Step Tests:*

7.6.1.1 Adjust the walker seat and tray to the manufacturer's highest recommended use position. If the walker has any consumer controllable features (that is, manual brakes, toy bars, etc.), place them in the configuration deemed most likely to cause failure of this test.

7.6.1.2 The dummy may be secured to the tray to maintain contact during the test. Raise the dummy's legs just enough so its feet do not touch the platform during the performance of the test and position using the rope specified in Fig. 10. The dummy's head shall remain unrestrained for all the step tests.



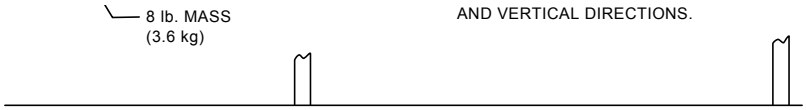


FIG. 10 Test Platform

7.6.2 Establish a vertical Plane A that passes through the center of the seating area and is parallel to the direction the child faces. Establish a vertical Plane B that is perpendicular to Plane A and passes through the center of the seating area.

7.6.3 *Forward Facing Step Test*:

7.6.3.1 Center the walker on the test platform facing forward so that Plane A is perpendicular to the front edge of the platform and the walker is distance *d* from the center of the most forward wheel(s) to the edge of the test platform.

$$d_{\mathrm{CAMI}} = \frac{(V_f^2 - V_o^2) * (W_{\mathrm{CAMI}} + W_{\mathrm{walker}} + W_{\mathrm{drop\ weight}})}{2g(W_{\mathrm{drop\ weight}} - \mu_k N_{\mathrm{CAMI}})} \quad (1)$$

TABLE 1 Summary of Step(s) Tests

Section Number	Facing Direction of Walker	Weight of CAMI Dummy, lb	Simulated Speed, ft/s	Apply Tipover Test
7.6.3	forward	17	4	yes
7.6.3.7	forward	28 (vest)	4	yes
7.6.4	sideward	17	2	yes
7.6.4.7	sideward	28 (vest)	2	yes
7.6.5	rearward	17	4	no
7.6.5.6	rearward	28 (vest)	4	no

where:

V_f = maximum velocity of walker at edge of platform (4 ft/s)

V_O = initial velocity (0)

W_{CAMI} = measured weight of CAMI dummy

W_{walker} = weight of walker

$W_{drop\ weight}$ = drop weight (8 lb)

μ_k = dynamic coefficient of friction (0.05)

N_{CAMI} = normal force (for CAMI dummy scenario) (weight of CAMI dummy + walker)

g = acceleration of gravity (32.2 ft/s²)

Position the swivel wheels in such a way that the walker moves forward in a straight line parallel to Plane A.

7.6.3.2 Place a CAMI Infant Dummy Mark II in the walker and position it as shown in Fig. 11 with the torso contacting the front of the occupant seating area and arms placed on the walker tray.

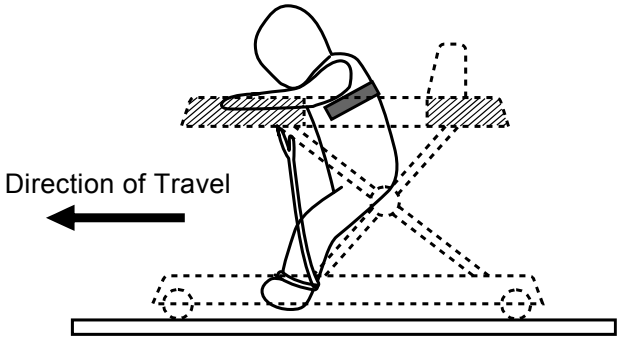


FIG. 11 Dummy Position for Forward Facing Test

7.6.3.3 While holding the walker stationary, attach an 8-lb (3.6-kg) weight to the front of the walker base at Plane A by means of a 7-strand military rope with a 550 lb tensile strength (for example, paracord 550) and a stainless steel ball bearing pulley with an outside diameter of 1.25 in. (32 mm) and adjust the pulley so that the force is applied horizontally (0 ± 0.5° with respect to the table surface).

7.6.3.4 Release the walker. When the walker comes to rest the 8 lb (3.6 kg) weight must still be applied to the walker.

7.6.3.5 If any part of the walker extends over the edge of the test platform, perform the following tipover test. Without repositioning the walker, remove the CAMI dummy and the 8 lb (3.6 kg) weight. Perform the tipover test as specified in 7.3.4.2 and 7.3.4.3 except that the aluminum angle should be positioned in Plane A.

7.6.3.6 Repeat 7.6.3.3-7.6.3.5 two additional times.

7.6.3.7 Repeat 7.6.3.1-7.6.3.6 using the CAMI dummy with the weighted vest (see Fig. 12) and with distance computed using the following equation:

$$d_{\text{CAMI w/vest}} = \frac{(V_f^2 - V_o^2) * (W_{\text{CAMI w/vest}} + W_{\text{walker}} + W_{\text{drop weight}})}{2g(W_{\text{drop weight}} - \mu_k N_{\text{CAMI w/vest}})} \quad (2)$$

where:

V_f = maximum velocity of walker at edge of platform (4 ft/s)

V_o = initial velocity (0)

$W_{CAMI\ w/vest}$ = measured weight of CAMI dummy and weighted vest

W_{walker} = weight of walker

$W_{drop\ weight}$ = drop weight (8 lb)

μ_k = dynamic coefficient of friction (0.05)

$N_{CAMI\ w/vest}$ = normal force (for CAMI dummy fitted with 11 lb vest scenario) (weight of CAMI dummy + vest + walker)

g = acceleration of gravity (32.2 ft/s²)

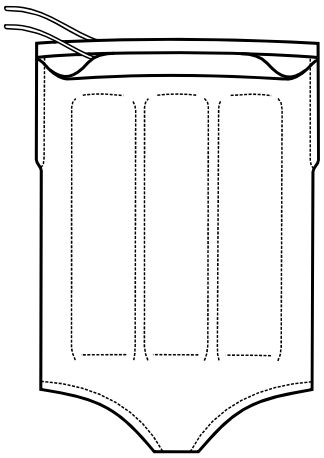


FIG. 12 Weighted Vest

7.6.4 ***Sideward Facing Step Test***:

7.6.4.1 Center the walker on the test platform facing sideways so that Plane B is perpendicular to the front edge of the platform and the walker is distance *d* from the center of the most sideward wheel(s) to the edge of the test platform.

$$d_{\text{CAMI}} = \frac{(V_f^2 - V_o^2) * (W_{\text{CAMI}} + W_{\text{walker}} + W_{\text{drop weight}})}{2g(W_{\text{drop weight}} - \mu_k N_{\text{CAMI}})} \quad (3)$$

where:

V_f = maximum velocity of walker at edge of platform (2 ft/s)

V_O = initial velocity (0)

W_{CAMI} = measured weight of CAMI dummy

W_{walker} = weight of walker

$W_{drop\ weight}$ = drop weight (8 lb)

μ_k = dynamic coefficient of friction (0.05)

N_{CAMI} = normal force (for CAMI dummy scenario) (weight of CAMI dummy + walker)

g = acceleration of gravity (32.2 ft/s²)

Position the swivel wheels in such a way that the walker moves sideward in a straight line parallel to Plane B.

7.6.4.2 Place a CAMI Infant Dummy Mark II in the walker and position it as shown in Fig. 13 with the torso contacting the side of the occupant seating area.

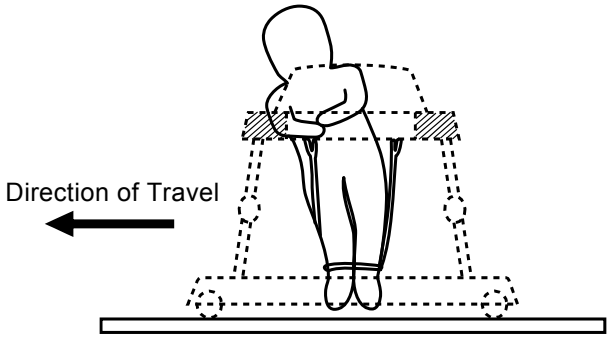


FIG. 13 Dummy Position for Sideward Test

7.6.4.3 While holding the walker stationary, attach an 8 lb (3.6 kg) weight to the side of the walker base at Plane B by means of a rope (as specified in 7.6.3.3) and a pulley (as specified in 7.6.3.3) and adjust the pulley so that the force is applied horizontally (0 ± 0.5° with respect to the table surface).

7.6.4.4 Release the walker. When the walker comes to rest the 8 lb (3.6 kg) weight still must be applied to the walker.

7.6.4.5 If any part of the walker extends over the edge of the test platform, perform the following tipover test. Without repositioning the walker, remove the CAMI dummy and the 8 lb (3.6 kg) weight. Perform the tipover test as specified in 7.3.4.2 and 7.3.4.3 except that the aluminum angle should be positioned in Plane B.

7.6.4.6 Repeat 7.6.4.3-7.6.4.5 two additional times.

7.6.4.7 Repeat 7.6.4.1-7.6.4.6 using the CAMI dummy with the weighted vest (see Fig. 12) and with distance computed using the following equation:

$$d_{\text{CAMI w/vest}} = \frac{(V_f^2 - V_o^2) * (W_{\text{CAMI w/vest}} + W_{\text{walker}} + W_{\text{drop weight}})}{2g(W_{\text{drop weight}} - \mu_k N_{\text{CAMI w/vest}})} \quad (4)$$

where:

V_f = maximum velocity of walker at edge of platform (2 ft/s)

V_O = initial velocity (0)

$W_{CAMI\ w/vest}$ = measured weight of CAMI dummy and weighted vest

W_{walker} = weight of walker

$W_{drop\ weight}$ = drop weight (8 lb)

μ_k = dynamic coefficient of friction (0.05)

$N_{CAMI\ w/vest}$ = normal force (for CAMI dummy fitted with 11 lb vest scenario) (weight of CAMI dummy + vest + walker)

g = acceleration of gravity (32.2 ft/s²)

7.6.5 *Rearward Facing Step Test*:

7.6.5.1 Center the walker on the test platform facing rearward so that Plane A is perpendicular to the front edge of the platform and the walker is distance d from the center of the most rearward wheel(s) to the edge of the test platform.

$$d_{\mathrm{CAMI}} = \frac{(V_f^2 - V_o^2) * (W_{\mathrm{CAMI}} + W_{\mathrm{walker}} + W_{\mathrm{drop\ weight}})}{2g(W_{\mathrm{drop\ weight}} - \mu_k N_{\mathrm{CAMI}})} \quad (5)$$

where:

V_f = maximum velocity of walker at edge of platform (4 ft/s)

V_o = initial velocity (0)

W_{CAMI} = measured weight of CAMI dummy

W_{walker} = weight of walker

$W_{drop\ weight}$ = drop weight (8 lb)

μ_k = dynamic coefficient of friction (0.05)

N_{CAMI} = normal force (for CAMI dummy scenario) (weight of CAMI dummy + walker)

g = acceleration of gravity (32.2 ft/s²)

Position the swivel wheels in such a way that the walker moves rearward in a straight line parallel to Plane A. If the walker has an open back base design, attach the ends of a lightweight bar to the back of the walker near the wheels using loops of cord to allow the bar to float. The distance between the attachment points on the bar and those on the walker must be equal to prevent pulling the wheels inward or outward during the test. The cord from the 8-lb (3.6-kg) weight is then attached to the bar halfway between the attachment points (see Fig. 14).

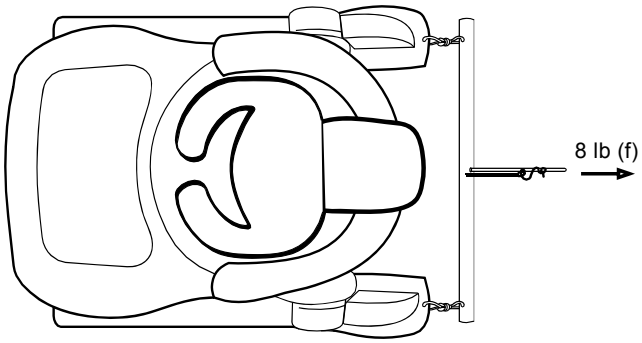


FIG. 14 Open Back Base

7.6.5.2 Place a CAMI Infant Dummy Mark II in the walker and position it as shown in Fig. 15 with the torso contacting the back of the occupant seating area.

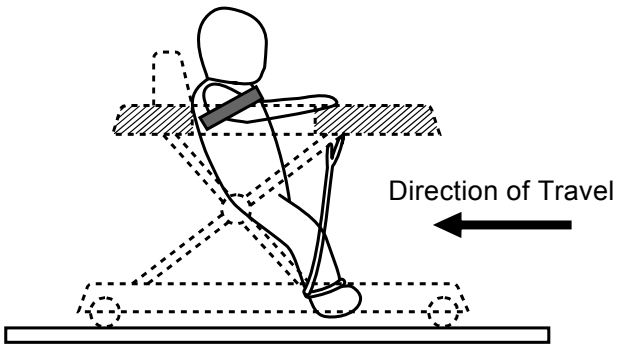


FIG. 15 Dummy Position for Rear Facing Test

7.6.5.3 While holding the walker stationary, attach an 8 lb (3.6 kg) weight to the rear of the walker base at Plane A by means of a rope (as specified in 7.6.3.3) and a pulley (as specified in 7.6.3.3) and adjust the pulley so that the force is applied horizontally (0 ± 0.5° with respect to the table surface).

7.6.5.4 Release the walker. When the walker comes to rest the 8 lb (3.6 kg) weight must still be applied to the walker.

7.6.5.5 Repeat 7.6.5.3 and 7.6.5.4 two additional times.

7.6.5.6 Repeat 7.6.5.1-7.6.5.5 using the CAMI dummy with the weighted vest (see Fig. 12) and with distance computed using the following equation:

$$d_{\text{CAMI w/vest}} = \frac{(V_f^2 - V_o^2) * (W_{\text{CAMI w/vest}} + W_{\text{walker}} + W_{\text{drop weight}})}{2g(W_{\text{drop weight}} - \mu_k N_{\text{CAMI w/vest}})} \quad (6)$$

where:

V_f = maximum velocity of walker at edge of platform (4 ft/s)

V_o = initial velocity (0)

W_{CAMI} = measured weight of CAMI dummy

W_{walker} = weight of walker

$W_{drop\ weight}$ = drop weight (8 lb)

μ_k = dynamic coefficient of friction (0.05)

N_{CAMI} = normal force (for CAMI dummy scenario) (weight of CAMI dummy + walker)

g = acceleration of gravity (32.2 ft/s²)

7.7 *Parking Device Test (see 6.4)*

7.7.1 Perform the parking device test using a Test Mass that is A rigid cylinder 6.30 ± 0.04 in. (160 ± 1 mm) in diameter, 11.02 ± 0.04 in. (280 ± 1 mm) in height with a mass of 16.9 lb (7.65 kg), with its center of gravity in the center of the cylinder.

7.7.2 Adjust the walker seat to the highest position (if applicable). Place the Test Mass vertically in the walker seat. Set any manual speed control to the fastest position (if applicable). Establish a vertical plane A that passes through the center of the seating area and is parallel to the direction the child faces. Establish a vertical plane B that is perpendicular to plane A and passes through the center of the seating area.

7.7.3 Perform the parking device test in the forward, sideward, and rearward directions.

7.7.4 *Forward Facing Test of Parking Devices*:

7.7.4.1 Position the walker including the Test Mass facing forward so that plane A is perpendicular to the front edge of the platform (see Fig. 10) and passes through the center of the pulley. Engage all parking devices in accordance with the manufacturer's instructions.

7.7.4.2 Within 1 min of placing the walker with the Test Mass on the platform, attach an 8-lb (3.6-kg) weight gradually within 5 s to the walker frame base at plane A by means of a rope and a pulley per the test apparatus specifications in the step test procedure, adjusted so that the force is applied horizontally (rope angle shall be 0 ± 0.5°). Remove the 8-lb (3.6-kg) weight after 1 min. Measure the displacement.

7.7.5 *Sideward Facing Test of Parking Devices*:

7.7.5.1 Position the walker including the Test Mass facing sideward so that plane B is perpendicular to the front edge of the platform and passes through the center of the pulley. Engage all parking devices in accordance with the manufacturer's instructions.

7.7.5.2 Within 1 min of placing the walker with the Test Mass on the platform, attach an 8-lb (3.6-kg) weight gradually within 5 s to the walker frame base at plane B by means of a rope and a pulley per the test apparatus specifications in the step test procedure, adjusted so that the force is applied horizontally (rope angle shall be 0 ± 0.5°). Remove the 8-lb (3.6-kg) weight after 1 min. Measure the displacement.

7.7.5.3 If the walker is equipped with fixed direction rear wheels and the walker is displaced in a curved path, establish the location of the rope attachment as the reference point and measure the linear displacement of that reference point after performing the procedure as described in 7.7.5.1 and 7.7.5.2.

7.7.6 ***Rearward Facing Test of Parking Devices*:**

7.7.6.1 Position the walker including the Test Mass facing rearward so that plane A is perpendicular to the front edge of the platform and passes through the center of the pulley. Engage all parking devices in accordance with the manufacturers' instructions.

7.7.6.2 Within 1 min of placing the walker with the Test Mass on the platform, attach an 8-lb (3.6-kg) weight gradually within 5 s to the walker frame base at plane A by means of a rope and a pulley per the test apparatus specifications in the step test procedure, adjusted so that the force is applied horizontally (rope angle shall be 0 ± 0.5°). Remove the 8-lb (3.6-kg) weight after 1 min. Measure the displacement.

8. Marking and Labeling

8.1 Each product and its retail package shall be marked or labeled clearly and legibly to indicate the following:

8.1.1 The name of the manufacturer, distributor, or seller and either the place of business (city, state, and mailing address, including zip code) or telephone number, or both.

8.1.2 A code mark or other means that identifies the date (month and year as a minimum) of manufacture.

8.1.3 The markings on the product shall be permanent.

8.1.4 Any upholstery label required by law shall not be used to meet the requirements of 8.1.

8.2 Each walker shall be labeled with warning statements. The warning statements shall be in contrasting color(s), permanent, conspicuous, and in sans serif style font.

8.2.1 In warning statements, the word " **WARNING**" shall not be less than 0.2 in. (5 mm) high and the remainder of the text shall be in letters not less than 0.1 in. (2.5 mm) high except as specified.

8.2.2 The warnings shall include the following exactly as stated below:

⚠ **WARNING**
Never leave child unattended. Always keep child in view while in walker.

8.2.3 Additional warnings shall address the following:

8.2.3.1 Use only on flat surfaces free of objects that could cause the walker to tip over.

8.2.3.2 To avoid burns, keep the child away from hot liquids, ranges, radiators, space heaters, fireplaces, etc.

8.2.3.3 If the walker is equipped with a parking brake, a warning statement shall address the following:

WARNING: Parking brake use does not totally prevent walker movement. Always keep child in view when in the walker, even when using the parking brakes.

8.2.4 Each walker shall be labeled with a separate stairs warning visible to the consumer when placing the child in the walker.

8.2.4.1 In the stairs warning, the safety alert symbol "⚠" and the word "**WARNING**" shall not be less than 0.2 in. (5 mm) high and shall be black lettering on orange background surrounded by a black border. The remainder of the text shall be characters whose upper case shall be at least 0.1 in. (2.5 mm) high and shall be black lettering on white background.

8.2.4.2 The stairs warning shall be stated exactly as follows:

⚠ **WARNING—STAIR HAZARD**
Avoid serious injury or death
Block stairs/steps securely before using walker even when using parking brake

1. The statement "even when using parking brake" applies only to walkers equipped with a parking brake.

9. Instructional Literature

9.1 Instructions must be provided with the walker, and shall be easy to read and understand. Assembly, maintenance, cleaning, operating, folding instructions, and warnings, where applicable, must be included.

9.1.1 The instructions shall include the following:

Read all instructions before assembly and use of the walker.
Keep instructions for future use.

9.2 *Warning Statements with the Instructional Literature:*

9.2.1 In warning statements located in the instructional literature, the letters of the word "**WARNING**" shall not be less than 0.2 in. (5 mm) high and the remainder of the text shall be in letters not less than 0.1 in. (2.5 mm) high.

9.2.2 If the unit is designed with a restraint, the instructions must advise that the restraint system be used.

9.2.3 The instructions must indicate the manufacturer's recommended height, weight, or age, or combination thereof, of the child for which the walker is intended. If the walker is not intended for use by a child who can already walk unassisted, the instructions shall so state this limitation.

9.2.4 The instructions shall contain warning statements which address the following:

1. Do not use the walker if it is damaged or broken.
2. Do not use until baby can sit up by itself.
3. *Address the following if the walker uses friction devices to pass the stair test*: Clean (*friction components*) regularly to maintain stopping performance.

9.2.5 The instructions must include all warnings in 8.2.

10. Keywords

10.1 infant walker

APPENDIX
(Nonmandatory Information)

X1. RATIONALE

X1.1 The 8 lb falling weight is based on the horizontal force generated when ten different children were tested in walkers. The children ranged in age from 6 ½ to 11 months and in weight from 15 to 23 lb. The children were placed in walkers on several different floor surfaces and the force they generated to move the walker was measured. The highest measured force out of approximately 125 readings was 7.5 lb.

X1.2 The use of the falling weight simulates a child in a walker approaching a step at approximately 4 ft/s (for the forward and rearward directions) or 2 ft/s (for the sideward direction). It assumes the walker's weight is 8 lb, the child's weight is 17 lb (or 28 lb), and the walker has normal caster wheels with normal rolling friction. By varying distance *d*, the desired number of ft/s can be achieved.

X1.3 The 4 ft/s is based on the test results of seven different children in walkers. The maximum speed attained was 4.02 ft/s. It should be noted that the children were selected because they were judged to be very active in a walker. Additionally, top speeds were sustained for only very brief moments under ideal conditions, that is, smooth floors with plenty of space to get up speed.

X1.4 The test is performed at both ends of the weight range for children who use walkers. The CAMI Infant Dummy Mark II represents the 50th percentile weight of 6 to 8 month old children. The 28 lb CAMI Infant Dummy (CAMI with weighted vest) represents the 95th percentile weight of 12 to 15 month old children.

X1.5 The 17 lb weight in the tipover test simulates a child leaning forward or sideways over the edge of the occupant seating area. Seventeen pounds represents the upper body weight of children in the 12 to 15 month age range (17 lb = ⅝ of 28 lb, the 95th percentile weight of 12 to 15 month old children.)

X1.6 The tipover sequence is not included in the rearward facing tests since the walker seat back prevents a child from leaning backward in a walker to any significant degree.

X1.7 The use of a 36 in. opening on the test platform is based on a CPSC study of walker stair/step incidents in which approximately 80 % of the openings the walkers passed through prior to going over steps were 36 in. or less.

X1.8 *Sections 6.2.3 and 7.1.3*— This test is to address entrapment in the leg openings. Leg openings are evaluated after application of a 25-lbf force to the small head probe. This is the same force used in evaluating leg openings in passive restraint systems in high chairs, entrapment in non-full-size crib/play yard attachments, entrapment in shelves in changing tables, and for evaluating mattress support systems in full-size cribs and non-full-size cribs/play yards. Users of these products are of similar developmental stage to users of infant walkers.