

US EPA ARCHIVE DOCUMENT

IGNITABILITY OF SOLIDS

SW-846 is not intended to be an analytical training manual. Therefore, method procedures are written based on the assumption that they will be performed by analysts who are formally trained in at least the basic principles of chemical analysis and in the use of the subject technology.

In addition, SW-846 methods, with the exception of required method use for the analysis of method-defined parameters, are intended to be guidance methods which contain general information on how to perform an analytical procedure or technique, which a laboratory can use as a basic starting point for generating its own detailed standard operating procedure (SOP), either for its own general use or for a specific project application. Performance data included in this method are for guidance purposes only and must not be used as absolute quality control (QC) acceptance criteria for purposes of laboratory QC or accreditation.

1.0 SCOPE AND APPLICATION

1.1 This method is suitable for the determination of the ignitability of solids and is appropriate for pastes, granular materials, solids that can be cut into strips, and powdery substances. Also, if it is impractical to perform this test because of the physical form of the sample, generator knowledge should be used to determine the ignitability hazard posed by the material. The test method described here is based on the test procedure adopted by the Department of Transportation (DOT) from the United Nations regulations for the international transportation of dangerous goods (see Appendix E to Part 173 of 49 CFR).

1.2 This method is not required by the Federal regulations to determine if a waste passes or fails the characteristic of ignitability according to the RCRA regulatory definition at 40 CFR 261.21. To clarify, the test results of this method cannot be used to directly classify a waste as a D001 hazardous waste, nor can the results be used by themselves to definitively classify a waste as non-hazardous. No specific test for ignitable solids is required by the RCRA regulations, and only a waste meeting the narrative regulatory definition at 40 CFR 261.21(a)(2) is an ignitable hazardous waste because it is an ignitable solid. In addition, the test in this method for a liquid may be helpful in determining whether a liquid waste has hazardous properties; however, a liquid waste is only a D001 hazardous waste if it is an oxidizer, as defined at 40 CFR 261.21(a)(4), or based on its flash point, as defined at 40 CFR 261.21(a)(1). This test method was developed to specifically illustrate the ignitability properties of materials, including wastes, and its results provide relevant and useful information that may be applied to knowledge of a waste in determining whether a waste meets the 40 CFR 261.21 criteria.

1.3 Prior to employing this method, analysts should consult the disclaimer statement at the front of the manual and the information in Chapter Two for 1) guidance on the intended flexibility in the choice of methods, apparatus, materials, reagents, and supplies; and 2) the responsibilities of the analyst for demonstrating that the techniques employed are appropriate for the analytes of interest, in the matrix of interest, and at the levels of concern.

In addition, analysts and data users are advised that, except where explicitly specified in a regulation, the use of SW-846 methods is *not* mandatory in response to Federal testing requirements. The information contained in this method is provided by the Environmental Protection Agency (EPA) as guidance to be used by the analyst and the regulated community in

making judgments necessary to generate results that meet the data quality objectives (DQOs) for the intended application.

1.4 This method is restricted to use by, or under supervision of, appropriately experienced and trained personnel. Each analyst must demonstrate the ability to generate acceptable results with this method.

2.0 SUMMARY OF METHOD

In a preliminary test, the test material is formed into an unbroken strip or powder train, 250 mm in length. An ignition source is applied to one end of the test material to determine whether combustion will propagate along 200 mm of the strip within a specified time period. Materials that propagate burning along a 200-mm strip within the specified time period are then subjected to a burning rate test. Materials that do not ignite or propagate combustion as described above do not require further testing. In the burning rate test, the burning time is measured over a distance of 100 mm and the rate of burning is determined. The test method described here is based on the test procedure adopted by the Department of Transportation from the United Nations regulations for the international transportation of dangerous goods and is contained in Appendix E to Part 173 of 49 CFR.

3.0 DEFINITIONS

Refer to Chapter One and the manufacturer's instructions for definitions that may be relevant to this procedure.

4.0 INTERFERENCES

4.1 In laboratory tests, the burning rate of duplicate runs is usually repeatable to within 10%. However, large differences in burning rates may occur if experimental conditions are not held constant. Variation in airflow rates, particle size, and moisture content of the test material will affect test results. Therefore, at least triplicate determinations of the burning rate should be conducted.

4.2 Particle size of test material can affect not only the burning rate, but also the ignition of the material. Therefore, the particle size of the test material should be the same for each test run. The particle size of the test material should be reported in a simple descriptive format (e.g., fine powder, sand, coarse granular).

4.3 Temperature of some test material (such as sulfur powder) affects the burning rate. For reproducible results, all tests should be performed at approximately the same initial temperature (ambient room or laboratory temperature).

4.4 All tests must be carried out inside a fume hood with the test apparatus situated perpendicular (90°) to the direction of airflow. Airflow parallel (0°) to the test apparatus results in non-reproducible burning rates.

4.5 The rate of airflow through the fume hood affects the burning rate. An airflow rate that is too high distorts the flame and retards its horizontal propagation. The optimum airflow rate appears to be in the range of 0.7-1 meters per second.

4.6 Materials that are moisture sensitive (i.e., readily absorb moisture from air) should be tested as quickly as possible after removal from the sample container. All materials should be tested as received by the laboratory.

5.0 SAFETY

5.1 This method does not address all safety issues associated with its use. The laboratory is responsible for maintaining a safe work environment and a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method. A reference file of material safety data sheets (MSDSs) should be available to all personnel involved in these analyses.

5.2 Prior to starting the preliminary screening test, all sample materials must be tested to determine if that material is explosive or extremely flammable (see WARNING below). Use a very small portion of material (1 g or less) for this test.

WARNING: If the sample material is explosive or extremely flammable, do not conduct this test.

5.3 This method could involve the combustion of highly flammable materials and the generation of toxic fumes. All tests must be conducted in a suitable fume hood fitted with a pull-down sash to prevent the escape of toxic fumes into working areas. The analyst should wear appropriate protective clothing, including a laboratory jacket or apron, safety glasses, and protective gloves. The laboratory should have appropriate firefighting equipment (such as a Class A fire extinguisher) readily available to extinguish small fires.

6.0 EQUIPMENT AND SUPPLIES

The mention of trade names or commercial products in this manual is for illustrative purposes only, and does not constitute an EPA endorsement or exclusive recommendation for use. The products and instrument settings cited in SW-846 methods represent those products and settings used during method development or subsequently evaluated by the Agency. Glassware, reagents, supplies, equipment, and settings other than those listed in this manual may be employed provided that method performance appropriate for the intended application has been demonstrated and documented.

This section does not list common laboratory glassware (e.g., beakers and flasks) that might be used.

6.1 Low-heat conducting, non-combustible, impervious ceramic tile or equivalent material, an approximate dimension of 25 cm x 25 cm x 2.5 cm (the tile must be at least 25 cm in length to support a 250-mm test sample).

6.2 High temperature marker or equivalent marking device for marking ceramic plates.

6.3 Powder train mold (see Figure 1) for molding powdered and granular materials for the burn rate test. The material of construction can be aluminum, brass, stainless steel, or plastic. The mold is 250 mm in length and has a triangular cross-section, with a width of 20 mm, and a depth of 10 mm as measured from the bottom of the triangular opening to where the sides meet. On both sides of the mold, in the longitudinal direction, two sheets are mounted as lateral limitations which extend 2 mm beyond the upper edge of the triangular cross-section.

This device can be fabricated by most machine shops. The complete burn rate apparatus is available from: Associated Design and Manufacturing Co., Lorton, Virginia, 22079.

6.4 A Bunsen (propane gas and air) burner with a minimum diameter of 5 mm capable of attaining a temperature of at least 1,000 °C.

6.5 Stop watch.

6.6 Thermocouple to measure the temperature of the gas flame.

6.7 Thermometer to measure initial temperature of material (i.e., room temperature).

6.8 Anemometer to measure airflow in the fume hood.

7.0 REAGENTS AND STANDARDS

No special reagents or standards are required to conduct this test.

8.0 SAMPLE COLLECTION, PRESERVATION, AND STORAGE

8.1 Samples should be tested on an as-received basis unless requested otherwise. No sample preservation is required, but sample containers should be completely filled and tightly sealed to preserve sample integrity.

8.2 Samples should be tested as soon as possible after removal from the sample container (i.e., samples should not be allowed to dry or absorb moisture for excessive periods or to lose volatiles). Samples that are chilled or cooled upon receipt to the laboratory should be allowed to equilibrate to the ambient laboratory temperature in the sample container.

9.0 QUALITY CONTROL

9.1 Refer to Chapter One for additional guidance on quality assurance (QA) and quality control (QC) protocols. When inconsistencies exist between QC guidelines, method specific QC criteria take precedence over both technique specific criteria and Chapter One criteria; technique specific QC criteria take precedence over Chapter One criteria. Any effort involving the collection of analytical data should include development of a structured and systematic planning document, such as a Quality Assurance Project Plan (QAPP) or a Sampling and Analysis Plan (SAP), which translates project objectives and specifications into directions for those implementing the project and assessing the results.

Each laboratory should maintain a formal quality assurance program. The laboratory should also maintain records to document the quality of the data generated. Development of in-house QC limits for each method is encouraged. Use of instrument specific QC limits is encouraged, provided such limits will generate data appropriate for use in the intended application. All data sheets and quality control data should be maintained for reference or inspection.

9.2 All tests must be performed on a clean ceramic plate at room temperature.

9.3 All replicate runs must be at the same initial temperature (ambient laboratory temperature).

9.4 All replicate tests must be run at approximately the same airflow through the fume hood.

9.5 Only materials of the same particle size distribution should be used for all replicate tests.

9.6 The burn rate test must be conducted in triplicate if the preliminary screening test is positive. Any burn rate for non-metallic samples that exceeds 2.2 mm/sec (or a burn time of less than 45 seconds for 100 mm) is considered to have a positive result. For metals, a burn rate of more than 0.17 mm/sec (or burn time of less than 10 minutes for 100 mm) is considered to have a positive result.

10.0 CALIBRATION AND STANDARDIZATION

There are no calibration or standardization steps directly associated with this procedure. See the equipment manufacturer's instructions for the calibration of certain equipment used in this method (e.g., the thermocouple).

11.0 PROCEDURE

WARNING: Prior to starting the preliminary screening test, all sample materials must be tested to determine if that material is explosive or extremely flammable. Use a very small portion of material (1 g or less). If the sample material is explosive or extremely flammable, do not conduct this test.

11.1 Preliminary screening test

11.1.1 The preliminary screening test for ignitability is conducted on all waste materials. On a clean, impervious ceramic tile (Sec. 6.1), clearly mark a 250 mm long test path. Make another mark at exactly 200 mm from the start of the sample path.

11.1.2 Prepare the test material in its "as received" form by forming an unbroken strip or powder train of sample 250 mm long by 20 mm wide by 10 mm high on the ceramic tile. Use the mold to form the material as described in Sec. 11.2.3.1, if appropriate.

11.1.3 Place the ceramic tile with the loaded sample in a fume hood about 20 cm (~8 inches) from the front of the hood and in an area of laminar airflow. Position the sample perpendicular to the airflow (See Figure 2). The airflow across the perpendicular axis of the sample should be sufficient to prevent fumes from escaping into the laboratory and should not be varied during the test. The air velocity should be approximately 0.7 meters/second. Measure the air velocity with an anemometer.

11.1.4 Light the Bunsen burner and adjust the height of the flame (6.5 to 7.5 cm) by adjusting the propane gas and air flows. Measure the temperature of the flame (tip of the flame) by a thermocouple. The temperature of the flame must be at least 1000 °C.

11.1.5 Apply the tip of the flame to one end of the sample strip. The test period will depend on the sample matrix (whether non-metallic or metallic) as described below in Sec. 11.1.5.1 and 11.1.5.2.

11.1.5.1 If the waste is non-metallic, hold the flame tip on the sample strip until the sample ignites or for a maximum of 2 minutes. If combustion occurs, begin timing with a stop watch and note whether the combustion propagates up to the 200 mm mark within the 2 minute test period.

11.1.5.2 If the waste is a metal or metal alloy powder, hold the flame tip on the sample strip until the sample ignites or for a maximum of 5 minutes. If combustion occurs, begin timing with a stop watch and note whether the combustion propagates up to the 200-mm mark within the 20 minute test period.

11.1.6 If the waste does not ignite and propagate combustion either by burning with open flame or by smoldering along the 200-mm sample strip within the 2 minute test period (or 20 minute test period for metal powders), the waste is not considered flammable and no further testing is required. If the waste propagates burning of 200 mm of the test strip within the 2 minute test period (20 minute test period for metals), the material must be evaluated by the burning rate test (proceed to Sec. 11.2).

11.2 Burning rate test

11.2.1 The preparation of the test sample for the burning rate test will depend on the physical characteristics of the waste. Wastes that exist in a powdered or granular state are molded in a powder train mold as shown in Figure 1. Pasty materials are formed into a rope that is 250 mm in length with a cross-section of 1 cm². All tests for the burn rate test are performed on clean, ambient temperature, ceramic plates.

11.2.2 On a clean, impervious ceramic tile (Sec. 6.2), clearly mark a 250-mm long test path. Make two additional timing marks at 80 mm and 180 mm from the start of the sample path. The distance between the two marks (100 mm) will be used to calculate the rate of burn in Sec. 12.0.

11.2.3 Sample preparation based on physical characteristics

11.2.3.1 Powder or granular material -- Tighten the side plates on the mold. Place the mold on the base plate. Pour the material to fill the triangular cross section of the mold loosely. Drop the unit from a height of 2 cm onto a solid surface three times to settle the powder. Remove the side supports. Lift the mold off the base plate. Place a clean ceramic test plate with the appropriate timing marks (Sec. 11.2.2) face down on top of the mold. Invert the setup and remove the mold.

11.2.3.2 Pasty wastes - Spread the waste on a marked ceramic tile (Sec. 11.2.2) in the form of a rope 250 mm in length with a cross-section of 1 cm².

11.2.4 Place the ceramic tile with the loaded sample prepared in Sec. 11.2.3 in a fume hood about 20 cm (~8 in) from the front of the hood and in an area of laminar airflow. Position the sample perpendicular to the airflow (See Figure 2). The airflow across the perpendicular axis of the sample should be sufficient to prevent fumes from escaping into the laboratory and should not be varied during the test. The air velocity should be

approximately in the range of 0.7-1 meters/second. Measure the air velocity with an anemometer.

11.2.5 Light the Bunsen burner and adjust the height of the flame (6.5 to 7.5 cm) by adjusting the propane gas and air flows. Measure the temperature of the flame (tip of the flame) by a thermocouple. The temperature of the flame must be at least 1000 °C.

11.2.6 Apply the tip of the flame to one end of the sample strip to ignite the test strip as described in Sec. 11.1.5.1 or 11.1.5.2 (based on whether the sample is non-metallic or metallic).

11.2.7 When the test strip or powder train has burned up to the 80-mm time marker, begin timing the rate of combustion with a stop watch. Stop the timer when the burned strip reaches the 180-mm time marker. Record the amount of time (in sec) required to burn the 100-mm test strip.

12.0 DATA ANALYSIS AND CALCULATIONS

Calculate the rate of burning by dividing the length of the burn test strip (100 mm) by the total time (sec). Results of the burn rate test should be reported in mm/sec. Wastes that have a rate of burning of more than 2.2 mm/sec (or burn time of less than 45 sec for 100 mm) are considered to have a positive result for ignitability according to DOT regulations. For metals, this time is 10 minutes or less for 100 mm (or a burn rate of more than 0.17 mm/sec). The following format may be used to document the data.

Test Material Information

Source of material (e.g., company, operation or process):
 Description of material (e.g., powder or paste, metallic or non-metallic):
 Particle size (e.g., fine powder, granular, sand, etc.):
 Preliminary burning time (sec):

Test Conditions

Date of Test:
 Temperature of test material (°C):
 Air velocity through fume hood (m/s):

| Ignitability Test Data | | | | |
|------------------------|---|--------------------------------|-----------------------|----------|
| Test Number | Time (sec) Elapsed Between Application of Flame and Start of Ignition | Burning Time over 100 mm (sec) | Burning Rate (mm/sec) | Comments |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |

13.0 METHOD PERFORMANCE

13.1 Performance data and related information are provided in SW-846 methods only as examples and guidance. The data does not represent required performance criteria for users of the methods. Instead, performance criteria should be developed on a project-specific basis, and the laboratory should establish in-house QC performance criteria for the application of this method. Performance data must not be used as absolute QC acceptance criteria for laboratory QC or accreditation.

13.2 An independent laboratory validation was conducted on the robustness of the burn rate test procedure. The materials selected for this evaluation included:

1. A 50/50 mixture of metallic silicon and lead dioxide (PbO₂)
2. Excelsior
3. Dextrin (yellow powder)
4. Sulfur (fine yellow powder)
5. Aluminum metal (coarse)
6. Magnesium metal (coarse)
7. Polyethylene high density (granular)
8. Polyethylene low density (fluffy white powder)
9. Scott fertilizer (32-3-10:N-P-K)
10. JP-4 contaminated soil (approximately 5000 ppm)

Of these materials, the 50/50 mixture of metallic silicon and lead dioxide (PbO₂), elemental sulfur, and excelsior gave a positive ignitability result under the conditions of the test. The remaining materials gave negative (nonflammable) results under the conditions of the test. Several test variables including: ignition source, ambient temperature, and apparatus orientation, were studied using these materials. Partial results of this study are summarized in Table 1. These data are provided for guidance purposes only.

13.3 In another evaluation of the DOT burn rate test, potentially ignitable finishing wastes from the furniture industry were collected and tested for burning rates. Each waste was tested in triplicate to establish a mean value for the burning rate. The results for the flammable wastes are summarized in Table 2. These data are provided for guidance purposes only.

13.4 In order to evaluate the ruggedness of the DOT burn rate test, select ignitable finishing wastes were split and tested by a state laboratory and an independent contract laboratory. The results of this comparison are summarized in Table 3. These data are provided for guidance purposes only.

14.0 POLLUTION PREVENTION

14.1 Pollution prevention encompasses any technique that reduces or eliminates the quantity and/or toxicity of waste at the point of generation. Numerous opportunities for pollution prevention exist in laboratory operations. The EPA has established a preferred hierarchy of environmental management techniques that places pollution prevention as the management option of first choice. Whenever feasible, laboratory personnel should use pollution prevention techniques to address their waste generation. When wastes cannot be feasibly reduced at the source, the Agency recommends recycling as the next best option.

14.2 For information about pollution prevention that may be applicable to laboratories and research institutions consult *Less is Better: Laboratory Chemical Management for Waste Reduction*, a free publication available from the American Chemical Society (ACS), Committee on Chemical Safety,
http://portal.acs.org/portal/fileFetch/C/WPCP_012290/pdf/WPCP_012290.pdf.

15.0 WASTE MANAGEMENT

The Environmental Protection Agency requires that laboratory waste management practices be conducted consistent with all applicable rules and regulations. Laboratories are urged to protect air, water, and land by minimizing and controlling all releases from hoods and bench operations, complying with the letter and spirit of any sewer discharge permits and regulations, and by complying with all solid and hazardous waste regulations, particularly the hazardous waste identification rules and land disposal restrictions. For further information on laboratory waste management, consult *The Waste Management Manual for Laboratory Personnel* available from the American Chemical Society at the address listed in Sec. 14.2.

16.0 REFERENCES

1. "Test Methods for Readily Combustible Solids. Burning Rate Test." (14.2.2.5). Recommendations on the Transport of Dangerous Goods, Fifth Revised Edition, United Nations, New York, 1988.
2. 49 CFR, Appendix E to Part 173 (12-31-91 Edition), pp. 597-598.
3. "Flammability (solids). Method A.10," Official Journal of the European Communities, No. L251/63, September 19, 1984.
4. Foster Wheeler Enviresponse, Inc., Edison NJ., "Validation of Ignitability Method For Solids," submitted to the Office of Solid Waste, US EPA, February 1994.
5. Internal Report (AMFA Report), North Carolina Department of Environmental Health and Natural Resources (Bill Hamner).

17.0 TABLES, DIAGRAMS, FLOW CHARTS, AND VALIDATION DATA

The following pages contain the tables and figures referenced by this method. A flow diagram of the procedure is included after the figures.

TABLE 1
TEST VARIABLES FOR IGNITABILITY

| Material Tested | Test Number | Variable combination ¹ | Burn Time over 100 mm (sec) | Burn Rate (mm/sec) |
|--|-------------|-----------------------------------|-----------------------------|--------------------|
| 50% Metallic Silicon and 50% Lead IV Oxide | 1 | ABC | 0.84 | 119 |
| | 2 | Abc | 0.50 | 200 |
| | 3 | aBc | 0.69 | 145 |
| | 4 | abC | 0.65 | 154 |
| Excelsior (wood shavings) | 1 | ABC | 13.45 | 7.43 |
| | 2 | Abc | 9.14 | 10.9 |
| | 3 | aBc | 13.37 | 7.47 |
| | 4 | abC | 13.59 | 7.36 |

¹Key:

A - Flame ignition

a - Hot wire ignition source

B - Ambient temperature of 20 ° C

b - Ambient temperature of 100 ° C

C - Orientation of test apparatus of 90 ° to air flow

c - Orientation of test apparatus of 0 ° to air flow

These data are provided for guidance purposes only.

TABLE 2
EXAMPLE BURNING RATES FOR IGNITABLE WASTES

| Sample No. | Description of Waste | Burn Time over 100 mm (sec) | Burn Rate (mm/sec) |
|------------|----------------------------|-----------------------------|--------------------|
| A2 | Segregated Lacquer Dust | 4.7 | 21.3 |
| J2 | Segregated Lacquer Dust | 4.6 | 21.7 |
| U | Segregated Lacquer Dust | 8.6 | 11.6 |
| K | Consolidated Lacquer Dust | 6.0 | 16.7 |
| H | Catalyzed Lacquer Dust | 6.7 | 14.9 |
| F | Water Based Lacquer Dust | 19.4 | 5.15 |
| P | Booth Coat-Stain Overspray | 12.5 | 8.0 |
| O | Pallet Covered Cardboard | 11.1 | 9.0 |
| Q | Pallet Covered Cardboard | 12.3 | 8.13 |

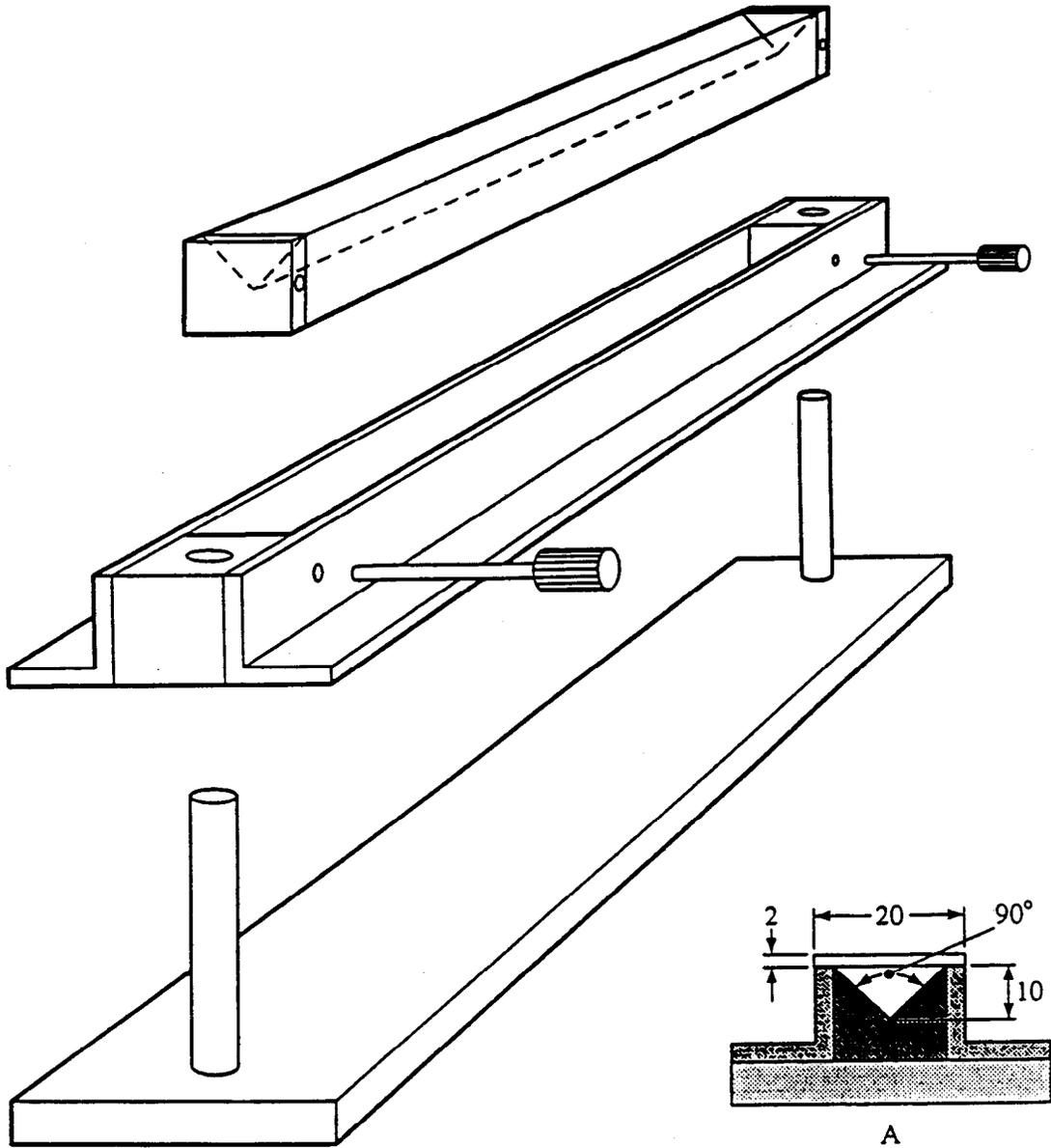
These data are provided for guidance purposes only.

TABLE 3
EXAMPLE COMPARISON OF BURN RATES

| Sample No. | Description of Waste | Mean Burn Time Over 100 mm (Seconds) | |
|------------|----------------------------|--------------------------------------|---------------------|
| | | State Laboratory | Contract Laboratory |
| A1 | Segregated Lacquer Dust | 4.7 | 5 |
| J1 | Segregated Lacquer Dust | 4.6 | 4.3 |
| 12 | Booth Coat-Glaze Overspray | 0 ¹ | 0 ¹ |

¹ Waste was found to be nonflammable under conditions of the test. These data are provided for guidance purposes only.

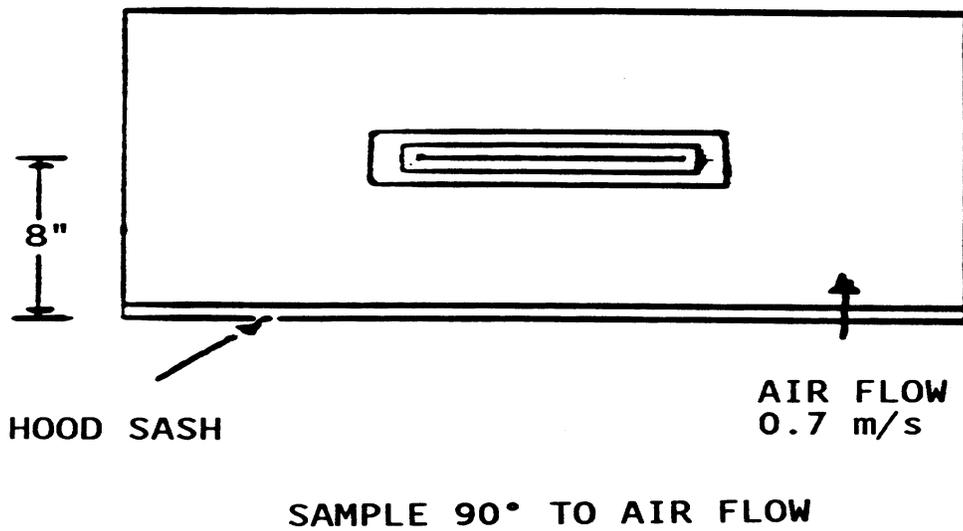
FIGURE 1
POWDER TRAIN MOLD



(A) Cross-section of 250 mm long mould

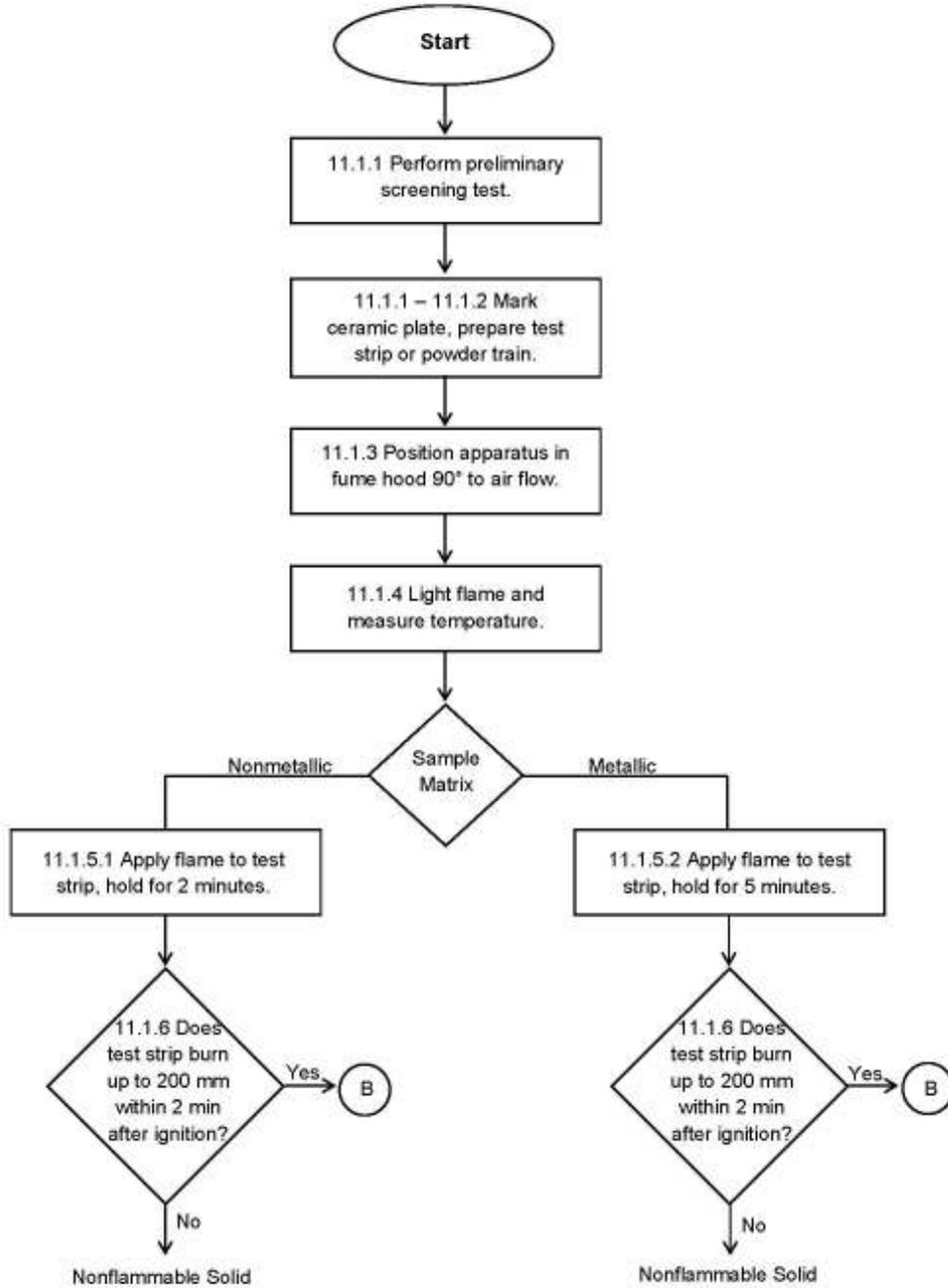
FIGURE 2

TEST APPARATUS POSITION IN FUME HOOD

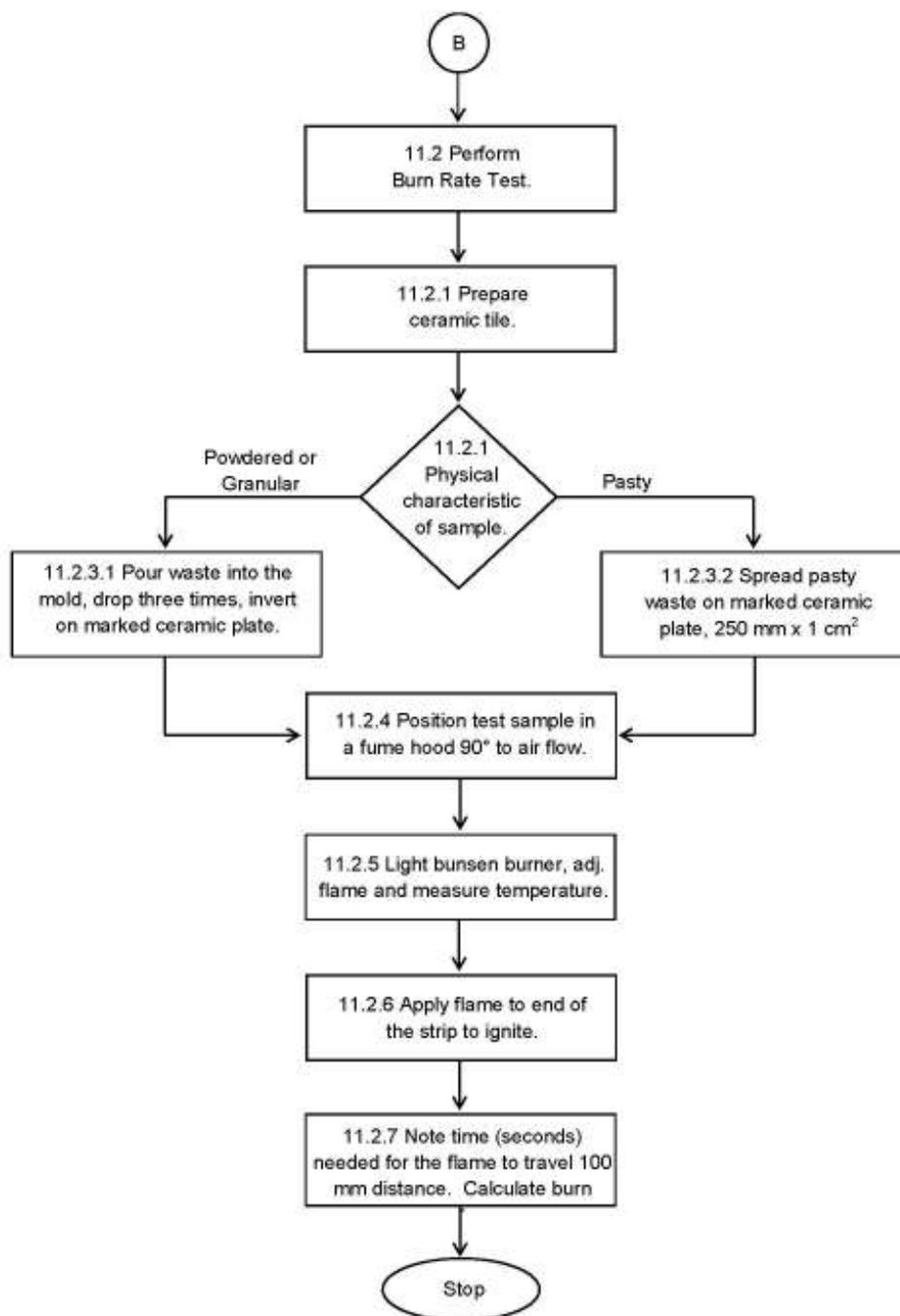


METHOD 1030

IGNITABILITY OF SOLIDS



METHOD 1030 (Continued)



Appendix A:

Summary of Revisions to Method 1030 (From Revision 0 December 1996)

1. Improved overall method formatting for consistency with new SW-846 methods style guidance. The format was updated to Microsoft Word .docx.
2. Minor editorial and technical revisions were made throughout to improve method clarity.
3. The flowcharts on pages 14 and 15 were updated to improve visual clarity and edited for content.
4. The revision number was changed to 1 and the date published was changed to July 2014.
5. This appendix was added showing changes from the previous revision.
6. Items regarding regulatory use of this method in Sec. 1.1 and 1.2 were updated to reflect current guidance.