

ASTM International/Definitions and Sample Standards

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.

Definitions for the types of ASTM International standards (classification, guide, practice, specification, terminology, and test method) are quoted below from the current Regulations Governing ASTM Technical Committees. Select the link identifying each type of standard to view a sample.

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[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 of the [Form and Style for ASTM Standards](#) on Precision and Bias.)



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Designation: C 1336–96 (Reapproved 2002)

Standard Practice for Fabricating Non-Oxide Ceramic Reference Specimens Containing Seeded Inclusions¹

This standard is issued under the fixed designation C 1336; 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. Scope

1.1 This practice covers a procedure for fabricating both green and sintered test samples of silicon carbide and silicon nitride containing inclusions. These samples can be used to determine the sensitivity and detection capability of a nondestructive examination (NDE) method.

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 *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:

B 331 Test Method for Compressibility of Metal Powders Uniaxial Compaction²

C 373 Test Method for Water Absorption, Bulk Density, Apparent Porosity, and Apparent Specific Gravity of Fired Whiteware Products³

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

3.1.1 *green specimen*—formed ceramic specimens as originally compacted prior to high-temperature densification.

3.1.2 *inclusion*—a solid discontinuity in a specimen, with a composition not that of the specimen.

3.1.3 *seeded inclusions*—discontinuities intentionally placed at prescribed locations in reference specimens.

3.1.4 *sintered specimen*—formed ceramic specimen after firing to densify and remove solvents or binders.

4. Significance and Use

4.1 This practice describes a method of fabrication of known discontinuities in a ceramic specimen. Such specimens are needed and used in nondestructive examination to demonstrate sensitivity and resolution and to assist in establishing proper examination parameters.

5. Apparatus

5.1 *Aerosol Duster*, moisture-free.

5.2 *Die*, capable of exerting pressure up to 120 MPa and will not contaminate the compacted material.

5.3 *Optical Magnifier*, capable of providing 10 to 30 \times magnification.

¹This practice is under the jurisdiction of ASTM Committee C28 on Advanced Ceramics and is the direct responsibility of Subcommittee C28.03 on Physical Properties and Non-Destructive Evaluation.

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²*Annual Book of ASTM Standards*, Vol 02.05.

³*Annual Book of ASTM Standards*, Vol 15.02.

5.4 *Tubing*, latex, thin-wall, for encapsulating compact during isopressing.

5.5 *Carver Press*, or similar type of apparatus capable of exerting the necessary pressure to consolidate the sample.

5.6 *Cold Isostatic Press*, capable of maintaining 500 MPa.

5.7 *Oven or Furnace*, which can maintain a temperature of 500°C.

5.8 *Imaging Equipment*, with the capability of producing a hard copy output of the image (that is, 35 mm camera, charge coupled device (CCD) camera outputted to a video printer, a stereo microscope with 4 by 5 instamatic film, etc.).

5.9 *Sintering Furnaces*, capable of reaching temperatures of 1400 to 2200°C. Depending on the ceramic system chosen, the furnace may be required to operate in a vacuum or under inert gas atmospheres, or both, at pressures as high as 200 MPa.

5.10 *Mettler Scale*, or similar device capable of measuring within 0.01 mg. Measuring densities according to Archimedes principle requires the use of a sample holder suspended in water attached to the scale.

6. Materials

6.1 *Silicon Carbide or Silicon Nitride Powders*, of appropriate purity and particle size, prepared with sintering aids and binder representative of the product to be inspected and in a manner appropriate for dry pressing with granule size less than -100 mesh.

6.2 *Inclusion Spheres*, diameters as needed. Inclusion materials selected based on applicable green and sintered inclusion that is desired to be investigated for a specific silicon nitride or silicon carbide application.

6.2.1 The size, shape, and composition of the inclusions shall be determined a priori before seeding. The inclusion particles must be carefully selected based on the ceramic system of interest and the purpose of the test samples.

6.2.1.1 Samples fabricated to determine the sensitivity and resolution of the NDE test method should have inclusions that represent the type that would be encountered in actual applications. The selection of the inclusion type should reflect the possible impurities that are commonly seen after processing and that are present in the raw material.

6.2.1.2 Test samples being fabricated for NDE calibration standards may require the use of inclusion particles with well-defined properties (that is, geometry, density, modulus, composition, etc.). Such particles may be chosen to be exceptionally stable during sample fabrication.

7. Fabrication of Internal Seeded Inclusions

7.1 For Green Specimens:

7.1.1 The test piece geometry must be appropriate for the size and geometry limits of the NDE test method. If the purpose of the test is to determine if the NDE method is suitable for the detection of inclusions in a particular part/sample, ideally the test sample should be identical to the part/sample. If this is not feasible due to fabrication or testing limitations, the test sample should be similar to the part/sample in chemical composition, density, and thickness (the thickness of the test sample should be the same as the thickness in the area of the part/sample being examined).

7.1.2 Procedure:

7.1.2.1 Prepare test specimen bars by pouring powder into a die in an amount to position the inclusions at the desired distance from the specimen surfaces. If the inclusions to be seeded are less than 200 μm in diameter, level the surface and press at 60 MPa to facilitate positioning of the inclusions. Pressing is not necessary if the diameter will be greater.

7.1.2.2 Remove the ram to expose the specimen. Clean the specimen of all particles that are not flush with the top surface; this can generally be done with a moisture-free aerosol duster.

7.1.2.3 Place large inclusions in the desired location on the specimen surface. Small inclusions may be moved to the desired position with a single human hair taped to a stiff plastic rod with the assistance of an optical magnifier.

7.1.2.4 Press the inclusions into the surface at a pressure of 60 MPa to hold them in position.

7.1.2.5 Record the positions of the inclusions photographically using a CCD camera attached to a stereo microscope or other suitable imaging equipment depending on the size of the inclusions used.

7.1.2.6 Add ceramic powder of a sufficient amount to separate the adjacent layers of inclusions. If this is the final layer of powder, press to provide handling strength to the green compact (nominally 120 MPa); otherwise press at 60 MPa and repeat 7.1.2.2–7.1.2.5 through until the desired number of inclusion layers are obtained.

7.1.2.7 After final pressing, remove the specimen from the die and place into thin-wall latex tubing, evacuate the air, and seal the end. Cold isopress at 420 MPa or a pressure most suitable for specific material.

7.1.2.8 Remove the specimen from the tubing and heat to a sufficient temperature to decompose the binder if it has been added for powder compaction assistance.

7.1.2.9 Mark the specimen orientation with a scribe mark or by beveling a corner or edge. Remove extraneous particles from all surfaces with an aerosol duster or brush (adherent particles may require light sanding).

7.1.2.10 Measure bulk density of the specimen from direct volume and weight measurements.

7.2 For Sintered Specimens:

7.2.1 Procedure:

7.2.1.1 Follow steps in 7.1.2 to produce green specimens.

7.2.1.2 Sinter green samples under suitable conditions to achieve full densification. Nominal sintering conditions for silicon nitride are: 1700 to 1900°C for 1 h in an inert atmosphere at 0 to 200 MPa; for silicon carbide, sintering temperatures of 2000 to 2200°C for 0.5 h under vacuum are commonly used. The sintering aids used will dictate the firing conditions. Measure bulk density using a method referenced in 2.1 (Test Methods B 331 and C 373) or from volume and weight measurements.

7.3 Sintered Inclusion Characteristics :

7.3.1 *For Silicon Nitride Test Bars*— Many inclusions react with silicon nitride powder and sintering aid powders during densification, potentially resulting in chemical and structural changes to the inclusion and possibly resulting in a reaction zone different in size from the size of the original inclusion before densification. For example, iron inclusions can react with free silica in the silicon nitride powder during densification to form iron silicide, with a larger resulting reaction zone than the original iron inclusion size. The dimensions of the inclusion may increase by 50 %. The final dimensions of the inclusion are affected by the environmental conditions within the furnace, cooling rates, soak times, etc. Thus, the effect densification has on inclusions in silicon nitride should be known a priori to ensure correct interpretation of results.

7.3.2 *For Silicon Carbide Test Bars*— Many inclusions may also react with the SiC powder and some of the sintering aid powders during densification. This reaction may result in structural and chemical changes to the inclusion causing the dimensions of the inclusion to be different than that of the original. The reactivity of the inclusion with the SiC powders or additives should be understood for proper interpretation of the results.

8. Fabrication of Surface Seeded Inclusions

8.1 For Green Specimens:

8.1.1 Procedure:

8.1.1.1 Prepare test specimen bars by pouring powder into a die in an amount sufficient to make a specimen of the desired thickness. Level the surface and press at a nominal pressure of 60 MPa.

8.1.1.2 Remove the ram to expose the specimen. Clean the specimen of all particles that are not flush with the top surface; this can generally be done with a moisture-free aerosol duster.

8.1.1.3 Place large inclusions in the desired location on the specimen surface. Small inclusions may be moved to the desired position with a single human hair taped to a stiff plastic rod with the assistance of an optical magnifier.

8.1.1.4 Press the inclusions into the surface at a suitable pressure to obtain desired strength for handling of the green compact (typically 120 MPa).

8.1.1.5 Record the position of the inclusions with the use of imaging equipment or other suitable means.

8.1.1.6 Remove the bar from the die and clear surfaces of extraneous particles. An aerosol duster or brush should be adequate.

8.1.1.7 Remove the specimen from the die and place into thin-wall latex tubing, evacuate the air, and seal the end. Cold isopress at 420 MPa or a pressure most suitable for specific material.

8.1.1.8 Remove the specimen from the tubing and heat to a sufficient temperature to decompose the binder if it has been added for powder compaction assistance.

8.1.1.9 Mark the specimen orientation with a scribe mark or by beveling a corner or edge. Remove extraneous particles from all surfaces with an aerosol duster or brush (adherent particles may require light sanding).

8.1.1.10 Measure bulk density of the specimen from direct volume and weight measurements.

8.2 For Sintered Specimens:

8.2.1 Procedure:

8.2.1.1 Follow steps in 8.1.1 to produce green specimens.

8.2.1.2 Sinter green samples under suitable conditions to achieve full densification. Nominal sintering conditions for silicon nitride are: 1700 to 1900°C for 1 h in an inert atmosphere at 0 to 200 MPa; for silicon carbide, 2000 to 2200°C for 0.5 h under vacuum is commonly used. The sintering aids used will dictate the firing conditions. Measure bulk density using a method referenced in 2.1 or from volume and weight measurements.

9. Report

9.1 Report the location and measured size of the inclusion. Depending on the size of the inclusion and the precision required, the inclusion can be measured directly or by indirect methods using suitable imaging equipment.

10. Keywords

10.1 advanced ceramics; non-oxide ceramics

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Designation: D 2379-04

Standard Test Method for Acidity of Formaldehyde Solutions¹

This standard is issued under the fixed designation D 2379; 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. Scope*

1.1 This test method covers the determination of the acidity of commercially available formaldehyde solutions.

1.2 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 For purposes of determining conformance of an observed or a calculated value using this test method to relevant specifications, test result(s) shall be rounded off “to the nearest unit” in the last right-hand digit used in expressing the specification limit, in accordance with the rounding-off method of Practice E 29.

1.4 For hazard information and guidance, see the supplier's Material Safety Data Sheet.

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. Specific hazard statements are given in Section 7.*

2. Referenced Documents

2.1 *ASTM Standards:*²

D 1193 Specification for Reagent Water

D 2380 Test Method for Methanol Content of Formaldehyde Solutions

E 200 Practice for Preparation, Standardization, and Storage of Standard and Reagent Solutions for Chemical Analysis

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

3. Summary of Test Method

3.1 A specimen is titrated with standard alkali to the bromthymol blue end point.

4. Significance and Use

4.1 This test method provides a measurement of acidity (as formic acid) in formaldehyde solutions. The results of these measurements can be used for specification acceptance.

5. Apparatus

5.1 *Buret*, 25-mL, calibrated in 0.1-mL divisions. A TFE-fluorocarbon resin stopcock is suitable for this purpose.

6. Reagents and Materials

6.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society,

¹This test method is under the jurisdiction of ASTM Committee D01 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.35 on Solvents, Plasticizers, and Chemical Intermediates.

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

²For 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.

where such specifications are available.³ 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 conforming to Type IV of Specification D 1193.

6.3 *Bromthymol Blue Indicator Solution* (1.0 g/L)—Dissolve 0.1 g of the water-soluble form of bromthymol blue indicator powder in 100 mL of water.

6.4 *Sodium Hydroxide, Standard Solution* (0.1 N)—Prepare and standardize 0.1 N sodium hydroxide (NaOH) solution as described in Practice E 200.

7. Hazards

7.1 Formaldehyde and formaldehyde solutions are hazardous and exposure to them should be minimized to avoid acute effects and possible sensitization. Consult your supplier's Material Safety Data Sheet for specific hazard information.

7.2 Sodium hydroxide solutions are corrosive and hazardous. Exercise steps to prevent contact with the skin or eyes. Consult supplier's Material Safety Data Sheet for specific hazard.

8. Procedure

8.1 Measure 50 mL of the sample into a 250-mL Erlenmeyer flask, add 3 or 4 drops of bromthymol blue indicator solution, and titrate with 0.1 N NaOH solution to a blue end point.

8.2 If good laboratory practice dictates that the concentration of NaOH be adjusted as a result of higher or lower acid levels, then adjust as necessary using Practice E 200, and titrate to a blue end point.

9. Calculation

9.1 Calculate the percent of formic acid as follows:

$$\text{Formic acid, weight \%} = \left[\frac{(V \times N \times 0.046)}{(S \times D)} \right] \times 100 \quad (1)$$

where:

V	=	millilitres of NaOH solution, required for titration of the specimen,
N	=	normality of the NaOH solution,
0.046	=	the milliequivalent weight of formic acid,
S	=	millilitres of sample used, and
D	=	specific gravity of sample.

The value of D from Test Method D2380, may be used, although specific gravity estimated to the second decimal is adequate.

10. Report

10.1 Report the percent formic acid to the nearest 0.001 %. Duplicate determinations which agree within 0.002 % absolute are acceptable for averaging (95 % confidence level).

11. Precision and Bias

11.1 In an interlaboratory study of this test method, the within-laboratory standard deviation was found to be 0.0007 % absolute at 60 degrees of freedom, and the between-laboratories standard deviation 0.0031 % absolute at 9 degrees of freedom.

³ *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.

Based on these standard deviations, the following criteria should be used for judging the acceptability of results at the 95 % confidence level:

11.1.1 *Repeatability*—Two results, each the mean of duplicates, obtained by the same analyst on different days should be considered suspect if they differ by more than 0.002 % absolute.

11.1.2 *Reproducibility*—Two results, each the mean of duplicates, obtained by analysis in different laboratories, should be considered suspect if they differ by more than 0.010 % absolute.

NOTE 1—The above precision estimates are based on an interlaboratory study involving ten laboratories using three samples with two analysts performing duplicate runs on each of two days. The mean level of the acidity value of the samples studied was 0.02 %.

11.2 *Bias*—Bias of this test method has not been determined because primary standards do not exist.

12. Keywords

12.1 formaldehyde; formic acid

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SUMMARY OF CHANGES

Subcommittee D01.35 has identified the location of selected changes to this standard since the last issue (D 2379–99) that may impact the use of this standard.

- (1) Added reference to Practice E 29 in 1.3 of the Scope section.
- (2) Added Practice E 29 to the list in 2.1 of the Referenced Documents section.

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INTERNATIONAL Designation: D 4149–82 (Reapproved 2004)

Standard Classification for Sampling Phytoplankton in Surface Waters¹

This standard is issued under the fixed designation D 4149; 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. Scope

1.1 This classification covers both qualitative and quantitative techniques that are used commonly for the collection of phytoplankton. The particular techniques that are used during an investigation are dependent upon the study objectives. Of additional importance in the selection of a technique is the uneven distribution of organisms both temporally and spatially. This classification describes qualitative and quantitative ways of collecting phytoplankton from inland surface waters. Specifically, qualitative samplers include conical tow nets and pumps; quantitative samplers include the Clarke-Bumpus plankton sampler, Juday plankton trap, water sampling bottles, and depth-integrating samplers.

2. Referenced Documents

2.1 ASTM Standards:

D 1129 Terminology Relating to Water²

3. Terminology

3.1 Definitions:

3.1.1 For definitions of terms used in this method refer to Terminology D 1129.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *phytoplankton*—is the community of suspended or floating, mostly microscopic plants that drift passively with water currents. Frequently, phytoplankton are differentiated on the basis of size. The generally accepted size ranges, as commonly used are (1):³

Macroplankton	>500 μm
Microplankton (net plankton)	10 to 500 μm
Nannoplankton	10 to 50 μm
Ultraplankton	<10 μm

4. Significance and Use

4.1 Because of the direct association of phytoplankton with the water and the water masses that move in response to wind-or-gravity-generated currents, the species composition and abundance of phytoplankton are related to water quality. Moreover, the phytoplankton directly affect water quality, notably dissolved oxygen, pH, concentrations of certain solutes, and optical properties. At times the abundance or presence of particular species of algae result in nuisance conditions (2).

¹This classification is under the jurisdiction of ASTM Committee E47 on Biological Effects and Environmental Fate and is the direct responsibility of Subcommittee E47.01 on Aquatic Assessment and Toxicology.

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²For 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.

³The boldface numbers in parentheses refer to the references at the end of this classification.

4.2 Organisms of the phytoplankton communities are collected and studied for many reasons, and the techniques used will vary with the study objectives. In the design of a sampling program and in the selection of techniques, the investigator must take into consideration the uniqueness of each study area and the natural characteristics of phytoplankton communities.

4.3 The principal factors to consider when collecting phytoplankton are the uneven distribution, composition, and abundance of phytoplankton in space and time. Phytoplankton blooms can occur quickly and can be of short duration. Succession of taxa can occur in a matter of 1 to 2 weeks. Furthermore, phytoplankton abundance and composition can change abruptly in the horizontal plane. There also can be remarkable numerical and qualitative differences between depths. The heterogeneous abundance and composition can occur not only over small areas but also over large areas. The uneven distribution makes it difficult to collect a representative sample from a given area and makes replication of samples and, especially, an adequate vertical and horizontal sampling program essential (3).

5. Basis of Classification

5.1 Qualitative samplers include the conical tow nets and pumps. Quantitative samplers include the Clarke-Bumpus plankton sampler, Juday plankton trap, water-sampling bottles, and depth-integrating samplers.

5.2 *Conical Tow Nets*—Most qualitative samplers are cone-shaped nets constructed of silk bolting cloth or a synthetic material such as nylon. Nets should not be used for quantitative studies because they do not retain all the phytoplankton taxa; for example, nanoplankton and ultraplankton generally will pass through a net. Even so, nets are valuable collecting tools and excellent for many types of studies.

5.3 *Pumps*—Pumping systems of various kinds have been used to collect qualitative or semiquantitative samples of phytoplankton. Several papers summarizing these techniques have been published in the literature (4, 5, 6). Although a variety of pump apparatus have been used, the basic design consists of a pump, generally with a volume register, a base, and a concentrating net, such as a simple tow net sampler or Wisconsin net sampler. Water is pumped from a discrete depth and through the net. The sample is removed from the net.

5.4 *Clarke-Bumpus Plankton Sampler*—The sampler utilizes a net for the concentration of organisms and, as such, may be considered to be a semiquantitative sampler. It is quantitative in that the actual volume of water entering the sampler is measured by a calibrated flow meter.

5.5 *Juday Plankton Trap*—Like the Clarke-Bumpus plankton sampler, the Juday plankton trap utilizes a net for the concentration of organisms. The trap collects a discrete sized sample from a predetermined depth.

5.6 *Water-Sampling Bottles*—The closing water bottles, which are actuated by a messenger, are perhaps the most satisfactory and simple quantitative sampling device.

5.7 *Depth-Integrating Samplers*—Depth-integrating samplers are used to obtain a representative, quantitative sample of phytoplankton in the cross section of a stream. The sampler and sampling procedure compensates for the disparity of phytoplankton density in the cross section.

REFERENCES

- (1) Wetzel, R. G., *Limnology*, W. B. Saunders Co., Philadelphia, PA, 1975, p. 743.
- (2) Greeson, P. E., et al., "Methods for Collection and Analysis of Aquatic Biological and Microbiological Samples." *U.S. Geological Survey Technology of Water-Resources Investigations*, Book 5, Chapter A4, 1977, p. 332.
- (3) National Academy of Sciences, "Recommended Procedures for Measuring the Productivity of Plankton Standing Stock and Related Oceanic Properties," National Academy Sciences, Washington, 1969, p. 59.
- (4) Aron, W., "The Use of a Large Capacity Portable Pump for Plankton Sampling, with Notes on Plankton Patchiness," *Journal of Marine Research*, Vol 16, 1958, pp. 158–174.
- (5) Gibbons, S. G., and Fraser, J. H., "The Centrifugal Pump and Suction Base as a Method of Collecting Plankton Samples," *Journal Construction Permanent International Explorer Merchants*, Vol 12, 1937, pp. 155–170.
- (6) Weber, C. I., ed., "Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents," U.S. Environmental Protection Agency. EPA-670/4-73-001, 1973.

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INTERNATIONAL Designation: D 6346–98 (Reapproved 2004)

Standard Guide for Accepting, Segregating and Packaging Materials Collected Through Household Hazardous Waste Programs¹

This standard is issued under the fixed designation D 6346; 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. Scope

1.1 This guide covers Household Hazardous Waste (HHW) programs for accepting, segregating and packaging materials collected through HHW programs to minimize the risk associated with managing these materials and to identify applicable regulations. This guide does not address storing, vehicle loading or transporting collected and packaged materials. This guide does not attempt to define the hazardous nature of materials.

1.2 Certain existing local, state and federal regulations apply to HHW program operations. This guide does not replace these existing regulations, and is not intended to be used as the basis for regulations for HHW Programs. This guide does not reference all applicable applications, since applicable regulations will vary. HHW Programs should research all applicable regulations before establishing a materials collection program.

1.3 *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 guide to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *Code of Federal Regulations (CFR):*

Title 49, Transportation, Parts 171–178²

CFR Title 40, Protection of Environment, Part 261.5²

3. Terminology

3.1 *Definitions:*

3.1.1 *bulking*—the act of emptying multiple containers of compatible materials and mixing those materials together in a single package unit destined for shipment. This would also include material placed in storage tanks to be packaged for shipment at a later date, or pumped into a bulk tank truck for shipment.

3.1.2 *consolidation*—the act of combining two or more materials to make a single package unit. Common types of consolidation packaging used by HHW programs include: bulking, lab packaging, and composite packaging.

3.1.3 *package or outside package*—a package plus its contents.

3.1.4 *packaging*—a receptacle and any other components or materials (drums, boxes, liners, absorbents, etc.) necessary for the receptacle to perform its containment function in conformance with the minimum packing requirements of 40 CFR 171, 172, 173.

4. Significance and Use

4.1 This guide is intended to provide general guidance to HHW programs for accepting and segregating materials, selecting a management method, and packaging materials collected by HHW programs.

¹This guide is under the jurisdiction of ASTM Committee D34 on Waste Management and is the direct responsibility of Subcommittee D34.03.02 on Municipal Recovery and Reuse.

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²Available from U.S. Government Printing Office, Washington, DC.

5. Procedure

5.1 *Accepting Materials*—HHW Programs should establish a list of materials that will be accepted at its facilities or event collections. The list should be distributed to the public prior to the facility opening or event collection. Types of materials commonly collected by HHW Programs include:

5.1.1 Materials that exhibit a hazardous characteristic, as defined in 40 CFR 261.5, such as ignitability, toxicity, corrosivity, oxidizer, reactivity, or are a listed hazardous waste;

5.1.2 Materials prohibited from local municipal waste management systems; and

5.1.3 Materials collected to provide a convenience or public service to a community.

5.1.4 HHW Programs will need to establish traffic flow, vehicle unloading and safety procedures. All personnel involved with material acceptance should receive training in material identification, proper lifting procedures, safety and personnel protective equipment.

5.1.5 Leaking containers should be repackaged immediately into a container that is compatible with the material in the container.

5.1.6 Unlabeled containers should be segregated from other wastes. The individual who brought the container should be interviewed to assist in identification. Any further categorization and identification of the material should be completed as soon as possible. A hazardous materials contractor or trained staff could perform tests to identify the materials.

5.2 *Segregating Materials*—As the materials are collected they should be segregated into general categories based on DOT incompatibility and packaging regulations.

5.2.1 *Commonly Collected Materials* —DOT classifies materials generated from households as a consumer commodity, which exempts them from DOT regulations. The materials listed below are sub-categories of DOT classes and are not intended to be all inclusive, but a guide to the most common materials collected by HHW programs.

Oil Based Paint	Water Based (latex) Paint/Sealer
Fuels	Antifreeze
Corrosive Acids	Corrosive Bases
Cyanides	Dioxins
Pesticide Liquids (including herbicides)	Pesticide Solids (including herbicides)
Flammables and Chlorinated Products	Organic Peroxides
Oxidizers	Reactive Solids
Arsenic/Heavy Metals	Mercury Compounds
PCB Containing Devices	Motor Oil
Compressed gas cylinders	Aerosols
Batteries	Fluorescent and HID lamps

5.2.1.1 Once a material is collected by a HHW program, it should be handled in an appropriate manner based on whether it exhibits a hazardous characteristic. A material that exhibits a hazardous characteristic or meets the definition of a listed hazardous waste or material should be transported in accordance with DOT regulations for its specific hazard class.

5.2.2 *Materials Requiring Special Handling*—The materials listed below require special handling. HHW Programs do not typically promote accepting these materials through their programs. However, these materials are brought to collection facilities and it is wise to be prepared to refer people to the appropriate local management option or to handle the materials at the facility. Management options are suggested below for these materials. The handling of these materials should be addressed in the site safety and emergency response plan for the facility.

5.2.2.1 *Explosives, Ammunition or Fireworks* —Contact local law enforcement or bomb squad.

5.2.2.2 *Radioactive Materials*—Refer to appropriate management option or contact Nuclear Regulatory Commission.

5.2.2.3 *Friable Asbestos*— Refer to local management facility or accept in accordance with local, state and federal regulations.

5.2.2.4 *Medical/Infectious Materials* —Refer to local management option or accept in accordance with local, state and federal regulations.

5.2.2.5 *Consumer Electronics and Appliances* —These items may have hazardous components and should be handled by a local handler, or may be managed through the HHW program.

5.2.3 *Incompatibility and Segregation of Materials*—Incompatible materials, when mixed, generate chemical reactions which may result in serious safety and health concerns. These include toxic gas generation, heat generation, flammable gas generation, fire, explosion, or polymerization of materials. Containers of incompatible materials should be adequately separated using bins, drums, dikes, walls or other devices, such that mixing of incompatible materials is prevented in the event of a spill, or a break or leak in a container.

5.2.3.1 Material and container segregation procedures should be established before waste is accepted. Procedures should be based on the type of materials accepted, facility design and facility operation. Personnel responsible for segregating wastes

should be properly trained in chemical management and safety. The following list gives only general guidance on incompatible categories of materials.

Always Segregate: Acids Oxidizers Cyanides	From: Bases, cyanides Flammables Acids, oxidizers
-----------------------------------------------------	------------------------------------------------------------

5.3 Selecting a Management Method for Collected Materials—Prior to consolidating materials, the ultimate management method for the material should be considered. The management method selected may affect how the materials will be packaged. Common management practices include: reuse, recycling, energy recovery, on-site treatment, incineration, land disposal, and waste water treatment.

5.3.1 When selecting the most appropriate material management method, HHW Programs should consider several factors, including:

5.3.1.1 Compliance with permitting requirements and local, state and federal regulations (especially when performing on-site treatment of materials);

5.3.1.2 Operational or structural limitations at facilities or event collections (that is, no product reuse available on-site, no connection to sewer treatment facility, limited space);

5.3.1.3 Personnel training and expertise;

5.3.1.4 Consideration of a materials management hierarchy that favors reuse, recycling, and energy or material recovery over incineration or land disposal;

5.3.1.5 Cost;

5.3.1.6 Potential liability related to each management method; and

5.3.1.7 Contractual or contractor restrictions or preferences.

5.4 Packaging Collected Materials —Collected materials need to be packaged or handled according to facility standards, local, state and federal regulations. Materials management contractors may also have specific packaging protocol that must be followed so that they can properly and efficiently process materials at their facilities. Unlabeled containers or questionable materials should not be packaged until they are properly identified.

5.4.1 On-site Management Options and Packaging:

5.4.1.1 *Reuse*—Usable materials in original containers that are offered to local residents or organizations during an event collection or at a permanent site should be left in their original containers. This allows users to reference original label information for proper use, and preserves the manufacturers' product liability.

5.4.1.2 *Paints or other materials* may be bulked into larger containers. However, the HHW Program may be considered to be engaging in a manufacturing operation when this is done.

5.4.1.3 *Recycle*—If materials are to be recycled on-site, they do not need to be packaged according to DOT protocol. Some items may be bulked or packaged into larger containers according to facility protocol and local regulations.

5.4.1.4 *Treatment or Disposal on-Site* —Many water-based cleaners and non-hazardous liquid materials may be sewered if the site is connected to the local wastewater treatment plant and has permission from the plant to do so. Some acids and bases may also be neutralized and sewered on-site in accordance with local or state regulations. Materials do not need to be packaged according to DOT protocol if treated or sewered on-site. A site safety or operational plan should be developed to describe in detail the process used to treat or dispose of wastes on-site.

5.4.1.5 Non-hazardous solids may be disposed of using the facility's solid waste management service and container.

5.4.1.6 *Energy Recovery*— If an energy recovery option is available on-site (that is, used oil furnace, municipal solid waste incinerator), the material should be handled and packaged according to the facility's standard protocol and all applicable regulations.

5.4.2 *Off-Site Management and Packaging* —Materials that will be shipped off-site for further management at recycling, energy recovery, incineration or land disposal facilities should conform to DOT regulations. Therefore, it makes sense to initially package all materials which will leave the site in accordance with DOT regulations. These packaging methods are fully detailed in DOT regulations, 49CFR Parts 171–178. These regulations describe the specific container types, packaging procedures, and container labeling required for each sub-category of material identified in 5.2.1. HHW Programs that intend to package their own materials need to become familiar with DOT regulations in order to properly package materials. Programs may also hire trained contractors to perform packaging on-site.

6. Keywords

6.1 compatibility; household hazardous waste; incompatibility; packaging; segregation

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Designation: E 957–03

Standard Terminology Relating to Geothermal Energy¹

This standard is issued under the fixed designation E957; 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.

aquifer, *n*—a water-bearing, permeable body of rock or granular material below the surface of the earth.

binary cycle plant, *n*—a facility that generates electric power by transferring heat from produced geothermal fluids to a non-aqueous working fluid that vaporizes and causes a turbine to rotate the shaft of a generator.

brine, *n*—in geothermal, fluids in a liquid phase that have been produced from geothermal wells or from hot springs and that contain appreciable amounts of sodium chloride and other salts.

capacity, *n*—the power which a component of a geothermal facility (e.g., a well, a reservoir, a power plant, or a direct-use facility) is capable of supplying at a point in time, assuming that other required components of the geothermal facility are available. Capacity is expressed in units of power (e.g., Megawatts, kilowatts).

direct-use facility, *n*—a facility which uses geothermal energy for purposes other than the generation of electricity (e.g., space heating, greenhouses, bathing, and industrial processes).

fumarole, *n*—a vent at the earth's surface that emits steam or gaseous vapor. Discussion—Such vents are usually found in volcanic areas.

geochemistry, *n*—the study of the chemistry of the rocks and fluids of the earth for the purpose of understanding their composition, their temperature, and their origin.

geothermal, *adj*—relating to or derived from the natural heat of the earth.

geothermal anomaly, *n*—a conspicuous deviation of the earth's temperature, geothermal gradient, or heat flow from average values; an area where such a deviation exists.

geothermal energy, *n*—the thermal energy contained in the rocks and fluids of the earth.

geothermal facility, *n*—the physical components necessary for the utilization of geothermal energy, including the reservoir, production and injection wells, pipelines, and the power plant or direct-use facility.

geothermal fluid, *n*—water in a vapor or liquid phase or in a mixture of these phases that exists within or has been emitted from a geothermal reservoir, together with any entrained or dissolved substances.

geothermal gradient, *n*—the change in temperature of the earth with depth, expressed either in degrees of temperature per unit depth, or units of depth per degree.

geothermal power plant, *n*—a facility for the production of electricity using geothermal energy, typically including a turbine, a generator, and associated surface equipment.

geothermal heat pump, *n*—a heat pump that transfers energy to or from the earth.

geothermal reserves, *n*—the amount of energy anticipated to be economically recoverable from a geothermal facility over a specified time period (e.g., the project life) using existing technology. Geothermal reserves are expressed in units of energy (e.g., terajoules in SI units), which are dimensionally equivalent to units of power multiplied by units of time (e.g., Megawatt-years or kilowatt-hours). Geothermal reserves may also be expressed as an equivalent amount of another energy source (e.g., barrels of oil equivalent). Discussion—Geothermal reserves can also be characterized as to the degree of certainty of recovery. By analogy to usage in the mining and petroleum industries, reserves may be qualified as proved, probable, or possible.

Example of Usage:

This facility has geothermal reserves of 4,000 Megawatt-

¹This terminology is under the jurisdiction of ASTM Committee E44 on Solar, Geothermal and Other Alternative Energy Sources and is the direct responsibility of Subcommittee E44.15 on Geothermal Field Development, Utilization and Materials.

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years, recoverable over a project life of 30 years.

geothermal reservoir, *n*—an aquifer of sufficient temperature and permeability to support the economic use of geothermal energy. Discussion—The extent of a geothermal reservoir is determined by the degree of hydrologic interconnection. When an aquifer contains both hot portions and portions that are too cool for economic use, those portions that are sufficiently interconnected to have a significant hydrologic or thermal impact on each other are considered part of the same geothermal reservoir.

geothermal steam, *n*—a geothermal fluid in the vapor phase.

geothermometer, *n*—a method of estimating the temperature of a geothermal reservoir based on the minerals in the reservoir rock or the concentration of chemical species in geothermal fluids that have come from the reservoir.

geyser, *n*—a spring that intermittently blows forth hot water and steam.

heat flow, *n*—dissipation or transfer of heat coming from within the earth by conduction, convection or radiation at the surface; usually reported in units of energy per unit time per unit area, for example, joules per second per square metre or watts per square metre.

hot spring, *n*—a thermal spring whose temperature is above that of the human body. source *Meinzer (1923)*

magma, *n*—molten rock within the earth or within other planets.

moisture content, *n*—the percentage by mass of liquid-phase water in a two-phase mixture of vapor-and liquid-phase water. Discussion—The moisture content of a two-phase mixture is equivalent to 100 minus the steam quality

noncondensable gas content, *n*—the concentration of noncondensable gas in a geothermal fluid. Discussion—The principal geothermal noncondensable (NC) gases include carbon dioxide, hydrogen sulfide, ammonia, nitrogen, methane, hydrogen, and argon. Standard usage is to express NC gas content as a percentage by mass in the reference fluid; that is,

(NC gas content = [mass NC gas/ (mass fluid + mass NC gas)] × 100, where fluid = water vapor, or water vapor + liquid (total fluid)

Other units for NC gas content (such as percentage by volume or mole ration) may also be used. The units and the reference fluid for NC gas content should always be explicitly stated.

noncondensable gases, *n*—in geothermal, chemical species (such as carbon dioxide or hydrogen sulfide) that are constituents of geothermal fluids, that partition primarily into the vapor phase when geothermal fluids boil, and that do not condense along with geothermal steam when put through a condenser in a geothermal power plant.

permeability, *n*—the ability of a rock to transmit fluid. Discussion—The amount of permeability of a rock depends on the size, shape, and degree of interconnection of the rock's pores and fractures. Permeability is expressed as the ability to transmit fluid of a specified viscosity at a specified flow rate through a specified area under the influence of a specified pressure gradient. The traditional unit of permeability is the darcy or the millidarcy. The SI unit is the square micrometer. These units have the dimension of length squared.

phreatic eruption, *n*—an explosion of the surface of the earth that results from a sudden increase in the volume of groundwater when it flashes to steam due to contact with hot rocks. Discussion—Typically in an area of hot springs or fumaroles, and no lava or other materials derived from magma are erupted.

porosity, *n*—the ratio of the aggregate volume of interstices in a rock or soil to its total volume, usually stated as a percent.

project life, *n*—the time period over which the economic viability of a geothermal facility is evaluated.

re injection/injection, *n*—the process of conveying geothermal fluids to sub-surface formations through wells. Discussion—After such fluids have been processed by a geothermal power plant or its associated facilities, or both, this process is sometimes referred to as “re injection” when injected water circulates back through the geothermal reservoir to the production wells.

steam purity, *n*—the proportion by mass of pure vapor-and liquid-phase water in a fluid mixture that consists primarily of steam. Discussion—Geothermal steam may contain impurities, such as silica, sodium, chloride, iron and solid particulates. Steam purity expresses the proportion by mass of pure water (in both liquid and vapor phases) in this mixture. Typically, only steam impurity is discussed in quantitative terms; the impurities are expressed in units of concentration by mass in the steam mixture.

Impurities such as sodium and chloride may be present as dissolved species in liquid water, or as particulate material, such as solid NaCl. Likewise, silica may be dissolved in water or present as a solid particulate. In cases where volatile chloride exists (HCl and/or NH₄ Cl), the volatile and nonvolatile species of chloride may be listed independently. Baron is a semi-volatile species that partitions between the vapor and liquid phases and is typically not grouped with the other non-volatile species. Noncondensable gas is not usually classified as a steam impurity, but is considered separately.

Example— Geothermal steam purity may be expressed in terms of the known impurities in the steam:

Chloride	0.75 ppm
Sodium	0.30 ppm
Silica	0.05 ppm
Iron	0.02 ppm

Other non-volatile dissolved impurities	0.18 ppm
Total Dissolve Solids (TDS, sum of nonvolatile, dissolved impurities)	1.3 ppm
Particulate matter	0.50 ppm
Total Solids (TS, sum of all non-volatile impurities)	1.8 ppm
Boron (semil-volatile impurity, considered separately)	35.0 ppm

steam quality, *n*—the percentage by mass of vapor-phase water in a two phase mixture of vapor- and liquid-phase water. Discussion—Geothermal steam may contain a small amount of liquid-phase water, as well as non-aqueous constituents, such as noncondensable gas and silica. Steam quality expresses the proportion of vapor-phase water relative to the mixture of vapor-and liquid-phase water only. The term “steam quality” is synonymous with the term “steam dryness”.

Example — A two-phase geothermal fluid consists of the following mass percentages: 90% vapor-phase water, 6% liquid-phase water, 3% noncondensable gas, 1% total dissolved solids.

The steam quality of this mixture is $[90/(90+6)] \times 100 = 93.75\%$.

sustainable capacity, *n*—the power which a component of a geothermal facility (such as a reservoir or a power plant) is capable of sustaining for a specified period of time. Discussion—The period of time over which a certain capacity can be sustained may be different than the project life.

Examples of Usage:

This reservoir has a sustainable capacity of 100 MW for at least 30 years.

This reservoir has a capacity of 50 MW, sustainable for at least the first 20 years of a 30-year project life.

With proper maintenance, this power plant has a sustainable capacity of 30 MW for 30 years.

total dissolved solids content of steam, *n*—the concentration by mass of non-volatile, dissolved impurities in geothermal steam. Discussion—Geothermal steam may contain non-volatile impurities, such as silica, sodium, chloride and iron, that may be considered dissolved in droplets of liquid water. The total dissolved solids content (TDS) of steam expresses the sum of these impurities as a concentration by mass in the water vapor and liquid mixture. Semi-volatile constituents such as boron (boric acid, H₃BO₃) are not usually considered part of the total dissolved solids in steam.

warm spring, *n*—thermal spring whose temperature is appreciably above the local mean annual temperature but below that of the human body. source *Meinzer (1923)*

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Designation: F 79–69 (Reapproved 2005)

Standard Specification for Type 101 Sealing Glass¹

This standard is issued under the fixed designation F79; 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. Scope

1.1 This specification covers Type 101 sealing glass for use in electronic applications.

NOTE 1—This specification is primarily intended to consider glass as most generally used, this is, glass in its transparent form as normally encountered in fabricating electronic devices. X1.3 lists sealing metals and alloys that are compatible with this glass. Type 101 glass in other forms such as powdered, crushed, sintered, fibrous, etc. are excluded. The requirements of this specification, as applied to these forms, must be established in the raw glass prior to its conversion.

2. Referenced Documents

2.1 *ASTM Standards*:²

C 336 Test Method for Annealing Point and Strain Point of Glass by Fiber Elongation

C 338 Test Method for Softening Point of Glass

C 598 Test Method for Annealing Point and Strain Point of Glass by Beam Bending

D 150 Test Methods for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulating Materials

D 257 Test Methods for DC Resistance or Conductance of Insulating Materials

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E 228 Test Method for Linear Thermal Expansion of Solid Materials with a Vitreous Silica Dilatometer³

F 14 Practice for Making and Testing Reference Glass-Metal Bead-Seal

F 140 Practice for Making Reference Glass-Metal Butt Seals and Testing for Expansion Characteristics by Polarimetric Methods

F 144 Practice for Making Reference Glass-Metal Sandwich Seal and Testing for Expansion Characteristics by Polarimetric Methods

3. Ordering Information

3.1 Orders for material under this specification shall include the following information:

3.1.1 Form,

3.1.2 Type of glass,

3.1.3 Dimensions,

3.1.4 Marking and packaging, and

3.1.5 Certification (if required).

¹This specification is under the jurisdiction of ASTM Committee C14 on Glass and Glass Products and is the direct responsibility of Subcommittee C14.04 on Physical and Mechanical Properties.

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²For 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.

³Withdrawn.

4. Chemical Composition

4.1 The typical chemical composition of this glass is as follows (Note 2):

Major Constituents	Weight %
Silica (SiO ₂)	56.0
Alumina (Al ₂ O ₃)	1.5
Soda (Na ₂ O)	4.0
Potash (K ₂ O)	8.5
Lead oxide (PbO)	29.0
Antimony trioxide (Sb ₂ O ₃)	1.0, max
Arsenic trioxide (As ₂ O ₃)	1.0, max
Halogens	0.2, max

NOTE 2—Major constituents may be adjusted to give the desired electrical and physical properties to the glass. However, no change shall be made that alters any of these properties without due notification of, and approval by, the user.

5. Physical Properties

5.1 The material shall conform to the physical properties prescribed in Table 1. For electrical properties see Table 2 and its Footnote A.

6. Workmanship, Finish, and Appearance

6.1 The glass shall have a finish that ensures smooth, even surfaces and freedom from cracks, checks, bubbles, and other flaws of a character detrimental to the strength or life of the component or device for which its use is intended.

7. Test Methods

7.1 *Softening Point*—See Test Method C 338.

7.2 *Annealing Point*—See Test Method C 336 or Test Method C 598.

7.3 *Thermal Expansion Coefficient*—Pretreat the specimen by heating to 10°C above the annealing point and hold it at that temperature for 15 min; then cool it from that temperature to 100°C at a rate of 2 to 5°C/min. The cooling rate below 100°C is optional. Place the specimen in the dilatometer and determine the mean coefficient of linear thermal expansion for the 0 to 300°C range in accordance with Procedure A of Test Method E 228.

7.4 *Contraction Coefficient*—Heat the specimen in a vitreous silica dilatometer to 20°C above the annealing point and hold it at that temperature for 15 min; then cool at a rate of from 1.0 to 1.5°C/min to a temperature below 200°C. The rate of cooling from the point below 200 to 100°C shall not exceed 5°C/min. The rate of cooling from 100°C to room temperature is optional. During this cooling schedule, determine the thermal contraction curve and calculate the mean coefficient of linear thermal contraction between a point 15°C below the annealing point and 30°C in accordance with Procedure B of Test Method E 228.

7.5 *Bead Seal Test*—The thermal contraction match between the glass and a sealing alloy may be determined by preparing and testing an assembly in accordance with Practices F 14, F 140, or F 144.

8. Test Results

8.1 Observed or calculated values obtained from measurements, tests, or analysis shall be rounded in accordance with the rounding method of Practice E 29, to the nearest unit in the last right-hand place of figures used in expressing the specified limit.

9. Investigation of Claims

9.1 Where any material fails to meet the requirements of this specification, the material so designated shall be handled in accordance with the agreement mutually acceptable to the manufacturer and the purchaser.



10. Packaging and Package Marking

10.1 Packing shall be determined by the form in which this material shall be supplied and shall be subject to agreement between the manufacturer and the purchaser.

10.2 The material as furnished under this specification shall be identified by the name or symbol of the manufacturer. The lot size for determining compliance with the requirements of this specification shall be one day's production.

11. Keywords

11.1 glass; sealing

TABLE 1 Physical Requirements

Property	ASTM Test Method ^A	Condition ^A	Value
Softening point	C 338	sec 7.1	630 ± 10°C
Annealing point	C 336 or C 598	sec 7.2	435 ± 10°C
Thermal expansion coefficient	E 228	sec 7.3 0 to 300°C	8.95 ± 0.20 ppm/°C
Contraction coefficient	E 228	sec 7.4 (annealing point minus 15 to 30°C)	10.10 ± 0.20 ppm/°C

^A Test methods and conditions are detailed in the appropriately referenced section of this specification.

TABLE 2 Electrical Properties ^A

Property	ASTM Test Method	Condition	Value (Typical)
Volume resistivity (dc)	D 257 ^B	25°C	$\log_{10} R (\Omega\text{-cm})$ 17.0
		250°C	$\log_{10} R (\Omega\text{-cm})$ 9.9
		350°C	$\log_{10} R (\Omega\text{-cm})$ 7.8
Dielectric constant (1 MHz)	D 150 ^B	20°C	6.7
Dissipation factor (1 MHz)	D 150	20°C	0.0014
Loss index (1 MHz)	D 150	20°C	0.009

^A While having no influence on the sealing capability of the glass, electrical properties are included as information pertaining to the effect of the material on the performance of electronic devices in which it may be used.

^B Test methods are cited in Section 2 of this specification.

APPENDIX
(Nonmandatory Information)
X1. ADDITIONAL INFORMATION

X1.1 *Physical Properties*—The physical properties as listed in Table X1.1, in addition to those included as requirements of the specification, are presented for guidance in negotiating with a specific vendor for their imposition when particularly appropriate. These criteria are not included within the specification because their values are averages of results obtained by various methods, no one of which is presently agreed upon by the glass industry as a whole.

X1.2 *Typical Values for the Mean Coefficient of Linear Thermal Contraction*—Typical values for the mean coefficient of linear thermal contraction of Type 101 glass are given in Table X1.2 for information only. These apply to a specimen of the glass when cooled during the thermal contraction test (see 7.4) from a point above the maximum temperature shown to 30°C at a rate not exceeding 1.5°C/min.

X1.3 *Type 101—Compatible Metals and Sealing Alloys*—The thermal expansion characteristics of Type 101 sealing glass are generally satisfactory for sealing to the metals and alloys in Table X1.3.

TABLE X1.1 Physical Properties

Property	Condition	Unit	Value	Tolerance
Density	...	g/cm ³	3.05	±0.02
Refractive index	sodium (D) line	...	1.56	±0.02
Birefringence, constant or stress-optical coefficient	...	10 ⁻¹² Pa ⁻¹	3.0	±0.2

TABLE X1.2 Typical Contraction Coefficients

Temperature Range, °C	Mean Contraction Coefficient, $\mu\text{m}/\text{m}/^\circ\text{C}$ or ppm/°C
100 to 30	8.6
200 to 30	8.9
300 to 30	9.2
400 to 30	9.7
420 to 30	10.1
450 to 30	10.8

TABLE X1.3 Metals and Sealing Alloys Compatible with Type 101 Glass

Metal or Alloy	ASTM Specification
Platinum	...
Titanium	...
Dumet	F 29, Dumet Wire for Glass to Metal Seal Applications
52 Alloy	F 30, Iron-Nickel Sealing Alloys
41-6 Alloy	F 31, 42 % Nickel-6 % Chromium-Iron Sealing Alloy

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