

METHOD 1030

IGNITABILITY OF SOLIDS

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. This method may be used to meet certain regulatory applications; with respect to the characteristic of ignitability in CFR § 261.21, this method may be used, but is not required, to determine whether a solid waste “when ignited, burns so vigorously and persistently that it creates a hazard.” If it is impractical to perform the test because of the physical form of the sample, generator knowledge should be used to determine the ignitability hazard posed by the material.

2.0 SUMMARY OF METHOD

2.1 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 INTERFERENCES

3.1 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.

3.2 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).

3.3 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).

3.4 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.

3.5 The rate of airflow through the fume hood affects the burning rate. Too high an airflow distorts the flame and retards its horizontal propagation. The optimum airflow appears to be in the range of 0.7-1 meter per second.

3.6 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.

4.0 APPARATUS AND MATERIALS

4.1 Low-heat conducting, non-combustible, impervious ceramic tile or equivalent material, of 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).

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

4.3 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.; 814 N. Henry Street; Alexandria, Virginia 22314.

4.4 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.

4.5 Stop watch.

4.6 Thermocouple to measure the temperature of the gas flame.

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

4.8 Anemometer to measure airflow in the fume hood.

5.0 REAGENTS

5.1 No special reagents are required to conduct this test.

6.0 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

6.1 All samples are tested on 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.

6.2 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.

7.0 PROCEDURE

SAFETY: Prior to starting the preliminary 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 gram or less). If the sample displays explosivity or extreme flammability, do not conduct this test.

7.1 Preliminary Screening Test

7.1.1 The preliminary ignitability test is conducted on all waste materials. On a clean, impervious ceramic tile (Section 4.1), clearly mark a 250 mm long test path. Make another mark at exactly 200 mm from the start of the sample path.

7.1.2 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 in 7.2.3 if appropriate.

7.1.3 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 by an anemometer.

7.1.4 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.

7.1.5 Apply the tip of the flame to one end of the sample strip. The test period will depend on the sample matrix as follows:

7.1.6 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.

7.1.7 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.

7.1.8 If the waste does not ignite and propagate combustion either by burning with open flame or by smoldering along 200 mm of 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 (Section 7.2).

7.2 Burning Rate Test

7.2.1 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 shown in Figure 1. Pasty materials are formed into a rope 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.

7.2.2 On a clean, impervious ceramic tile (Section 4.1), 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 Section 7.2.9.

7.2.3 Tighten the side plates on the mold. For powdered or granular materials: Place the mold on the base plate. Pour the material to fill the triangular cross section of the mold loosely.

7.2.4 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 (Section 7.2.2) face down on top of the mold. Invert the setup and remove the mold.

7.2.5 Pasty wastes are prepared by spreading the waste on a marked ceramic tile (Section 7.2.2) in the form of a rope 250 mm in length with a cross-section of 1 cm².

7.2.6 Place the ceramic tile with the loaded sample prepared in Sections 7.2.3 or 7.2.5 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.

7.2.7 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.

7.2.8 Apply the tip of the flame to one end of the sample strip to ignite the test strip as described in Section 7.1.6 and 7.1.7.

7.2.9 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 seconds) required to burn the 100 mm test strip. Calculate the rate of burning by dividing the length of the burn test strip (100 mm) by the total time (seconds). 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 seconds 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).

7.2.10 Report and Calculation Section

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: ____ seconds.

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 | | | | |

8.0 QUALITY CONTROL

8.1 All tests must be performed on a clean ceramic plate at room temperature. All samples must have been collected using a sampling plan that addresses the considerations discussed in Chapter Nine of this manual.

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

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

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

8.5 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.

9.0 METHOD PERFORMANCE

9.1 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 (PbO_2)
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 (PbO_2), elemental sulfur, and excelsior were considered to give 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.

9.2 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.

9.3 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.

10.0 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. DOT Regulation. Appendix E to Part 173 of 49 CFR, Chapter 1 (12-31-91 Edition). pp. 597-598.
3. Flammability (solids). Method A.10. Official Journal of the European Communities. 9/19/84. No. L251/63.

4. "Validation of Ignitability Method For Solids" Foster Wheeler Enviresponse, Inc., Edison NJ., 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)

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 |
| ¹ where: 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 | | | | |

TABLE 2
BURNING RATES FOR IGNITABLE WASTES

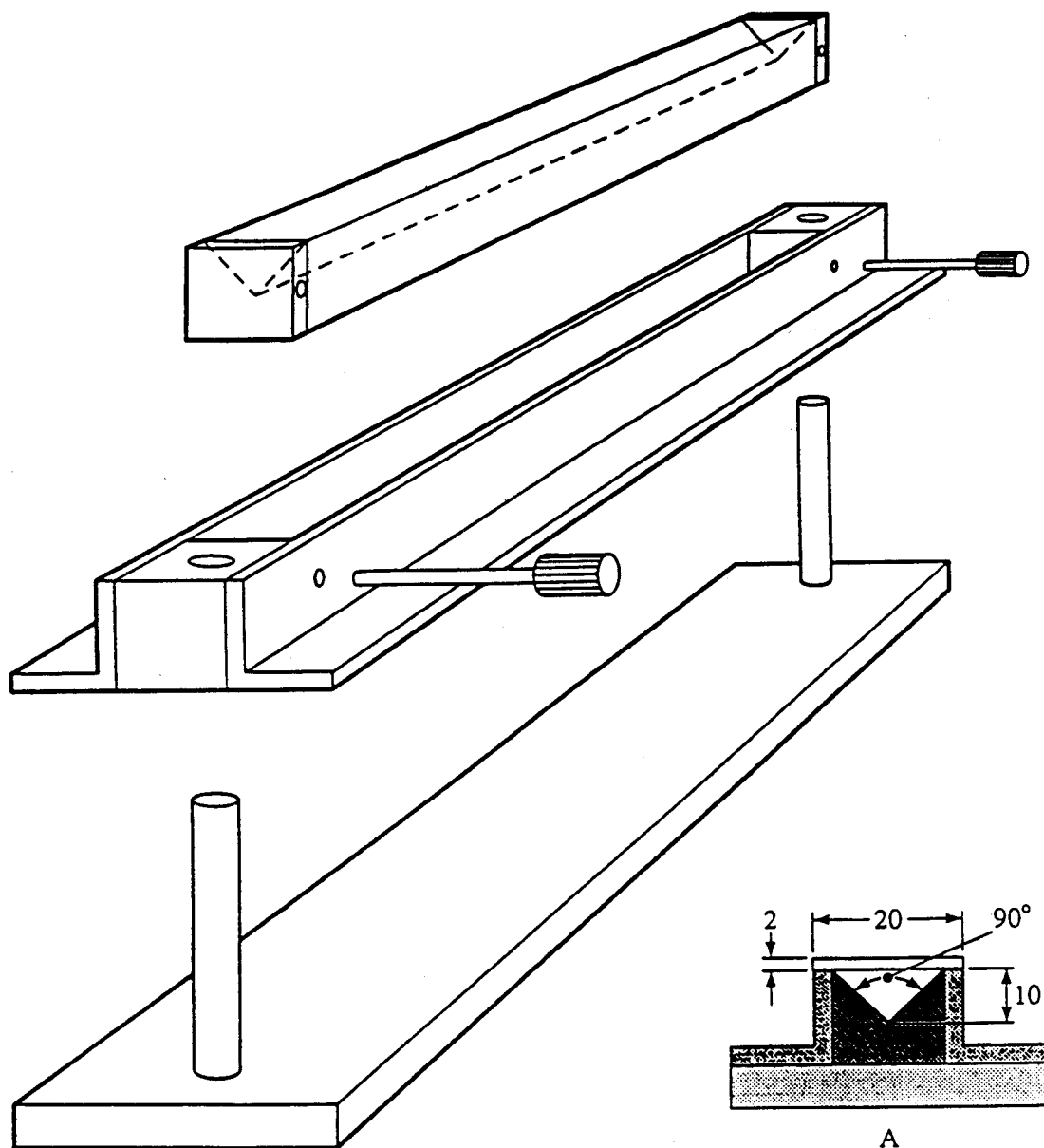
| Sample No. | Description of Waste | Burn Time over 100 mm (sec) | Burn Rate (mm/sec) |
|------------|----------------------------|-----------------------------|--------------------|
| A2 | Segregated Lacquer Dust | 4.7 | 21.3 |
| J2 | Segregated Lacquer Dust | 4.6 | 21.7 |
| U | Segregated Lacquer 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 |

TABLE 3
COMPARISON OF BURN RATES

| Sample No. | Description of Waste | Mean Burn Time Over 100 mm in 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.

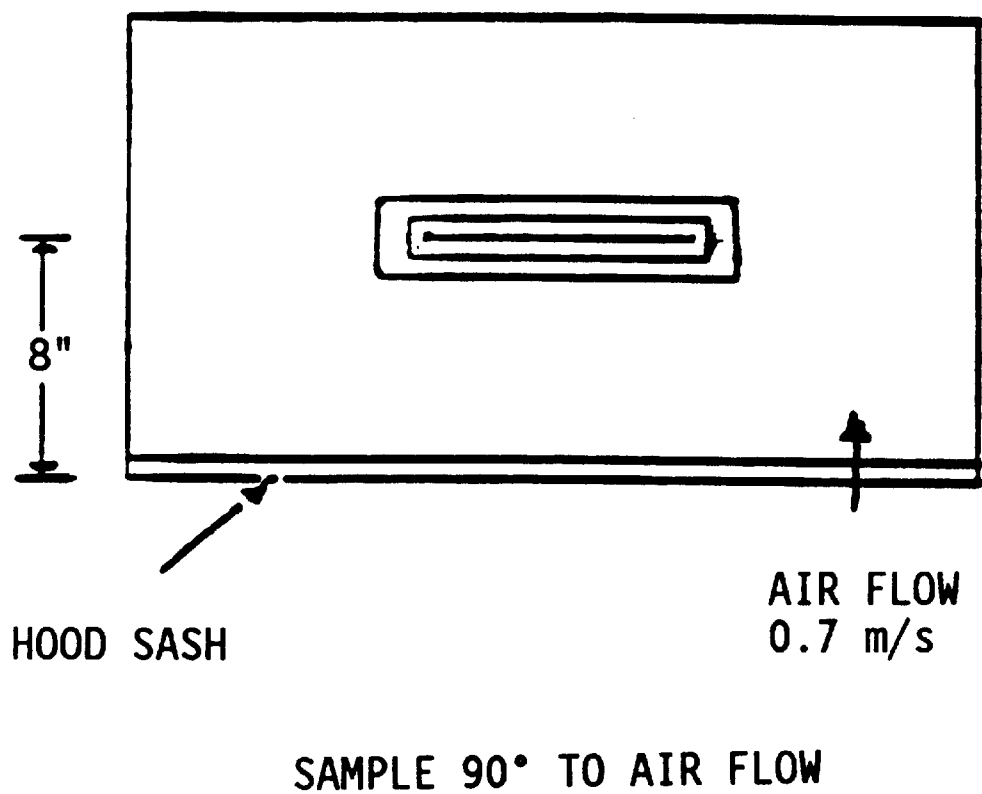
Figure 1
Powder Train Mold



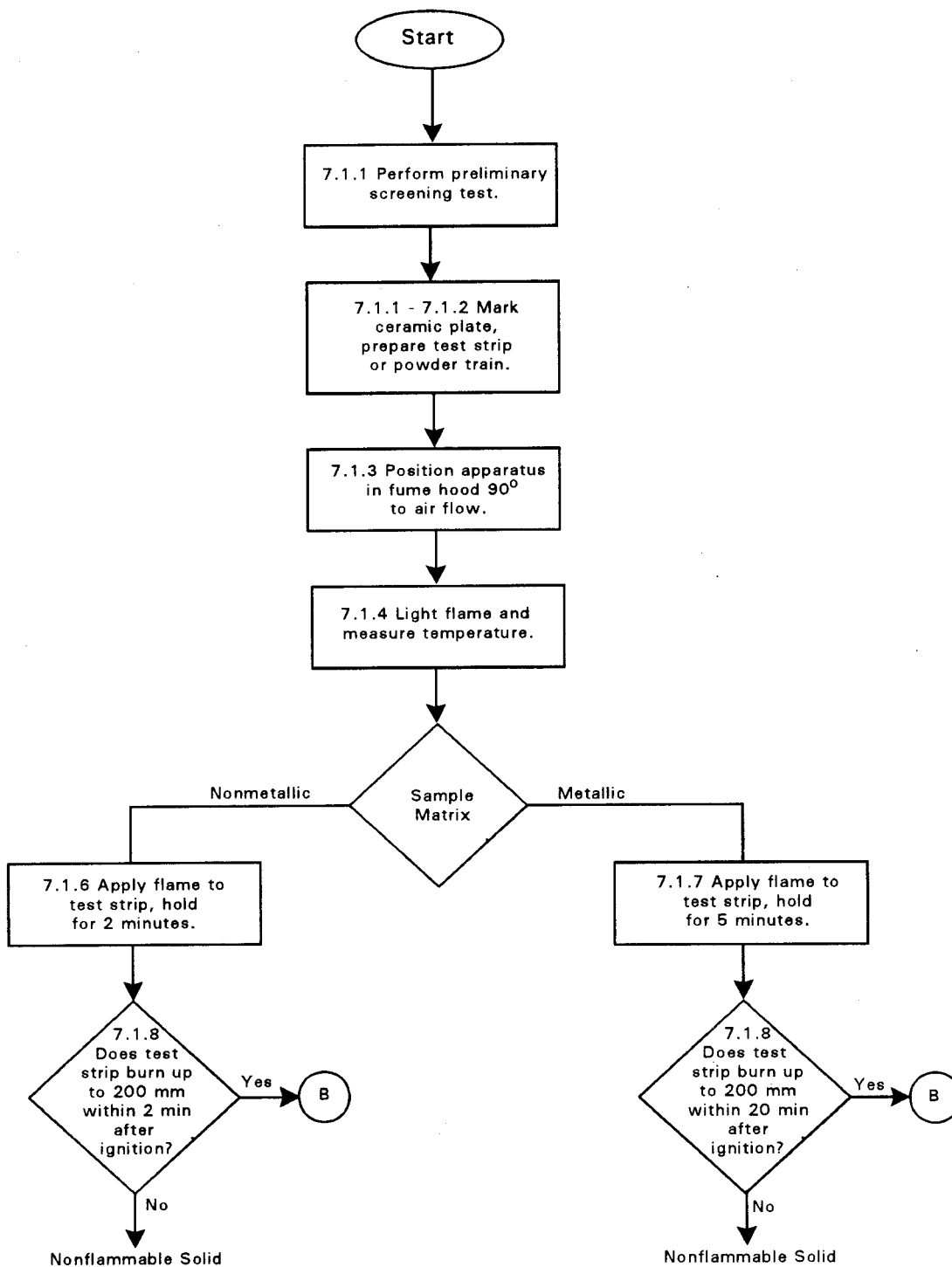
(A) Cross-section of 250 mm long mould

Figure 2

Test Apparatus Position in Fume Hood



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