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Flammability Testing of Solids Under the Federal Hazardous Substances Act

Richard D. Peacock and
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Center for Fire Research
National Engineering Laboratory
National Bureau of Standards
U.S. Department of Commerce
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Final Report

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

FLAMMABILITY TESTING OF SOLIDS UNDER THE FEDERAL HAZARDOUS SUBSTANCES ACT

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Abstract

The objective of the Federal Hazardous Substances Act is to protect the consumer from hazards that arise from a large variety of products. The Act and its regulations have several provisions pertaining to the measurement of the flammability of substances. Some are detailed and explicit; others provide only general guidelines.

This report presents the results of a program to provide improvements to particular provisions of the Act and includes test methods that may be used for the testing of various solid materials. An extensive review of the Federal Hazardous Substances Act, its predecessor, and the legislative history provides the basis for some specific recommendations for improvement or clarification. Experimental work performed for the improvement of test methods for shredded or slit films, powders, pastes, and granular substances, and for extremely flammable solids is discussed. This report is based on work sponsored by the Consumer Product Safety Commission and performed from 1974 through 1976.

Key words: Federal Hazardous Substances Act; flammability; granulars; hazardous substances; pastes; powders; shredded and slit films; solids; sparks; test methods.

1. INTRODUCTION

The objective of the Federal Hazardous Substances Act is to protect the consumer from hazards that arise from a large variety of products. The Act and its regulations have several provisions pertaining to the measurement of the flammability of substances. Some are detailed and explicit while others provide only general guidelines.

The results of a program to provide improvements to particular provisions of the Act and to develop test methods that may be used for the testing of various solid materials is presented. An extensive review of the Federal Hazardous Substances Act, its predecessor, and the legislative history provides the basis for some specific recommendations for improvement or clarification. Experimental work performed for the improvement of test methods for shredded or slit films, powders, pastes, and granular substances, and for extremely flammable solids is discussed. This report is based on work sponsored by the Consumer Product Safety Commission (CPSC) and performed from 1974-1976.

2. THE FEDERAL HAZARDOUS SUBSTANCES ACT

2.1 Legislative History

In 1927, Congress passed the Federal Caustic Poison Act which required the labeling of caustic or corrosive substances. It listed only 12 chemical substances that required labeling. By 1960, many new substances for household use had been introduced into commerce, some potentially hazardous. No warning labeling indicating possible hazard(s) was required for these new substances, since they were not covered by the 1927 Act. To remedy this situation, Congress passed the Federal Hazardous Substances Labeling Act (FHSLA) in 1960. It was intended to protect the health and safety of the public by establishing uniform standards for the labeling of those hazardous substances which are used in and around the household [1][1]. These labels were meant to (a) warn the user of any hazard in the normal use of the product and (b) list the hazardous ingredient(s) to aid the physician in case an accident did occur [2]. The bill covered those substances that were toxic, corrosive, flammable, irritants, strong sensitizers, and those that generate pressure. It also covered some radioactive substances [3].

In 1966, Congress determined that for most products this cautionary labeling offered sufficient protection, but that there were products (particularly among those intended for use by children) which were so extremely hazardous that they could not be made safe for household use by cautionary labeling [4,5]. Congress thereafter amended the FHSLA by passing the Child Protection Act of 1966. This combination became the Federal Hazardous Substances Act (FHSA). The amendment was intended to empower the enforcing

[1]Numbers in brackets refer to the literature references listed at the end of this report.

authority to ban hazardous toys, other hazardous articles meant for children, and any other article that was judged to be so hazardous as to be unsafe in the household, no matter what labeling was required. It also made the FHSA applicable to unpackaged articles that were intended to be used in the household [6].

In 1969, Congress became aware that the FHSA, as amended in 1966, failed to protect children from toys and other articles intended for use by children which are hazardous due to the presence of electrical, mechanical, or thermal hazards. The FHSA was limited by its definition of hazardous substance which confined the Act to substances that were toxic, corrosive, flammable, irritating, strongly sensitizing, or pressure generating through decomposition, heat, etc. [7]. Consequently, Congress amended the FHSA by passing the Child Protection and Toy Safety Act of 1969, thereby protecting children from toys and other articles intended for use by children whose primary source of hazard stemmed from electrical, mechanical, or thermal sources [8].

The FHSA was further amended in 1970 by the Poison Prevention Packaging Act of 1970 and in 1976 by the Consumer Product Safety Commission Improvements Act.

2.2 General Definitions Under the FHSA

As far as flammability is concerned, the FHSA defines a hazardous substance as any substance which is combustible, if such substance can cause substantial personal injury or illness as a result of reasonably foreseeable handling or use by the public. A misbranded hazardous substance is any hazardous household substance (including toys and children's articles) that is either not labeled or the label fails to comply with all the labeling requirements of the FHSA. If the source of the hazard is flammability, the label must contain (a) the name and place of business of the manufacturer, packer, and distributor or seller; (b) the common name of the substance that is the source of the hazard; (c) the signal word DANGER if the item is "extremely flammable;" (d) the signal word WARNING or CAUTION if the item is "flammable" or "combustible;" (e) the name of the principal hazard, such as "flammable," "causes burns," etc. (the wording must clearly describe the hazard involved); (f) a list of the precautionary steps the user should take; (g) instructions for first aid in case an accident does occur; (h) storage and handling instructions--whenever such information is necessary for the safe storage and handling of the item by the user; and (i) either the statement "Keep Out of the Reach of Children" or if it is a hazardous substance (but not a banned hazardous substance) designed to be used by children it should contain

sufficient directions so that the item can be safely used by children. The label must be located prominently, and the information on it must be in English, in legible and conspicuous type, and contrasting markedly with other printed matter on the label. A banned hazardous substance is a toy or item intended for use by children (except those specifically exempted by the Act), or any other substance used in or around the home that the Consumer Product Safety Commission determines to be so hazardous that in spite of labeling its presence or use in households still poses a hazard of personal injury or illness.

2.3 Flammability Under the FHSA

Except for certain toys, items and substances that present an imminent hazard to the consumer, the FHSA is a labeling act. By means of definitions and test methods, it classifies hazardous substances into three labeling categories: extremely flammable, flammable, and combustible. Unfortunately, the terms flammable, combustible, and extremely flammable do not have distinctly different meanings to either laymen or technicians. For labeling purposes, it would be more useful to the consumer to use the more common term "flammable" on those products whose burning characteristics are such that the consumer should be warned. The regulations should then specify appropriate tests to determine whether the product should be banned or labeled as flammable. Furthermore, the regulations should prohibit labeling with terms such as "nonflammable," "not flammable," "not combustible," etc., on products which pass the test, for most materials will burn given the appropriate conditions. Therefore, meeting the criteria of a small-scale flammability test does not necessarily indicate that the material or substance is not flammable (i.e., cannot burn).

The FHSA directs the CPSC to define the three labeling terms of "flammable," "extremely flammable," and "combustible" for the contents of self-pressurized containers and for substances which are solids. For all other substances, these three terms are defined by a test method and criteria specified in the FHSA itself. This test method, that the Act specifies, is the Tagliabue (Tag) Open Cup Test which consists of placing the sample in the cup of the Tag Open Cup Tester and heating it at a specified constant rate [the temperature of the sample should rise at a rate of 1.1 ± 0.3°C/min (2 ± 0.5°F/min)]. A 0.4 cm (5/32 in) long test flame is passed over the heating sample at a specified rate at specified intervals. The flash point is considered to be that temperature at which the test flame causes the surface vapors of the sample to ignite but not to continue burning. This test is limited, by practical considerations, to liquids. Gases are covered by this Act only if they happen to be the contents of self-pressurized containers.

The Act defines the limits in terms of the Tag test for the three degrees of flammability as follows:

Extremely Flammable - any substance which has a flash point at or below -6.7°C (20°F) as determined by the Tagliabue Open Cup Tester.

Flammable - any substance which has a flash point of above -6.7°C (20°F) to and including 27°C (80°F) as determined by the Tagliabue Open Cup Tester.

Combustible - any substance which has a flash point above 27°C (80°F) to and including 66°C (150°F) as determined by the Tagliabue Open Cup Tester.

These classifications and their definitions are an expressed part of the Act (rather than the associated regulations which CPSC can change as the need arises), and therefore, cannot be changed, except by Congress.

The definitions are based on flash points and indicate only the class for which the substance should be labeled; no test methods or criteria are given to determine when a substance actually becomes a banned hazardous substance, nor is the Commission directed to define such criteria and test methods. There are a considerable number of thermal burn accidents involving liquids each year, and one questions the adequacy of these definitions, based on flash point only, to protect the public health and safety. However, since the classifications and their definitions are part of the Act (rather than the regulations), the Commission cannot redefine the above labeling classifications to accurately reflect possible hazards involved in the use of these substances. The Commission can ban substances--for banning takes only a finding by the Commission that in spite of any cautionary labeling the hazard of the substance is such that it cannot be safely used around the household. Banning requires neither a standard test method nor a test criteria.

The FHSA directs the Commission to specify the test method and hazard definition of "extremely flammable," "flammable," and "combustible" for solids and for the contents of self-pressurized containers. Therefore, for solids and for contents of self-pressurized containers, the method of testing for hazards and their hazard criteria is to be set forth, not in the Act itself, but under its addendum of "Regulations." It is unfortunate that the Act directs such a classification scheme of flammability, for it implies that substances passing a flammability test method under the FHSA cannot burn, which may or may not be true. Items in many flammability tests may pass the pass/fail criteria, indicating a certain level of safety, but may still be capable of burning. This type of labeling gives the public an erroneous concept of the

safety of the substance and may itself be a hazard simply because it is misleading the public regarding the true physical behavior of the substance in the presence of ignition sources.

The "Regulations" (in section 1500.3) define an extremely flammable solid as a solid substance that ignites and burns at an ambient temperature of 80°F or less when subjected to friction, percussion, or electrical spark. A flammable solid is defined as a solid substance that ignites and burns with a self-sustained flame at a rate greater than 0.25 cm/sec (0.1 in/sec) along its major axis in a vaguely defined horizontal burn rate test. Combustible solid is not defined. "Extremely flammable contents of a self-pressurized container" are defined as the contents of a self-pressurized container that have a flash point below -6.7°C (20°F) when tested by the Tagliabue Open Cup Test and a flashback flame extending back to the dispenser when tested by a roughly described flame flashback test. "Flammable contents of a self-pressurized container" are defined as the contents of a self-pressurized container that exhibit a flame projection greater than 18 inches when tested by the same loosely-defined flame flashback test that defines extremely flammable contents of a self-pressurized container. "Combustible contents of self-pressurized containers" are not defined in the Regulations.

2.4 §1500.44 of the Regulations Under the FHSA

Section 1500.44 of the Federal Hazardous Substances Act Regulations (known as the Regulations) is entitled "Method for Determining Extremely Flammable Solids." It contains two modes of sample preparation and one method of testing, with one criterion for passing the test method. The test method (and criterion) described in the Regulations reflects the definition given for "flammable solid" and bears no relationship to the definition given for "extremely flammable solid." The word "Method" in the title of the section is used in the singular, thereby implying that the method of test given in the section is intended to apply to both "extremely flammable solid" and "flammable solid."

The criterion for all "flammable solids" is set by the definition given for flammable solid: a rate greater than 0.25 cm/sec (0.1 in/sec) along the major axis. This fails to take into account the fact that different types of solids under different end-use conditions may present different types of flammability hazard situations, requiring different test methods and criteria to reflect the actual hazard presented. It also fails to consider the fact that not all solids (such as shredded materials, granular materials, spheres, etc.) have a major axis.

The two modes of sample preparation given are (a) for granules, powders, and pastes and (b) for rigid and pliable solids. For "granules, powders, and pastes" the method of sample preparation given directs one to pack the sample into a flat, rectangular metal boat with inner dimensions 15.2 cm long by 2.5 cm wide by 0.6 cm deep (6 in x 1 in x 1/4 in). No mention is made as to what density is to be obtained in the packing--should one pack loosely, tightly, ...? Every experimenter is allowed his/her own interpretation, which could lead to differing test results with some materials. Work on improving the test method for powders, pastes, and granules was previously reported [11] and specific recommendations will be made.

The method of sample preparation for "rigid and pliable solids" directs one to measure the dimensions of the sample and to support it by means of metal ring stands, clamps, or any other suitable means in such a manner that the major axis is oriented horizontally and the maximum surface is freely exposed to the atmosphere. Measuring the dimensions of an object can become very complicated, since most solid objects are not rectangular or spherical, but odd-shaped. The directions imply that all dimensions of the item need to be measured, yet the burn rate is based on the rate of burning along the major axis. What constitutes the sample? Does the sample consist of the entire centerpiece, decoration, toy, etc., or does it consist of a component which has an entity of its own, such as a plastic or dried flower, small figurine, candle, or candle holder which is part of the "arrangement?" Again, it is left up to the person conducting the test to determine the sample definition, and again, each experimenter is left free to come up with a definition differing from that of his predecessor or competitor. The sample is to be supported by means of metal ring stands or other suitable devices as needed. Many systems of specimen support, considerably different from one another, may be "suitable," i.e., capable of supporting the sample. Since different experimenters are left free to use different specimen support systems for identical specimens, they are quite likely to obtain different test results. Which results, in such a situation, are legally valid? According to the definition and test method, as specified in the Regulations, all test results (even those differing radically from one another) can be valid. The specimen is to be supported in such a manner that its major axis is oriented horizontally. Aside from the fact that some specimens do not have a major axis (for example, shredded materials), and other specimens have a major axis that shifts directions (such as torus shaped solids), is the hazard presented by the solid to be tested reflected by the measurement of burn rate along the major axis oriented horizontally if the solid in question is generally used in such a manner that its major axis is not horizontally oriented? For that matter, is

burn rate necessarily the parameter which reflects the hazard presented by that solid under the conditions of its general or possible use?

The test procedure under §1500.44 of the Regulations specifies that the sample be ignited by holding a burning paraffin candle so that the flame is in contact with the surface of the sample at the end of the major axis for 5 seconds (or until the sample ignites, whichever is less). Unfortunately, this does not let the experimenter know whether to ignite on the top surface, bottom surface, etc. Since the ignition source is a burning candle, the simplest mode of ignition would be that of holding the flame under the sample. Flame propagation along its underside, however, may not be the normal mode of flame propagation for that solid and may yield results indicating a much lower level of hazard than would be obtained if the sample were ignited in such a manner that flame propagation could occur along the surface in its end-use configuration. If the sample is ignited on the upper surface, one has to contend with dripping wax resulting from the fact that this mode of ignition necessitates that the candle be turned nearly upside down in order to obtain flame contact with the upper surface of the sample. Since the dripping wax contaminates the sample being tested, erroneous (but legally valid) test results may be obtained. The candle ignition source specified may itself be a hazard in the testing laboratory, for it is not a very stable object, particularly when an experimenter is trying to quickly set it on a laboratory bench after ignition of the sample has occurred, while at the same time attempting to time the burning of the specimen.

2.5 The Scope of the FHSA as It Applies to the Flammability of Solids

The criteria for inclusion under the FHSA are (a) that the solid be used in or around a household, (b) that the solid be capable of causing substantial personal injury or illness because of its flammability properties (the Regulations consider a substantial personal injury or illness any illness or injury of a significant nature, excluding only those that are negligible), (c) the solid is not specifically exempted by the Act, and (d) the solid is not already covered by another act, such as the Flammable Fabrics Act, for example.

Two large categories of solids (not already covered by another act) found in a household that may be potentially capable of causing personal injury or illness due to their flammability properties are decorations and toys. The following list indicates the types of items that may have to be considered in the design of test methods under the FHSA.

Wall Decorations

-- Pictures

. Framed/Unframed

Cardboard
Wallboard

-- Wreaths/Floral Arrangements Made of

. Natural Materials

Cellulosic
Protein

. Synthetic Polymeric Materials

Thermoplastic Materials
Thermosetting Materials

. Fabrics

-- Carvings

. Wood
. Wax

-- Textile Wall Hangings

-- Animal Skins

-- Preserved Animal Heads, Etc.

-- Clock Frames

-- Wall Sconces

-- Wall "Planters"

. of Plastic Materials
. of Natural Dried Materials

-- Wall Plaques

-- Plastic Mirrors and Frames

Table Decorations

-- Floral Arrangements Made of

. Natural Dried Materials
. Artificial Materials
. Fabrics

-- Candles

-- Candle Holders

-- Carvings

-- Figurines Made of

. Wax
. Wood
. Straw
. Cloth
. Plastic

Seasonal Decorations

-- Easter

. Easter Baskets
. Easter Grass
. Easter Eggs (Artificial)
. Easter Bunnies

-- Christmas

. Trees
. Hanging Tree Decorations
. Under Tree Blankets
. Garlands

-- Halloween

-- Thanksgiving

-- Seasonal Dolls (Type Incorporated in "Arrangements")

General Party Decorations Such as Those Used at Weddings, Showers, Birthdays, Etc.

-- Accordian Tissue-Paper Shapes or Figures

-- Streamers

Toys

-- Puppets

-- Stuffed Toys (and Their Clothes)

-- Dolls and Their Clothes

-- Construction Toys

-- Puzzles

-- Building Blocks

-- Balls, Hoops

-- Baby Toys Such as Rattles, Mobiles

Some other possible sources of burn injuries from solids found in the household are:

-- Mobiles

-- Pompoms

-- Pot Holders

-- Cleaning Equipment Such as Brooms, Mops

Priority for the design of these test methods should be determined by demonstrated need for a test method for a given type of solid, based on accident/injury information involving that type of solid. If the item is new to the marketplace, accident data cannot be expected to exist, and priority setting must then depend upon the less desirable method of prediction of possible accident situations and sequences and simulating them in the laboratory to determine the probable nature of the hazard of the item.

2.6 Recommendations for Improvements of the Act and Regulations

Based on this review of the Act and its regulations, the following recommendations were made by NBS to CPSC in August 1976:

(a) That Congress be petitioned to amend the FHSA to remove the classification of extremely flammable, flammable, and combustible from the Act itself, allowing the Commission to determine the flammability labeling terminology that would most appropriately protect the public; to further amend the FHSA to remove the flammability test method and criteria from the Act itself, allowing the Commission to determine flammability test methods and criteria for all hazardously flammable substances (not covered by other acts) that reflect the hazard presented by the various flammable substances;

(b) That the definitions for the terms extremely flammable solid and flammable solid as presently given in the Regulations be abolished and that labeling terms be defined for different types of solids with a test method that approximates the end-use of the product and, therefore, relates to the hazard presented by the solid;

(c) That the flammability test method for solids given in the Regulations be abolished and replaced by test methods that appropriately and repeatedly measure the hazard presented by the different types of solids;

(d) That test methods be designed not only to allow the appropriate labeling of hazardously flammable solids, but that test methods also be designed to determine when a hazardous substance should be banned;

(e) That priorities be set by CPSC to determine the order in which these test methods are to be developed;

(f) That CPSC conduct in-depth flammability-accident investigations for the various types of solids so that proper priorities for test method development may be set and that the resulting test methods may reflect the hazard posed by the different solids.

3. METHODS FOR TESTING OF SOLIDS UNDER THE FHSA

NBS was requested to place special emphasis, initially, on the development of a method for the testing of shredded or slit films such as Easter grass, and to follow up with methods for testing decorations and other items until all products or product categories that are covered by the flammable solids regulations can be adequately tested and the regulations enforced by CPSC. It is anticipated that a series of test methods will be required to address the multitude of products covered by the flammable solids regulations. A tentative categorization of test methods for various products is shown below. These represent initial groupings, but are apt to be changed as materials are actually tested, potential hazards are reviewed, and test capabilities are evaluated.

Test Method I -- Trough: Deep

Shredded or slit films (as used for Easter grass).

Loose, fibrous materials (as used for artificial hair in wigs, beards).

Shredded materials (stuffing for dolls, animals).

Pelleted materials (stuffing for dolls, animals).

Chipped materials (stuffing for dolls, animals).

Components (smaller than 1 inch) of multicomponent structures (such as puzzles, building blocks).

Other related materials.

Test Method II -- Trough: Shallow

Granules

Powders

Pastes

Test Method III -- Spark Ignition

Materials that may be subjected to a spark in typical end-use conditions.

Test Method IV -- Vertical: Frame-Supported

Fabrics and films used in doll clothes, costumes, other toys.

Materials used in toys or decorations that must be frame-supported to hold the material in place and may be used as a vertical surface in the end-use configuration.

Test Method V -- Vertical: Not Frame-Supported

Decorations and toys of such a nature that they should be tested in the vertical mode but are not of a configuration amenable to being supported by means of a frame-type holder.

Test Method VI -- Horizontal: Frame-Supported

Decorations and toys of such a nature that they should be tested in the horizontal mode and are of a configuration which is easily supported by means of an appropriate frame.

Test Method VII -- Horizontal: Not Frame-Supported

Decorations and toys of such a nature that they should be tested in the horizontal mode but are not of a configuration amenable to being supported by means of a frame-type holder.

Test Method VIII -- Top Ignition

Decorations which by the nature of their use are likely to be ignited from the top (such as candle holders).

Before a particular test method is extended to types of materials not tested during the development process of that test method, additional testing will be required to insure that the test method is truly applicable to the testing of the material being proposed for inclusion in the scope of that test method. A prime objective is to minimize the number of different test methods, but to have test methods that are repeatable and reproducible and validly assess the hazards of the products tested.

4. TEST METHOD I FOR FIBERS, SHREDDED MATERIALS, AND SLIT FILMS

4.1 Introduction and Background

In the development of a test method for fibers, shredded materials, and slit films, Easter grass was selected as representative of the type of material that would be tested by this method. As currently covered by the Federal Hazardous Substances Act under a procedure for rigid and pliable solids, these grasses are to be tested horizontally along a major axis. No guidelines are included to define a sample of material and no provisions are made for materials which do not clearly indicate a major axis. Since Easter grass and similar materials (having no major axis) are not amenable to testing in this manner, it was necessary that a better defined and more suitable method for testing such materials be developed.

4.2 Accident Scenarios and Simulations

While there are no documented cases of injury or property loss involving Easter grass in either the Flammable Fabrics Accident Case and Testing System (FFACTS) or the National Electronic Injury Surveillance System (NEISS),

scenarios can be developed to point out the most likely ways for injury and property loss to occur. The following scenario seems probable. A child playing with a potential ignition source (matches, cigarette lighter) may either drop the ignition source onto Easter grass accidently, or hold the flame to the grass intentionally. In either case, if the grass will ignite, it will burn at a fire spread rate corresponding to its inherent flammability. As the grass burns, it may further involve the child's clothing or other nearby materials.

To ascertain the validity of this scenario, a number of preliminary experiments were conducted to determine the burning behavior of various grasses when exposed to a small ignition source. Easter grasses were obtained which are described in table 1 and placed in different Easter baskets as shown in table 2. After ignition by a wooden match placed centrally on top of the grass, four general classes of burning behavior were observed:

(a) Untreated thermoplastic grasses were difficult to ignite and flames from the burning grasses spread slowly. As the burning continued, molten grass formed puddles burning with larger flames when unrestrained by items such as eggs or candy.

(b) Treated thermoplastic grasses, also difficult to ignite, burned with a tenuous flame and extinguished as soon as the match burned out.

(c) Untreated cellulosic grasses were ignited readily and flames spread quickly over the entire surface of the grass. Burning continued with very large flames, consuming the remaining grass in a short time.

(d) Treated cellulosic grasses could not be ignited when exposed to a match ignition source.

Thus, the ignition and subsequent growth of fire depends on two important parameters:

(a) The ease of ignition of the Easter grass, and

(b) The rate of the spread of fire if the grass ignites.

4.3 Apparatus and Test Method

The apparatus designed for the testing of Easter grasses was constructed similar to an apparatus used for the testing of powders and pastes in an

earlier NBS study [11]. The apparatus, illustrated in figures 1 through 3, consists of a horizontal trough into which the grass is placed and ignited at one end with a flame from a gas burner. The grass is allowed to burn and the rate at which the flames travel down the trough is measured. Engineering drawings are included in the attached Proposed Test Method for the Flammability of Solids Under the Federal Hazardous Substances Act; Method I, for Fibers, Shredded Materials, and Slit Films, appendix A. Briefly, the features of the new apparatus are:

(a) A gas burner ignition source equipped with a needle valve to control the gas flow and flame length;

(b) An aluminum trough 30 cm (11-7/8 in) long, 10 cm (4 in) wide, and 7 cm (2-3/4 in) deep with a wire mesh insert to hold the specimen;

(c) Use of a wire mesh top restraint to hold the specimen in place (table 3);

(d) The use of trip threads strung across the trough 15 cm (6 in) apart which burn through as the flame travels down the trough to allow accurate timing of the flame spread rate.

4.4 Results and Discussion

A number of grasses were tested under several test configurations. Table 4 presents the results of experiments investigating the following test parameters: (a) specimen weight, (b) equipment cooling, (c) type of insert and specimen top restraint, (d) timing of the flame spread rate, and (e) ignition source.

4.4.1 Specimen Weight

Preliminary testing indicated that the specimen weight should be between 10 and 15 grams to insure sufficient flame travel to obtain a measurement of the flame spread rate. As table 4 shows, test results obtained with 10-gram specimens were considerably less variable than those obtained with the 15-gram specimens. A possible explanation may be that the increased density of the tightly-packed 15-gram specimens affected the measurements. The 10-gram specimen weight was used for all further testing.

4.4.2 Equipment Cooling

The variability of the test results was also reduced by allowing the test apparatus to cool between tests and inserting a clean aluminum foil liner for each test.

4.4.3 Specimen Trough Insert and Top Restraint

It was found that a 1.3 cm (1-2 in) mesh insert was preferable to a solid insert from the view of reducing the variability of the test results for both thermoplastics and cellulosics. Since some thermoplastic specimens had a higher tendency to puddle than others (strands of thermoplastic specimen tend to melt into the flame zone rather than the flame progressing along the specimen when the strands are free), it was found necessary to use a top restraint to hold the thermoplastic specimen in place in order to measure the flame spread rate and to simulate candies or eggs placed on the grass. For thermoplastics, a top restraint running across the specimen rather than along it yielded less variable results. Unfortunately, this top restraint tended to greatly increase the times obtained for cellulosic specimens, since there was a smothering effect on the cellulose whenever the flame-front reached one of the restraining cross-bars. Consequently, it became necessary to design a top restraint that would not interfere appreciably with the natural burning of the cellulosic specimen and still restrain the thermoplastic specimen sufficiently to obtain a reading. It was found that a top restraint of type D in table 3 yielded results for cellulosics similar to those obtained without a top restraint (type B in table 3) yet restrained the thermoplastics sufficiently to consistently yield a reading.

4.4.4 Timing of the Flame Spread Rate

Time of flame travel was noted for both the 10 and 15 cm (4 and 6 in) spacing between the trip threads. As table 4 indicates, the results were less variable for the times taken over the 15 cm (6 in) distance. Burn times were recorded by both manual (stopwatch) and electrical means. From figure 4, it can be seen that no appreciable differences in results were obtained by either timing mode, particularly for times greater than 30 seconds.

4.4.5 Type of Ignition

The validity of results for the two types of ignition were mixed, increasing for some specimens, and decreasing for others. The average coefficient of variation for five different grasses was slightly higher for gas ignition (15.8%) than for match ignition (14.2%). It should be noted, however,

that these experiments were performed with five replicates by one operator and with one type of match. It was felt that match ignition is much more prone to between-operator variability than is gas flame ignition and that additional error would be introduced into the tests by noncontrollable variations between match batches and sources. Since a gas flame is easily defined and consistently reproduced, it was felt that, for the purposes of a standard test method, a gas burner should be used for ignition. Consequently, the burner shown in figure 1 was used in the final testing for all available shredded or slit films that we were able to obtain.

4.5 Test Criteria

After determination of the optimum operating parameters, the available shredded and slit films were tested in accordance with the test procedure described in appendix A. Table 5 and figure 5 summarize the results of these tests. The untreated cellulosics had average burn times ranging from 11.3 seconds to 18 seconds. The untreated thermoplastics had average burn times ranging from 47.3 seconds to 74 seconds. Overall averages for the untreated cellulosics and the untreated thermoplastics were 13.5 and 61.4 seconds, respectively. Based on these preliminary results, an acceptance time of 40 seconds could provide discrimination between the untreated cellulosic and the thermoplastic grasses.

Although this method was designed to assess the flammability hazard of shredded or slit film such as Easter grass, it should be equally applicable to the testing of any loose fibrous material used in small quantities. The test procedure presented in this report should be subjected to an interlaboratory study, the scope of which should include shredded or slit films, loose fibrous materials, shredded materials, pelleted materials, chipped materials, and any other material suitable for testing in this test configuration. It is further suggested that when other types of materials are found to be amenable to testing by this method, the test method should again be subjected to laboratory evaluation to verify the applicability of the test method (or a variation thereof) to the type of material in question.

5. TEST METHOD II FOR POWDERS, PASTES, AND GRANULAR SUBSTANCES

The present method of testing the flammability of powders, pastes, and granular substances consists of packing the material into a small, horizontal trough, igniting with the flame from a paraffin candle and determining the flame spread rate. This method presents some difficulties in use. The

difficulties include making proper contact between the flame and the substance being tested, contamination of the substance by dripping wax, inappropriate shape of the candle flame when it is tipped to contact the horizontal surface of the substance, determining when ignition of the substance has actually occurred, lack of a procedure for packing a material into the trough, and timing the flame spread rate. There is a need for improvement and clarification of the test method.

An apparatus which was designed to replace the candle and trough currently in use is described in detail in the attached test method, appendix B. Briefly, the features of the new apparatus are:

(a) A gas ignition source instead of a candle;

(b) A low heat capacity trough, with leveling screws to maintain a horizontal surface to measure the flame spread on substances which melt;

(c) Use of stop cords 15 cm (6 in) apart which burn through to allow accurate timing of the flame spread rate;

(d) Use of an aluminum foil liner for the trough to minimize cleaning problems.

A substance is placed into an aluminum foil lined trough and smoothed to the surface level of the trough. Stop cords are strung across the trough at distances of 7.6 and 22.9 cm (3 and 9 in) from the end of the trough. The substance is ignited using a methane gas flame at one end of the trough and allowed to burn. When the flame burns through the first trip thread, timing of the burning rate begins. The time of burning between the breaking of the first and second trip threads is measured.

5.1 Apparatus and Test Methods

The apparatus that was developed for testing powders, pastes, and granular substances is illustrated in figure 6 and detailed in the engineering drawings in the attached Proposed Test Method for the Flammability of Solids Under the Federal Hazardous Substances Act; Method II, Powders, Pastes, and Granular Substances, appendix B. The details of the design are described below.

A number of substances were procured and tested under several test configurations in addition to testing in accordance with the existing test

method. Several different trough materials and several different ignition sources were explored.

Table 6 lists a number of materials which either did not ignite or did not show significant flame spread in the test as specified in the FHSA. It is noteworthy that one product, a tile cement, could not be ignited though it was labeled, "Caution--Combustible Mixture, N.Y.F.D.C. of A., No. 1640 - Use adequate ventilation - Open doors and windows; keep air circulating - Keep away from heat and flames." This designation indicates that the material ignited in the Tag Open Cup Test at temperatures between 43° and 149°C (110° and 300°F). While the material had not hardened completely, some solvent in the material may have evaporated, pointing out the importance of testing with fresh samples. Table 7 lists some substances which ignited readily, but burned faster than 0.1 second for the 15.2 cm (6 in) distance (the minimum time measuring capability of the apparatus).

Tables 8 and 9 list substances which exhibited flammability behavior intermediate between the substances listed in tables 6 and 7. As with the substances in tables 6 and 7, there was no uniformity of labeling; however, with one exception, all these substances were labeled with regard to their flame hazard in some manner. The behavior of the substances also made it possible to make comparisons between various test method variables to determine appropriate parameters for the final test method. The results presented in tables 8 and 9 represent testing under a variety of test conditions in order to compare the various test method parameters. Variations from the prescribed test method are noted on the tables.

5.2 Trough

A trough, 2.5 cm (1 in) wide, 30.5 cm (12 in) long, and 0.64 cm (0.25 in) deep, is cut into a block of "Teflon," a fluorocarbon based plastic, low heat capacity material. This trough was compared with a similar trough cut into asbestos cement (Transite) and one made of aluminum. Although the flame spread rate, shown in table 9 for the asbestos cement and aluminum troughs and table 10 for the Teflon trough is not appreciably affected by the trough material, the coefficients of variation are generally lower for the aluminum and Teflon troughs than for the Transite trough. It was observed during testing that the temperature of the trough affects the results, presumably because certain substances melt more rapidly or lose more solvent by evaporation in a trough retaining heat from previous tests. For these reasons, a trough material was chosen that would cool quickly, but with enough structural strength to allow spreading and leveling of the substances.

The test method included as appendix B describes a procedure for filling the trough with a substance to be tested and for leveling the surface of the substance. This operating procedure should be followed very carefully, especially with respect to the manner in which the trough is filled. Overfilling appears to result in somewhat higher flame spread rate than underfilling, as shown by the following typical results:

Car Wax #2 -- 0.32 cm (0.125 in) trip thread height, automatic ignition with hypodermic needle

	cm/sec	inches/sec
overfilled	0.38	0.15
as per procedure	0.33	0.13
underfilled	0.28	0.11

In some cases, it was difficult to smooth the surface of the substance. A rough surface resulted in a somewhat slower flame spread rate for materials which melt before burning. The molten material flows ahead of the flame and is slowed by high or low spots on the surface.

5.3 Ignition

There are several difficulties in igniting substances with the candle as prescribed in the current regulations. One is establishing the exact time of ignition of the substance since the flame from the candle is not easily distinguished from that of the substance, and the bulk of the candle interferes with visual observation of the ignition. In addition, there are drawbacks to using the candle as discussed earlier. To improve the ignition source, NBS investigated several methods of ignition and tested those that appeared promising and compared the results to those obtained with the candle. A micro-burner, hypodermic needle burner, and hypodermic needle burner designed for automatic flame impingement on the specimen surface were investigated. The results are shown in table 9. There appears to be no systematic effect of the various ignition methods on the flame spread rate or on the variability of the results. The reason for this is the new arrangement for flame spread measurement: It starts at a point at least 5.1 cm (2 in) from the application of the flame [7.6 cm (3 in) from the end of the trough], when the flame spread is likely to have attained a stable rate. This is in contrast to the present method which specifies a visual estimate of the time when the substance starts burning and when it reaches the far end of the trough.

The burner described in the attached recommended test method is a form of the manual hypodermic needle burner. As recommended for use with shredded or slit films, it is used with a needle valve to allow accurate gauging of the flame length. A pressure regulator is used to furnish the gas to the ignition source at a pressure of 130 $\pm$ 25 mm (2-1/2 $\pm$ 1/2 psig) at the needle valve inlet. Technical grade, 97 percent pure methane is used.

5.4 Measurement of Flame Spread Rate

Two cotton threads are placed at right angles to the trough. These trip threads are 15.2 cm (6 in) apart, and the first trip thread is 7.6 cm (3 in) from the right edge of the trough. The variability of the data is considered under these conditions. In addition, changing the first trip thread to a distance of 10.2 cm (4 in) did not seem to affect the results. Based on the data shown in table 10, a trip thread height of 0.32 cm (1/8 in) is recommended in the attached test method. At this height, the thread is severed by even quite low flames, but not likely to contact the substances during threading.

The use of the trip threads for timing allows accurate timing of the linear burn time. The proposed test method is written to allow, at the tester's option, the use of either manual or automatic timing of the burning rate. Both methods, however, make use of the trip threads and microswitches to keep tension on the threads during the test.

Table 10 shows that the effect of operator is statistically insignificant when the procedures outlined in the proposed test method are followed carefully.

5.5 Possible Test Criteria

Pending further testing, the acceptance criterion in the current regulations, a flame spread rate of 2.5 mm/sec (0.1 in/sec) or less, would provide differentiation between obviously hazardous materials such as gunpowder and other materials less hazardous. However, it is necessary to perform a hazard study in order to select an appropriate pass-fail criterion that passes materials that do not exceed a predetermined risk level. A program should be set up to evaluate this new test method and apparatus fully before a final decision is made on the criterion.

6. TEST METHOD III FOR EXTREMELY FLAMMABLE SOLIDS

6.1 Introduction and Background

The Federal Hazardous Substances Act regulations define "extremely flammable" solids as those which ignite when subjected to an electrical spark, percussion, or friction, at an ambient temperature of 23°C (80°F) or less. However, no definition of these ignition sources is given.

A spark is an unstable electrical discharge which ionizes the medium between two electrodes. An arc is a stable electrical discharge; it can be a prolonged electrical spark or it can be created by initial contact and subsequent separation of two electrodes carrying current [12]. While the duration of the discharge, to a large extent, would determine the materials that would be ignited, a suitable duration could be defined through a study of materials involved in accidents where sparking was the ignition source along with laboratory testing of these materials. The ignition of substances by an electrical discharge, be it spark or arc, requires that certain conditions be met. The electrical discharge must supply sufficient energy to the substance, maintained for a sufficient period of time, to insure that a minimum mass of material is raised to the ignition temperature to sustain burning.

Two theories for the energy transfer from electrical discharges to substances have been proposed--one based on hydrodynamic (shock wave) phenomena and the second on thermal transport (convection). An analysis of the relative importance of these two phenomena indicated that either phenomenon could theoretically account for ignition [13], but experiments by two investigators indicated that for low energy discharges, the primary mode of energy transfer appears to be thermal [12,13].

6.2 Test Methods for Spark Ignition

In the beginning stages of the project, a state-of-the-art survey was performed to identify existing test methods for spark ignition, as well as accident situations in which such ignition may have occurred. Several documents pertaining to tests for ignition due to percussion, friction, and electrical sparks were located [14-22]. Primarily, these test methods were designed to test explosives, blasting accessories such as detonators and detonating cords, oxidizing agents, propellants, and flammable liquids. The test methods have been developed and used by agencies such as the Bureau of Mines, Department of Transportation, Naval Ordnance Laboratories, Picatinny Arsenal, and suppliers and developers of explosives and propellants. The

substances for which these tests were developed may be expected, in many instances, to be much more sensitive to ignition than many of the substances under the Federal Hazardous Substances Act. The details of the test apparatus, the precautions given for the actual testing, the statistical methods used for evaluating the tests, and the typical test results discussed in these reports provided information for the development of a test method for spark ignition under the FHSA.

The spark ignition testers consist of several essential parts--an energy storage source, such as a capacitor; electrodes; a specimen holding arrangement for testing of many substances; and a line resistor. The latter is often used to modify the discharge rate of the capacitor which in turn affects the duration of the spark discharge and allows for modification of the character of the spark.

Westgate, et al. [12], performed extensive experiments on the spark sensitivity of explosives. They found that threshold voltage value for ignition did not vary with electrode material or capacitor size, if no series resistance was used. Furthermore, with the particular electrode configuration employed in this work, measurement of the efficiency of the spark revealed that only 15 percent of the stored energy was delivered through the gap through a given series resistance. Kirshenbaum [23] compared test results for explosive materials using two electrode geometries. He found better reproducibility with a parallel plate configuration than with a probe pointing at a platform electrode from above because the powder specimens tended to fly away from the spark zone in the latter configuration. The efficiency of energy discharged determined through the air gap was approximately the same in the two configurations.

Westgate [12] and Kirshenbaum [23], working with explosives, and Fitt [24], working nylon films in oxygen enriched atmospheres, found that insertion of series resistors into the circuit reduced the rate of energy input into the spark gap, but that the result of this lowered delivery rate was an increased sensitivity of some materials to spark ignition. This could be an important phenomenon in the design of a spark ignition test.

Westgate [12] also investigated the effect of humidity on the test results, a factor generally neglected by other workers. He found that an increase in humidity of the atmosphere caused a decrease in the threshold voltage necessary for specimen ignition where the sample moisture content was constant. The water vapor affects the dielectric constant of the air

and this affects the energy transfer. The ambient atmosphere thus apparently has an effect on the rate of energy transfer and should be considered in test design.

6.3 Initial Equipment Design and Evaluation

Based on the concepts discussed above and in the above-mentioned papers, a preliminary instrument was designed and constructed. Figure 7 shows the overall arrangement. The main features of this apparatus consist of an automotive or similar ignition coil, capacitors, the test chamber, and an adjustable series resistor. For the purposes of experimentation, an oscillograph is attached via a voltage divider, to enable an investigation of the effect of voltage and current variations on the charge energy density and the ignitability of various substances. Figure 8 shows the details of the spark power circuitry. A timing device and voltage adjustment provides a means to vary the length and intensity of the electrical discharge. The design also allows measurement of the discharge voltage and current providing information on the energy released by the spark. The specimen holder and electrode assembly is shown in figure 9. It consists of two replaceable copper electrode tips held in nonconducting nylon supports. The specimen holder is constructed of "Teflon," a fluorocarbon based, low heat capacity material with excellent flammability and electrical resistance. The specimen holder and electrode assembly is mounted on an optical bench to allow precision measurement of electrode to electrode and electrode to specimen spacing. Equally important, this design allows flexibility in spacing the electrodes and specimen holder to allow study of the effect of spacing and determination of the optimum operating conditions for a final test method.

A number of substances were procured that would exhibit a range of flammability characteristics. These materials in their end-use configuration were subjected to a spark ignition source to gain information for the following experiments:

(a) Different series resistors were used to vary the average power dissipated in the discharge;

(b) Different samples were exposed to the same discharge;

(c) The amount of energy necessary for ignition was measured for different materials.

Figure 10 illustrates the energy released on the spark discharge for this initial apparatus. With no specimen present, the spark was discharged, and the discharge time was varied. By changing the resistor in series with the discharge capacitors, the average power and discharge time can be varied, while the total energy remains the same. Table 11 shows the energy dissipated and the ignition/nonignition of various materials when exposed to a 0.2 sec spark discharge. The spark discharge grazed the surface of the specimen, and a determination was made of whether sustained burning occurred. In addition, it was determined whether the same materials could be ignited using a bookmatch as the ignition source. The energy dissipated for discharges with materials present is generally higher than simply the spark discharge in air, also shown in this table.

During the testing, several deficiencies of the apparatus became evident. With use, the copper electrode tips became dull and pitted causing the energy output to change. In addition, the high rate of energy release inherent in the design made it difficult to ignite an obvious "extremely flammable" substance, granular gunpowder. The main source of error, however, was due to machine malfunction (current leakage) which became worse as the machine was used more. A second generation apparatus, described below, was designed to prevent these problems.

6.4 Apparatus and Test Method

As a result of these machine failures, a new apparatus was designed and constructed. The apparatus is detailed in the attached Proposed Test Method for the Flammability of Solids Under the Federal Hazardous Substances Act; Method III, for ignition resistance of substances to electric sparking, appendix C. The details of the design are described below.

6.4.1 Power Supply and Timing Circuitry

The power supply and timing circuitry, shown in figure 11 and detailed in appendix C, provides power to the electrodes and to an electromagnet under the sample holder. Circuitry for the timing of the spark duration and for a safety switch to allow safe operation of the apparatus during specimen preparation and cleaning of the specimen holder is also included in the design. A high voltage transformer provides a dependable high voltage output to the electrodes, with timing provided by an electronic clock capable of timing accuracy of 0.01 sec for times up to 99.99 sec.

6.4.2 Specimen Holder and Electrode Assembly

The specimen holder and electrode assembly, as detailed in appendix C, is a modification of the assembly used with the earlier apparatus. The modified holder is shown in figure 12. The main features of the modified assembly are the addition of an electromagnet within the specimen holder to direct the spark discharge downward into the sample being tested, and a design of a removable top plate of the specimen holder to allow different specimen holders to be used for different materials if needed. In addition, the holder has been designed so that the electrodes are directly above the center of the magnetic field to direct the discharge properly into the specimen. In earlier testing of substances under the FHSA, it was observed that the temperature of the specimen holder affected test results [25]. In addition, the extremely high temperatures of the spark discharges required the use of a material with excellent flammability resistance. For these reasons, Teflon was chosen for the specimen holder as a material that would cool quickly, but with enough structural strength and with properties that would allow repeated exposure to the spark discharge.

Figure 13 shows the power output of the tester for different sets of test conditions. The power is constant above about 1 sec. Below 1 sec, the energy output drops, presumably since the spark is not as intense. In addition, some time is necessary for the discharge to stabilize.

6.4.3 Test Criteria

Figure 14 presents the ignition times for various substances when exposed to a spark discharge on the apparatus. These results should be considered preliminary. A discharge time of 0.3 sec provided a good differentiation between the few obviously extremely flammable substances tested and other substances. However, since this value of 0.3 sec is based on such a small population of substances, it is only provided as a basis of discussion. A hazard study should be performed in order to select an appropriate pass/fail criterion that passes materials that do not exceed a predetermined risk level. A program should be set up to evaluate this new test method and apparatus fully and to determine the criterion for differentiation for those materials considered hazardous.

7. CONCLUSIONS AND SUMMARY

This report presents the results of a program of the Federal Hazardous Substances Act and its regulations to identify those provisions related to flammability and to provide recommendations for revisions to those provisions and meaningful test methods for materials covered by the Act [26]. As described in section 2.6, a number of recommendations were made to the CPSC in August 1976 to provide the CPSC with enforceable regulations. An outline was proposed in section 3 providing a tenative categorization of products by expected test methods. CPSC priorities and funding limitations did not permit development of all test methods or extensive research on all of the recommendations made to the CPSC.

NBS was requested to place emphasis on the development of three particular test methods: a test for fibers, shredded materials, and slit films [27]; a test for powders, pastes, and granulars [11,25]; and a test using electric sparking as an ignition source. The development of these three test methods is described and a proposed test procedure is presented for each. However, a number of limitations that were outside the scope of this study are apparent:

(a) Only a small number of samples were used during the development of each test method. Although not within the scope of this study, a program should be developed to evaluate the new test methods fully before they are used for regulatory purposes.

(b) Hazard studies should be performed to determine materials that are involved in accidents to select appropriate criteria for the test methods.

(c) The effect of draft across the specimen surface, relative humidity, or ambient temperature was not studied fully. Variations due to these effects should be investigated.

The test development for ignition by electric sparking showed it most difficult to ignite most materials with a spark discharge. Those that did ignite would also show extreme flammability by other tests including those described in this report. The usefulness of this test method and the definition of extremely flammable solids in the FHSA is therefore questionable.

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9. APPENDICES

Proposed Test Methods for the Flammability of Solids Under the Federal Hazardous Substances Act

The attached appendices present three proposed test methods for testing of materials under the Federal Hazardous Substances Act and its associated regulations. These test methods are based on the work presented in this paper. Preliminary choices are provided based on laboratory testing for a number of test parameters and possible sampling plans are included as a basis of discussion. Further data developed during a full laboratory round-robin evaluation of the methods may indicate more appropriate test parameters, test criteria, or sampling plans. The Consumer Product Safety Commission, of course, has the authority to determine the final test methods, criteria, and sampling plans.

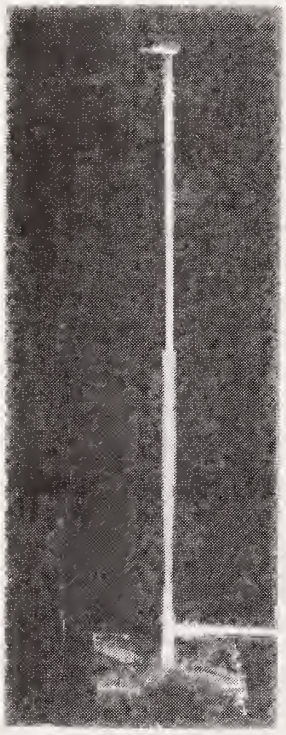
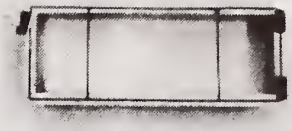
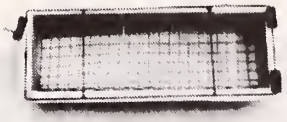


Figure 1. Gas burner



(a)

Top view of specimen holder



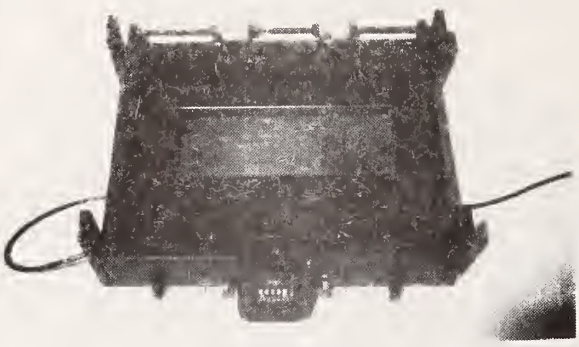
(b)

Specimen holder with insert

(c)

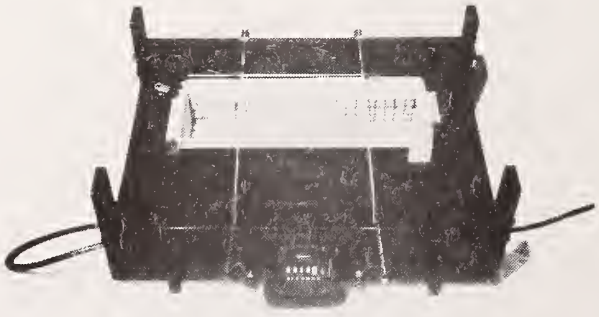
Front and side view of specimen holder

Figure 2. Specimen holder



(a) Without specimen holder

(b) With specimen holder



(c) With specimen holder and insert

Figure 3. Test apparatus

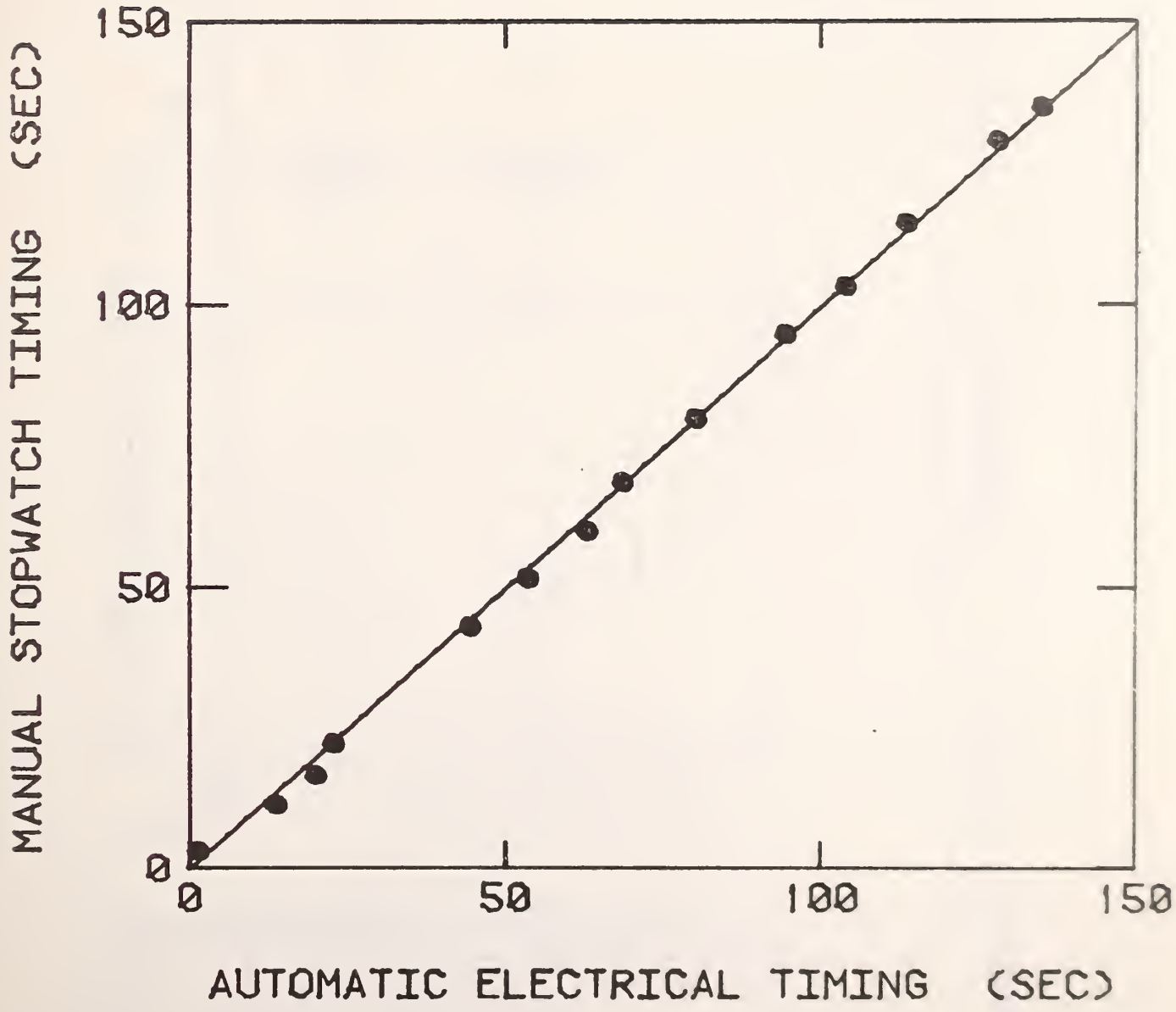


Figure 4. Comparison of manual and automatic timing

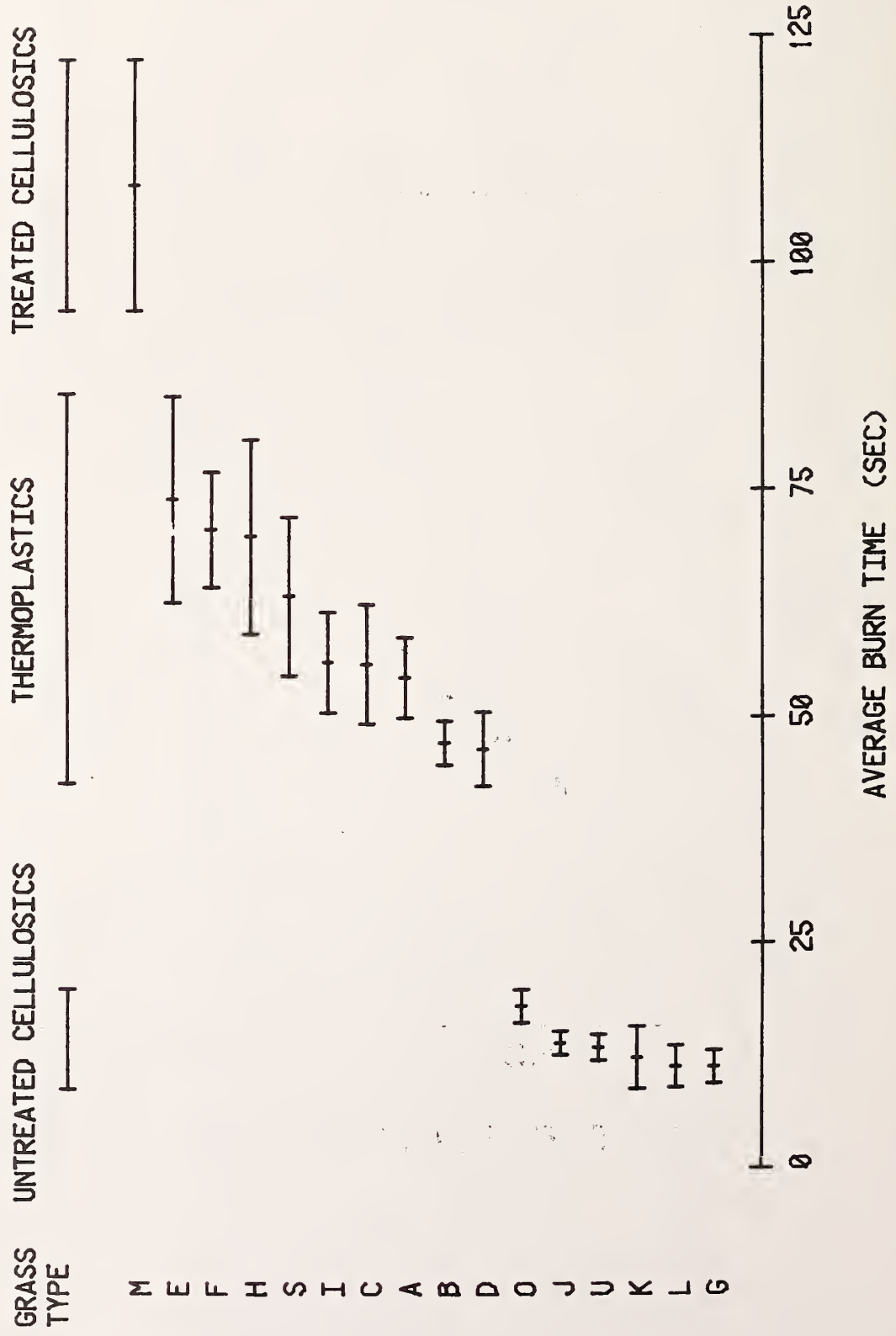


Figure 5. Average burn time with 95% confidence interval for 10 samples each of various shredded films

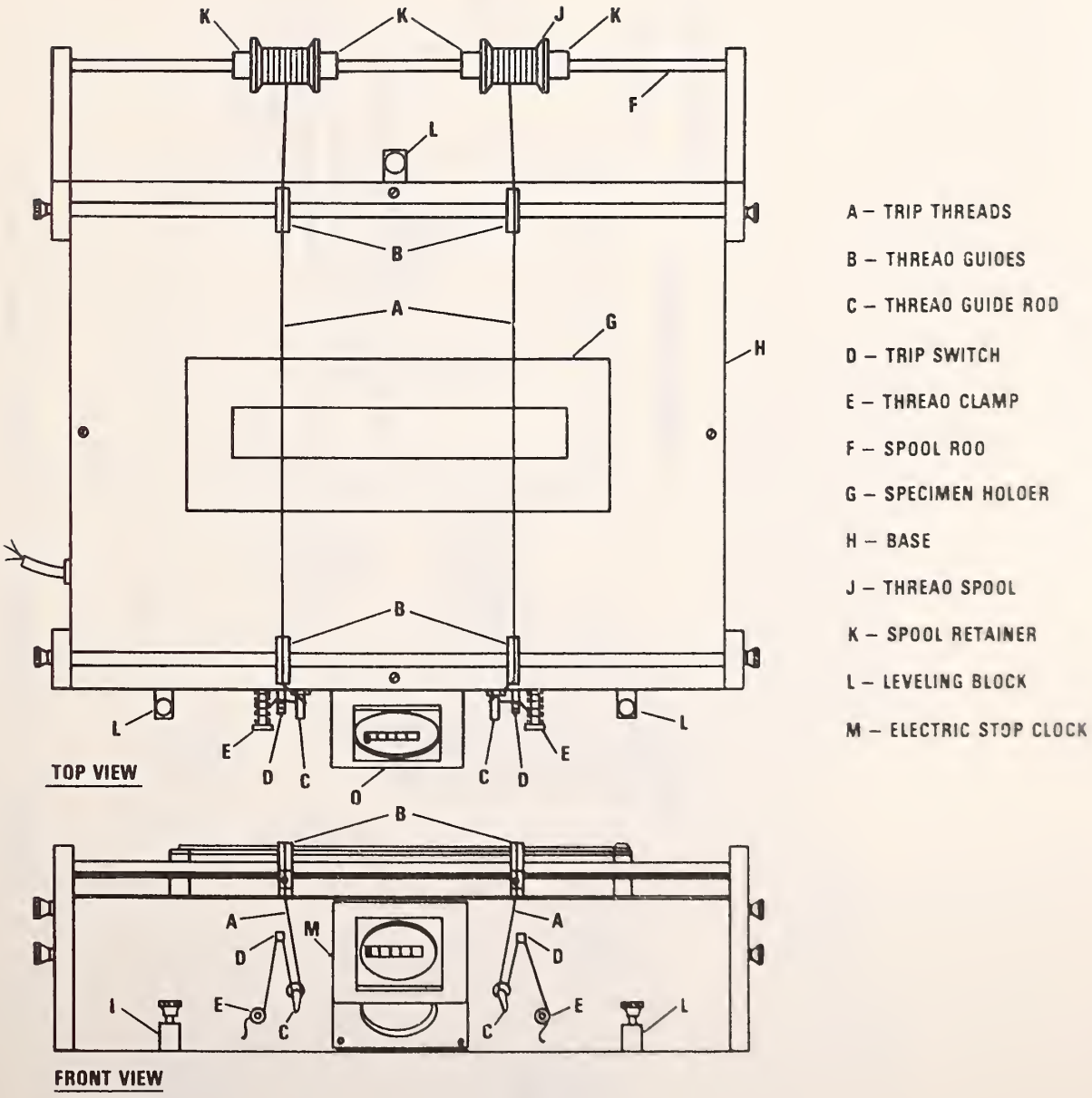


Figure 6. Trough flammability test apparatus

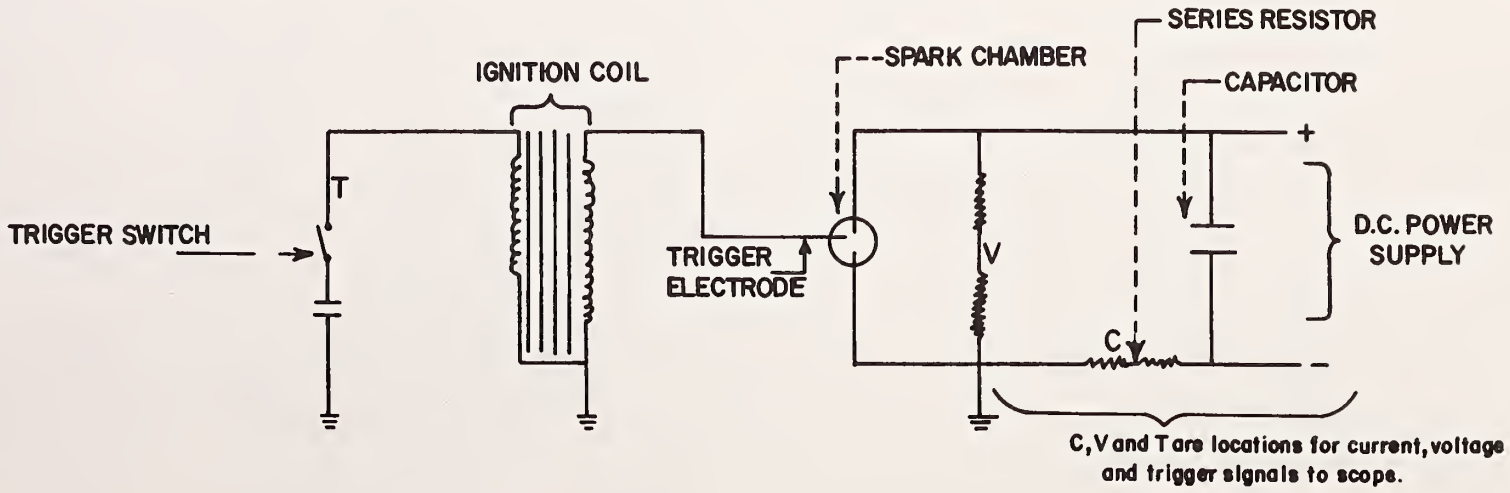


Figure 7. Schematic for electric spark tester

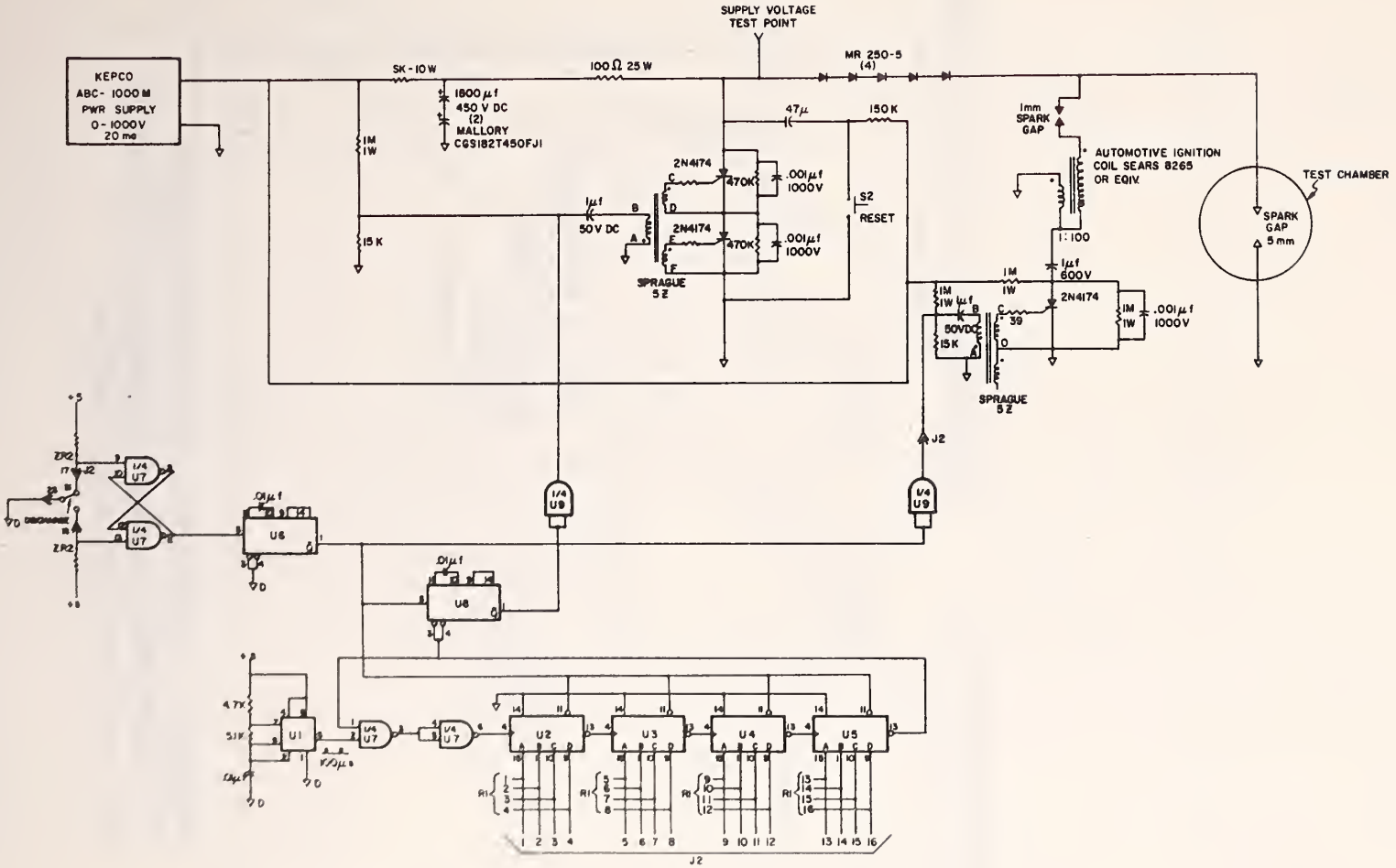


Figure 8. Initial spark apparatus

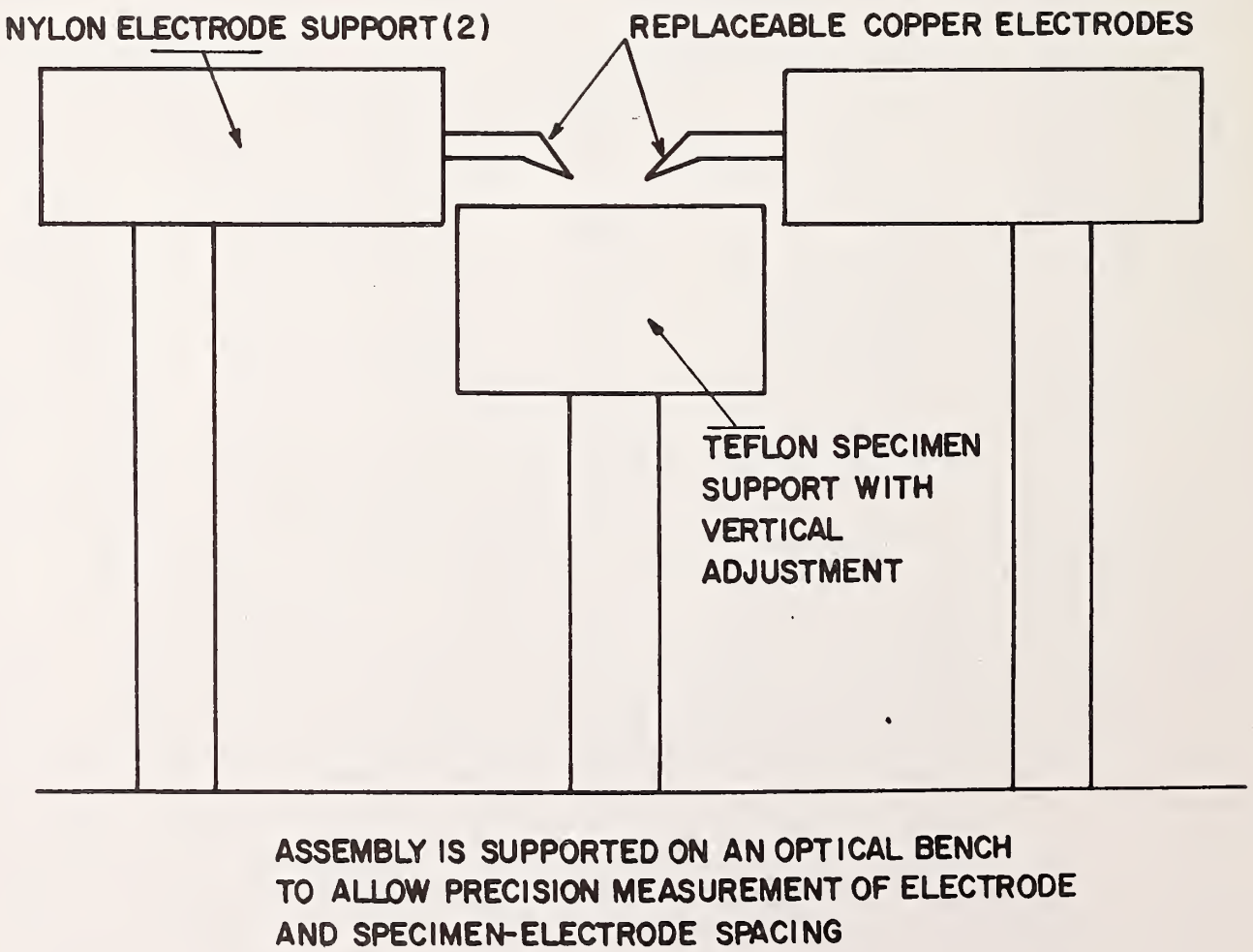


Figure 9. Specimen holder and electrode assembly

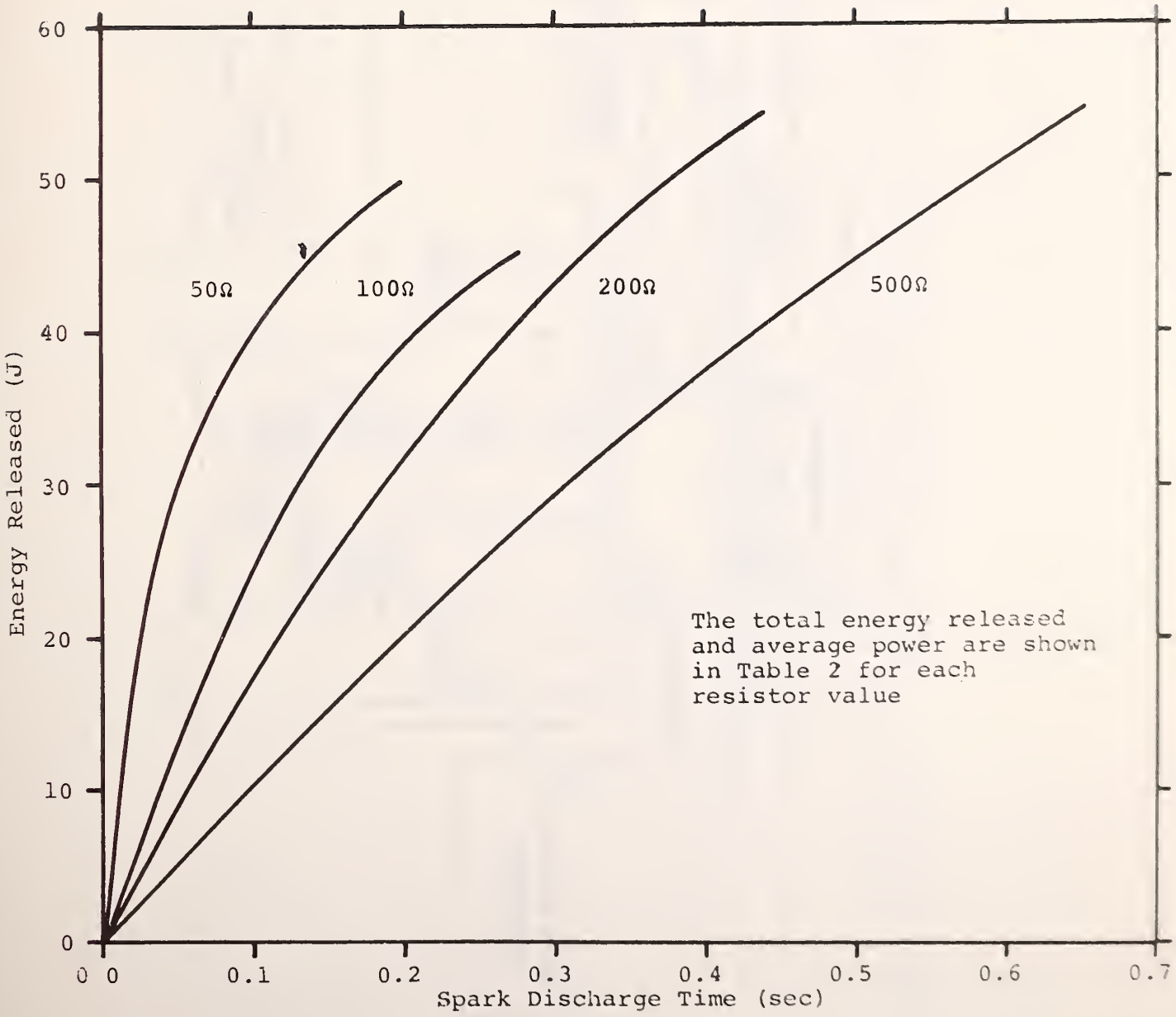


Figure 10. The energy released for various resistors

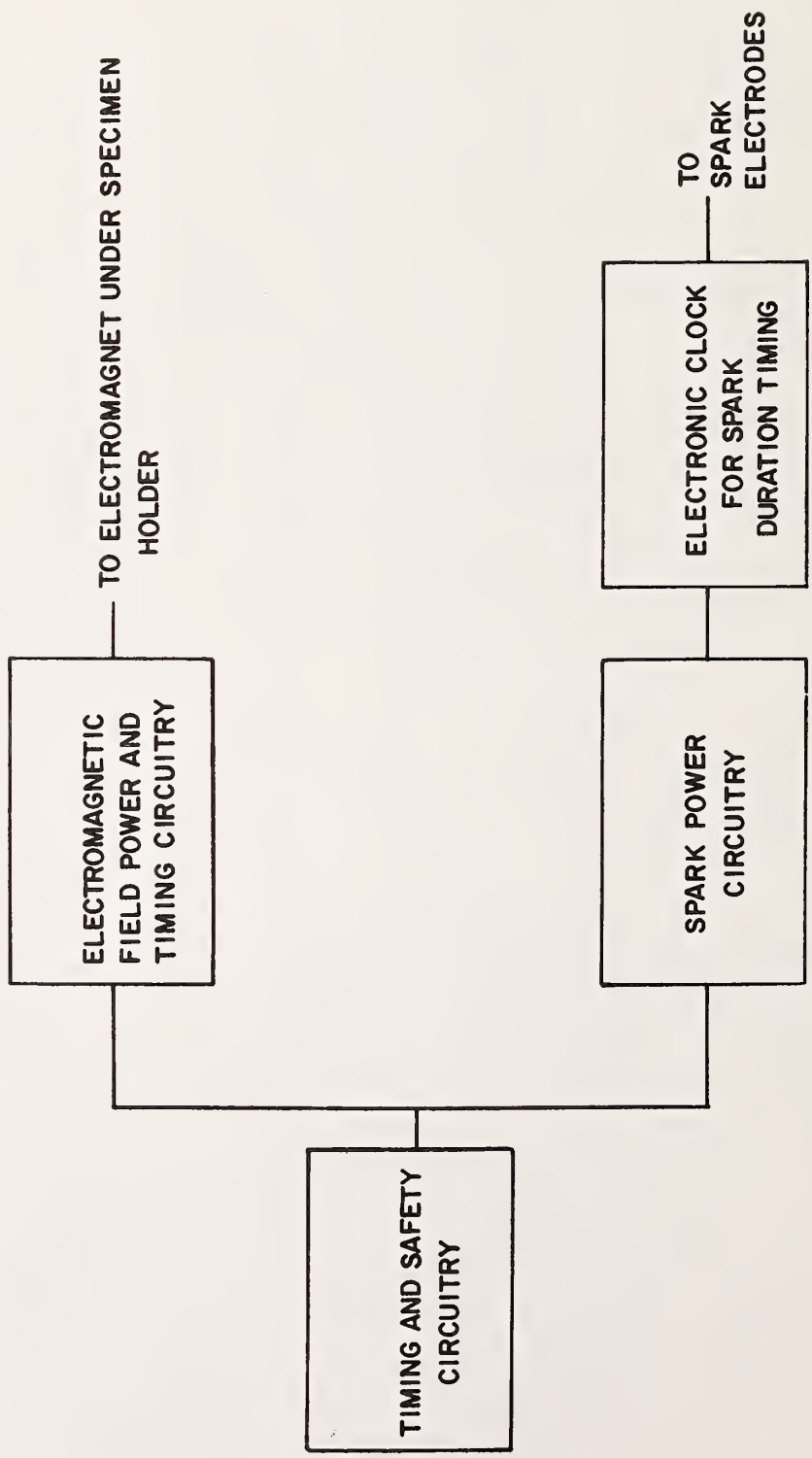


Figure 11. Schematic diagram of spark tester

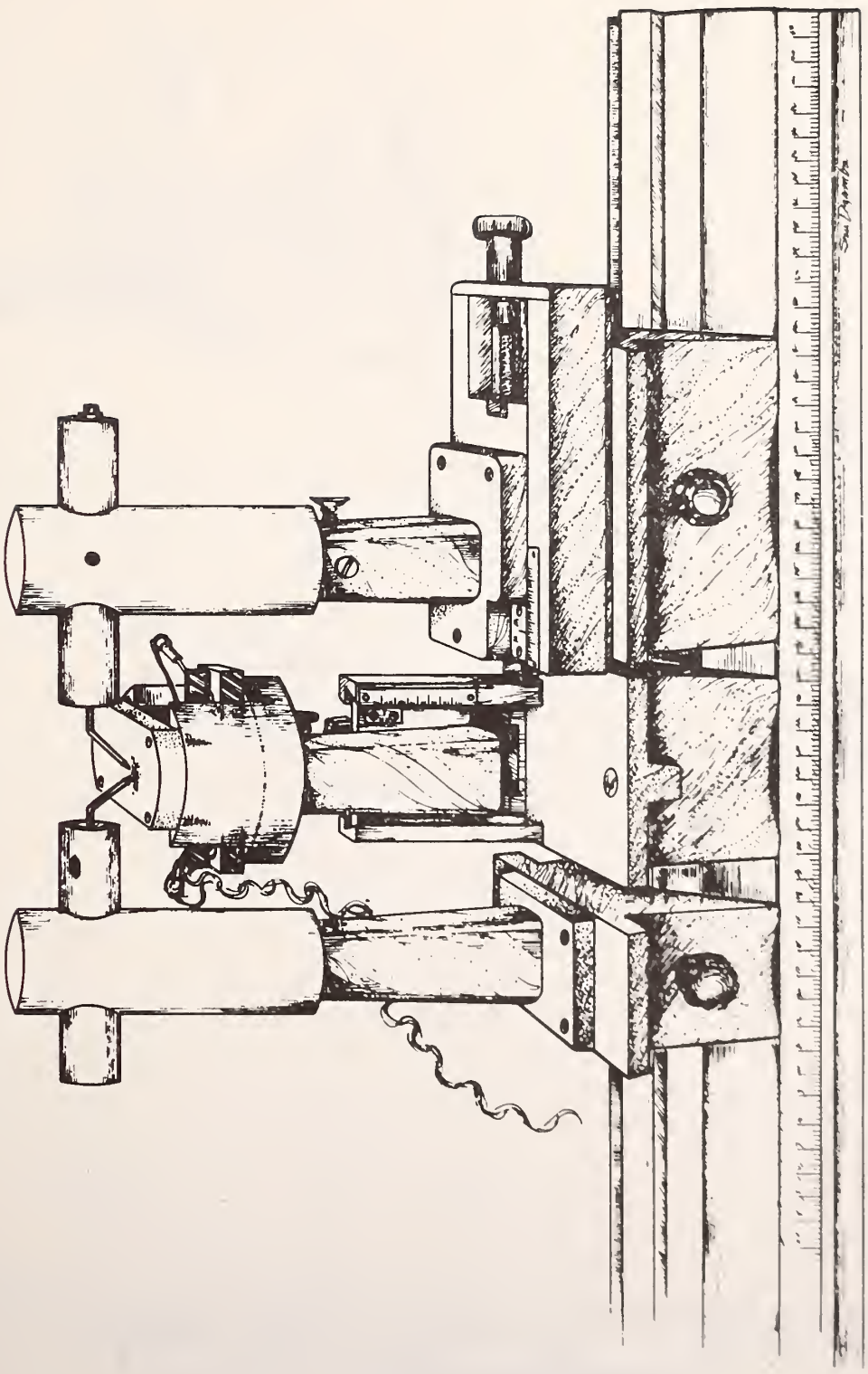


Figure 12. Spark apparatus

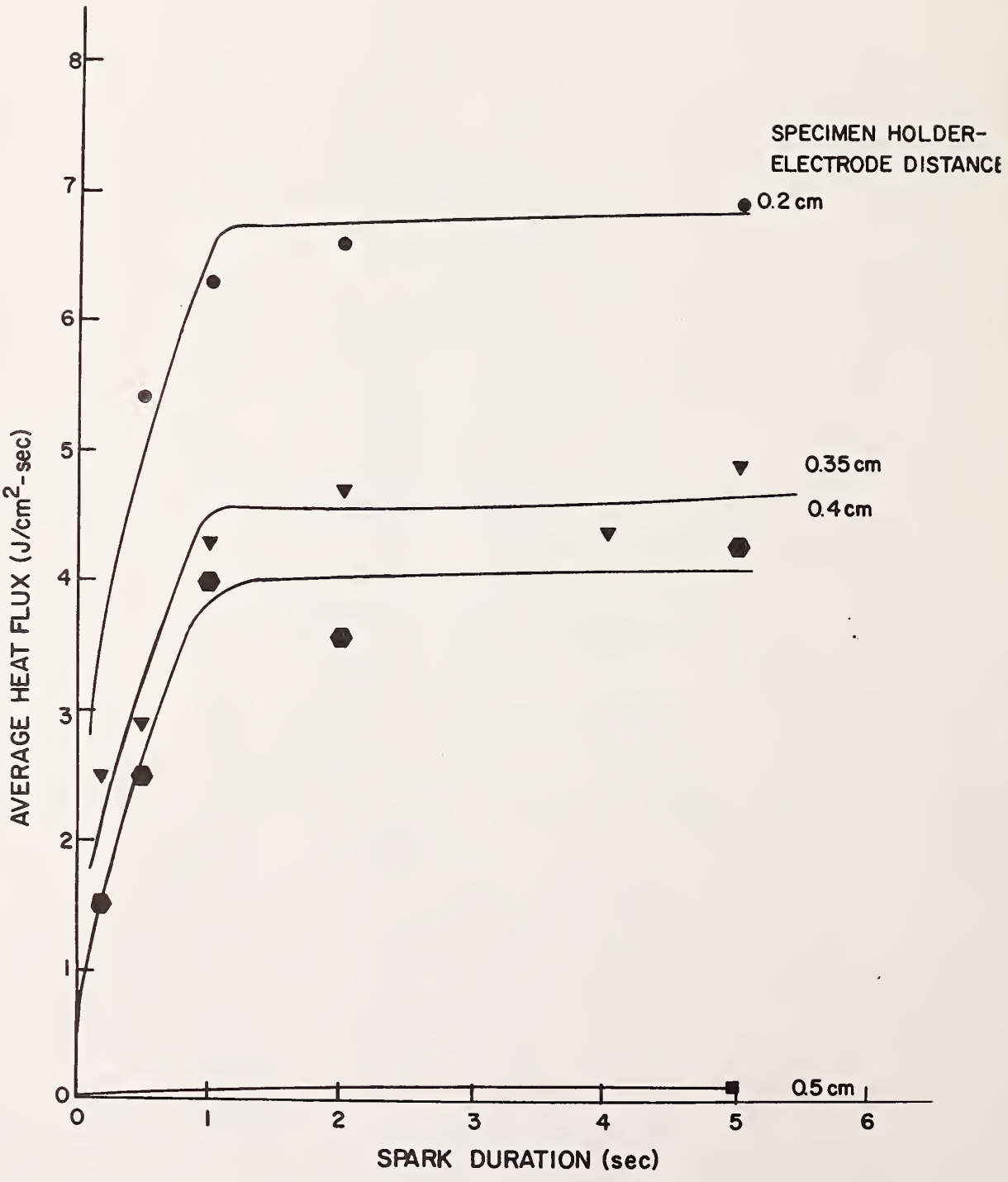


Figure 13. Power output of spark discharge

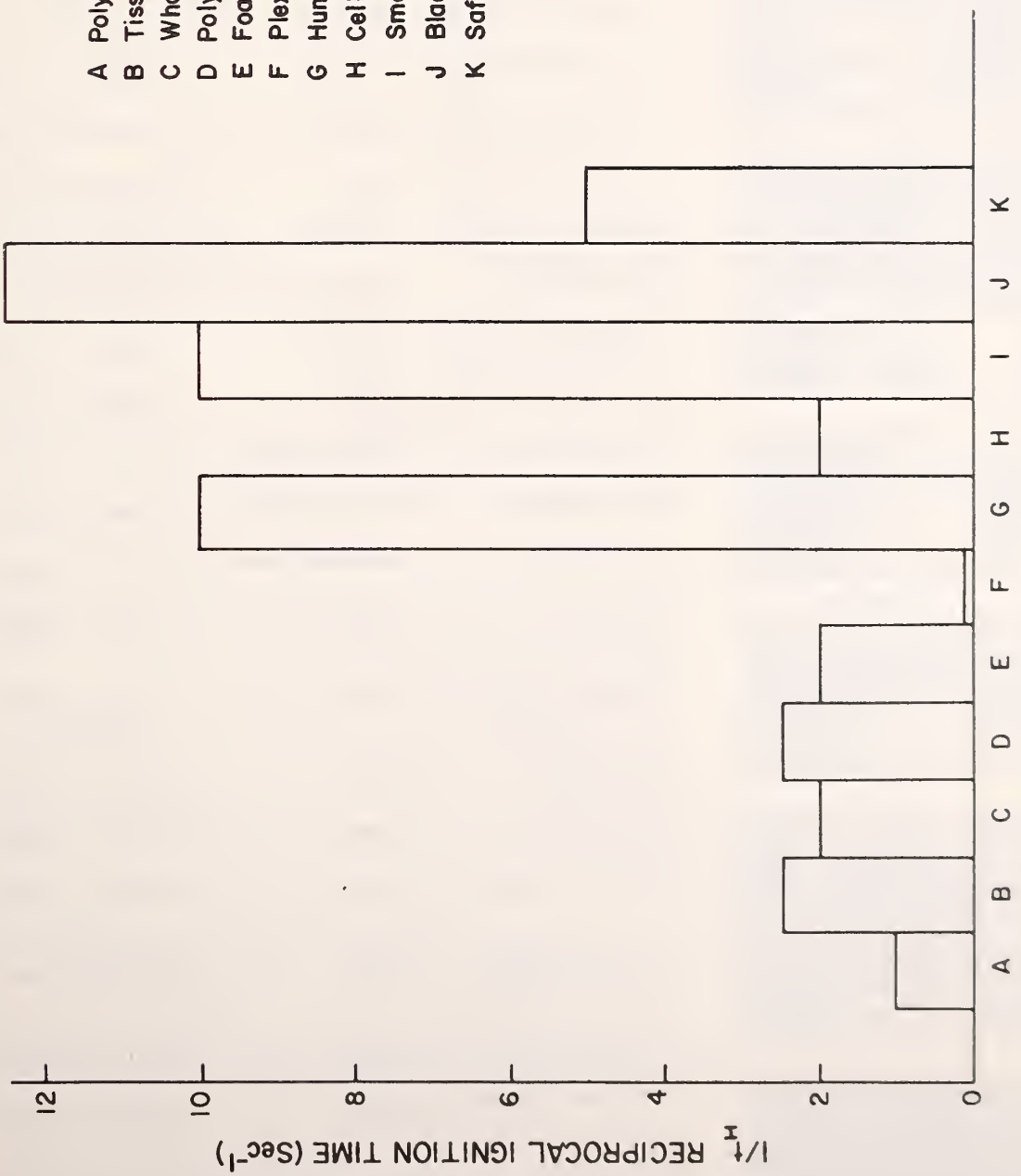


Figure 14. Ignition times of various substances

Table 1. Material description

Grass Designation	Type of Material	Material	Color	Type of Shredding
A	Thermoplastic	Polypropylene	Green	Coarse & Uneven
B	Thermoplastic	Polypropylene	Pink	Coarse & Uneven
C	Thermoplastic	Polypropylene	Yellow	Coarse & Uneven
D	Thermoplastic	Polypropylene	Yellow	Coarse & Uneven
E	Thermoplastic	Polypropylene	Pink	Coarse & Uneven
F	Thermoplastic	Polypropylene	Yellow	Coarse & Uneven
G	Cellulosic	Cellophane	Purple	Fine & Even
H	Thermoplastic	Polypropylene	Yellow	Fine & Uneven
I	Thermoplastic	Polypropylene	Pink	Fine & Uneven
J	Cellulosic	Cellophane	Green/Clear	Fine & Even
K	Cellulosic	Cellophane	Green/Clear	Fine & Even
L	Cellulosic	Cellophane	Yellow/Clear	Fine & Even
M	Treated Thermoplastic	Treated Polypropylene	Green	Fine & Even
N	Treated Cellulosic	Treated Paper	Green	Fine & Even
O	Cellulosic	Parchment	White	Coarse & Even
P	Cellulosic	Cellophane	Green	Fine & Even
Q	Treated Cellulosic	Treated Paper	Green	Fine & Uneven
R	Treated Cellulosic	Treated Paper	Green	Fine & Even
S	Thermoplastic	Polypropylene	Green	Fine & Uneven
T	Treated Cellulosic	Treated Paper	Green	Fine & Uneven
U	Cellulosic	Cellophane	Red	Coarse & Uneven

Table 2. Details of Faster baskets used in initial experiments

Type #	Material	Construction
1	Wood	Woven 
1A	Wood with plastic liner	Basket: woven Liner: solid 
2	Plastic	Solid 
3	Plastic	Solid with punched-out design 
4	Plastic & wood	Woven 
5	Plastic, wood & cardboard	Woven 

Table 3. Description of top restraints

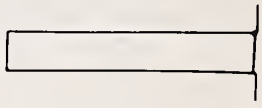
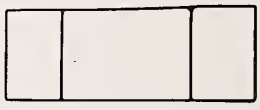
Type	Description
A	Cross-rods spaced 1 inch apart (except rod #1 and 2 which are 1-1/2 inches & 3 inches from right inner edge of trough). 
B	Threads placed across trough at 3 inches & 9 inches from right inner edge of trough. 
C	Rods placed along trough 2 inches apart & 1 inch from front & back edge of trough. 
D	Cross-rods at 2-3/4 inches & 9-3/16 inches from right inner edge of trough. 

Table 4. Investigation of parameters

PARAMETER DESCRIPTION		MATERIAL DESCRIPTION		RESULTS 5-SAMPLE AVERAGE							
Parameter	Code	Grass	Material	$\bar{T}$ime (sec)/6"		CV(%) for T		S E M		$\pm\bar{T}$ at 95%CL w. 4° of freedom	
				A	B	A	B	A	B	A	B
Weight of specimen	A = 10g B = 15g	E	Thermoplastic	90.5	109.1	5.5	24.2	2.2	15.3	6.2	42.4
Liner changed and equip. allowed to cool	A = yes B = no	E	Thermoplastic	90.5	103.9	5.5	11.0	2.2	5.1	6.2	14.2
Type of insert - no top restraint	A = 1/2" mesh B = solid	A J	Thermoplastic Cellulosic	59.2 13.6	58.0 17.4	27.5 7.5	13.2 7.9	7.3 0.5	3.4 0.6	20.2 1.3	9.5 1.7
Mesh insert - no top restraint	A = 1/4" mesh B = 1/2" mesh	E	Thermoplastic	94.1	103.9	28.7	11.0	12.1	5.1	33.6	14.2
Type of insert with top restraint "D"	A = 1/2" mesh B = solid	A E J	Thermoplastic Thermoplastic Cellulosic	52.0 70.2 14.7	57.4 76.8 17.0	8.4 8.1 12.3	10.6 16.0 18.7	2.3 2.8 0.8	2.7 5.5 1.4	6.5 7.9 2.2	7.5 15.3 3.9
Type of top restraint - solid insert	A = top restr. B B = top restr. C	A E J P	Thermoplastic Thermoplastic Cellulosic Cellulosic	58.0 84.1 17.4 16.3	56.8 81.3 16.6 17.4	13.2 20.9 7.9 14.8	9.7 11.4 7.6 13.9	3.4 7.8 0.6 1.1	2.5 4.1 0.6 1.1	9.5 21.8 1.7 3.0	6.9 11.5 1.6 3.0
	A = top restr. C B = top restr. A	A E J P	Thermoplastic Thermoplastic Cellulosic Cellulosic	56.8 81.3 16.6 17.4	70.1 85.5 43.3 26.0	9.7 11.4 7.6 13.9	8.7 9.5 18.4 10.4	2.5 4.1 0.6 1.1	2.7 3.6 3.6 1.2	6.9 11.5 1.6 3.0	7.5 10.1 9.9 3.4
	A = top restr. A B = top restr. D	C A E J O P	Thermoplastic Thermoplastic Thermoplastic Cellulosic Cellulosic Cellulosic	67.5 70.1 85.5 43.3 27.6 26.0	53.6 57.4 76.8 17.0 20.9 17.8	10.4 8.7 9.5 18.4 8.1 10.4	19.4 10.6 16.0 18.7 6.1 --	3.1 2.7 3.6 3.6 1.0 1.2	4.7 2.7 5.5 1.4 0.6 --	8.7 7.5 10.1 9.9 2.8 3.4	12.9 7.5 15.3 3.9 1.6 --
Type of top restraint - 1/2" mesh insert	A = restr. B B = restr. D	A J	Thermoplastic Cellulosic	59.2 13.6	62.0 14.7	27.5 7.5	8.4 12.3	7.3 0.5	2.3 0.8	20.2 1.3	6.5 2.2
Distance over which time is measured	A = 4" B = 6"	C A E J O P	Thermoplastic Thermoplastic Thermoplastic Cellulosic Cellulosic Cellulosic	50.2 49.7 56.0 26.8 18.9 17.7	67.5 70.1 85.5 43.3 27.6 26.0	14.8 10.0 10.0 25.6 10.7 17.0	10.4 8.7 9.5 18.4 8.1 10.4	3.3 2.2 2.5 3.1 0.9 1.3	3.1 2.7 3.6 3.6 1.0 1.2	9.2 6.2 7.0 8.5 2.5 3.7	8.7 7.5 10.1 9.9 2.8 3.4
Type of ignition - solid insert	A = match B = gas	C A E J O	Thermoplastic Thermoplastic Thermoplastic Cellulosic Cellulosic	53.6 57.4 76.8 17.0 20.9	75.3 66.1 82.9 18.8 22.2	19.4 10.6 16.0 18.7 6.1	27.5 17.7 14.8 11.3 7.6	4.7 2.7 5.5 1.4 0.6	9.2 5.2 5.5 1.0 0.6	12.9 7.5 15.3 3.9 1.6	25.7 14.5 15.3 2.6 2.1
Type of ignition - 1/2" mesh insert	A = match B = gas	A J	Thermoplastic Cellulosic	62.0 14.7	52.5 14.8	8.4 12.3	13.5 13.6	2.3 0.8	3.2 0.9	6.5 2.2	8.8 2.5

Time -- Average time for five samples of flame spread between stop cords at 6" spacing unless otherwise noted.
CV(%) -- Coefficient of Variation in percent for five samples.
SEM -- Standard Error of the Mean for five samples.
$\pm\bar{T}$ -- 95% Confidence limits for five samples.

Table 5. Burning behavior of various types of Easter grass

MATERIAL DESCRIPTION		RESULTS					
Grass	Type of Material	Time (sec)/6"		Standard Error of the Mean	CV (% Coefficient of Variation)	95% Confidence Interval for Mean	Number of Samples
		Mean	Median				
G	Cellulosic	11.3	11.3	0.60	11.9	9.6 to 13.0	5
L	Cellulosic	11.4	11.4	0.79	15.4	9.2 to 13.6	5
K	Cellulosic	12.4	12.4	1.10	17.8	8.9 to 15.9	4
U	Cellulosic	13.5	13.2	0.52	12.3	12.3 to 14.6	10
J	Cellulosic	14.1	14.0	0.56	12.5	12.8 to 15.4	10
O	Cellulosic	18.0	18.4	0.70	12.3	16.4 to 19.6	10
D	Thermoplastic	46.5	45.9	1.72	11.7	42.6 to 50.4	10
B	Thermoplastic	47.3	47.0	1.03	6.9	45.0 to 49.6	10
A	Thermoplastic	54.2	52.7	1.85	10.8	50.0 to 58.4	10
C	Thermoplastic	55.8	54.0	2.82	16.0	49.4 to 62.2	10
I	Thermoplastic	56.0	56.0	2.05	8.9	50.7 to 61.3	6
S	Thermoplastic	63.1	62.8	3.73	17.8	54.5 to 71.7	9
H	Thermoplastic	69.8	69.2	4.76	21.6	59.0 to 80.5	10
F	Thermoplastic	70.6	71.0	2.78	12.5	64.3 to 76.9	10
E	Thermoplastic	74.0	70.0	5.00	21.4	62.7 to 85.3	10
M	Thermoplastic, Treated	108.6	107.9	5.94	16.4	94.9 to 122.3	9
N	Cellulosic, Treated	DNI	-	-	-	-	10
Q	Cellulosic, Treated	DNI	-	-	-	-	10
R	Cellulosic, Treated	DNI	-	-	-	-	10
T	Cellulosic, Treated	DNI	-	-	-	-	10

Table 6. Substances which did not ignite, or if ignited, were self-extinguished before any significant flame spread[a]

Tile Cement[b]
Plastic Resin Glue
Linoleum Paste
Petroleum Jelly
Sun Tan Lotion
Car Wax
Dry Cleaner for Rugs
Instant Chocolate Flavored Mix
Instant Tea
Instant Coffee
Sugar
Flour
Rice
Fruit Cereal
Silver Polish
Fertilizer (10-6-4)

[a] Testing was performed as specified in the FHSA except an aluminum trough with microburner ignition was used.

[b] Label indicates that the product represents a fire hazard and refers to N.Y.F.D.C. of A.

Table 7. Substances that burned too fast for flame spread measurements[a]

Canned Fuel Gel[b]
Cement for Plastic[b]
Sporting Black Powder[c]
General Purpose Household Glue[b]
Panel and Dry Wall Adhesive[b]
Polystyrene Plastic Model Cement[b]
Wood Filler[b]

[a] Testing was performed as specified in the FHSA except an aluminum trough with microburner ignition was used. Measurement was possible to 0.1 second for the 6-inch length.

[b] Label indicates that product represents a fire hazard and refers to N.Y.F.D.C. of A.

[c] Label indicates that product represents a fire hazard.

Table 8. Flame spread rates for substances in two troughs

(8 x 3-3/4 x 1-inch asbestos-cement block with a 6 x 1 x 1/4-inch trough with a 1-ply aluminum foil inner lining) compared with aluminum (20 mil thick) trough (6 x 1 x 1/4-inch) with 1-ply aluminum foil inner lining. Five replicates for each sample.

Source of Ignition: Microburner

Substance	Rate of Flame Spread, in./sec		Std. Dev., in./sec	
	Transite Block	Al Trough	Transite Block	Al Trough
Paste Wax	0.43	0.44	0.061	0.046
Bowling Alley Wax	0.45	0.54	0.087	0.035
Smokeless Powder	0.45	0.43	0.046	0.019

Table 9. Effect of test conditions on results of "trough" flammability test[a]

Burner Type	Candle[b]		Micro Burner		Hypo. Needle		Hypo. Needle		Hypo. Needle		Micro Burner		Hypo. Needle[c]		Hypo. Needle		Micro Burner	
Ignition	Manual		Manual		Auto		Manual		Auto		Manual		Auto		Auto		Manual	
Thread Height	None		None		1/4"		1/4"		1/8"		1/8"		1/8"		1/16"		1/16"	
Substances:	Av. Rate in./sec	C.V.[d] %	Av. Rate in./sec	C.V. %	Av. Rate in./sec	C.V. %	Av. Rate in./sec	C.V. %	Av. Rate in./sec	C.V. %	Av. Rate in./sec	C.V. %	Av. Rate in./sec	C.V. %	Av. Rate in./sec	C.V. %	Av. Rate in./sec	C.V. %
Bowling Alley Wax	0.50	12	0.54	6	0.66	3	0.63	7	0.63	5	0.63	7	0.63	13	0.54	10	0.57	11
Vinyl Top Dressing	0.39	9	0.38	13	0.45	9	0.50	2	0.51	4	-	-	-	-	0.41	4	0.49	5
Car Wax #1	0.39	13	0.41	4	0.35	7	0.35	5	0.35	6	-	-	-	-	0.31	4	0.36	9
Paste Wax	0.40	13	0.44	10	0.57	11	0.56	4	0.58	3	0.56	10	0.60	6	0.55	4	-	-
Boot Polish	-	-	-	-	0.32	10	0.32	7	0.29	10	0.31	13	-	-	0.29	6	0.30	10
Shoe Polish	-	-	-	-	0.40	4	0.36	12	0.38	5	-	-	-	-	-	-	-	-
Car Wax #2	-	-	-	-	-	-	-	-	0.13	7	-	-	-	-	-	-	-	-
Smokeless Gunpowder	0.43	3	0.43	4	-	-	-	-	0.48	1	-	-	-	-	-	-	-	-

[a] Testing was performed in apparatus as specified in appendix A with exceptions as noted above, five samples each.

[b] Testing was performed in 6-inch asbestos-cement trough without trip threads.

[c] 1st thread 4 inches from trough end; all other tests with 1st thread 3 inches from end.

[d] Coefficient of variation.

Table 10. Operator bias

Operator #	1		2		3	
Substances:	Rate in./sec	C.V.[b] %	Rate in./sec	C.V. %	Rate in./sec	C.V. %
Car Wax #2	0.13	7	0.11	10	0.14	6
Paste Wax	0.58	3	0.58	5	0.57[a]	11

[a] Threads at 1/4" instead of 1/8".

[b] Coefficient of variation in percent.

Table 11. Samples exposed to 0.2 sec arc

Sample[a]	Energy (Joules)	Ignition Spark	Ignition Match
Lens Paper	64	Yes	Yes
Foam	53	No	Yes
Ironing Board Foam	54	Yes	Yes
Sponge	51	No	Yes
Plastic Bag	55	No	Yes
Shelf Liner	55	No	Yes
Crepe Paper (FR)	56	No	No
Foam (FR)	48	No	No
Polyethelene Sheeting	55	No	No
Camphor	66	No	Yes
Steel Wool	44	No	No
Air Conditioner Cover	48	No	Yes
Plastic Tablecloth	55	Yes	Yes
Dust Cloth	61	No	Yes
Paper Tablecloth	68	Yes	Yes
Drop Cloth	46	No	No
Polishing Cloth	51	No	Yes
Polystyrene Foam	41	No	Yes
Polymethylmethacrylate	48	No	No
Polymethylmethacrylate (FR)	52	No	No
Air (No Sample)	44	No	No

[a] Industrial samples, exact composition unknown.

APPENDIX A

Proposed Test Method for the Flammability of Solids Under the Federal Hazardous Substances Act

METHOD I

Fibers, Shredded Materials, and Slit Films

.1 Scope.

This standard provides a test method and sampling plan to determine the flammability classification of shredded and slit films under the Federal Hazardous Substances Act.

.2 Definitions.

(a) "Federal Hazardous Substances Act"--the Federal Hazardous Substances Act (1974) and the Federal Hazardous Substances Act Regulations (1973).

(b) "Horizontal burn time" means the time required for a shredded or slit film to burn 15.2 cm (6 in) from the first trip thread and to the second trip thread as defined in .5(c).

(c) "Ignition source" means the flame produced from the gas, burner, and flame length specified in .5(b).

(d) "Packaged unit" means the smallest primary unit of sale of the substance.

(e) "Production unit" means any quantity of finished material manufactured in 12 calendar months which has a specific identity that remains unchanged throughout the unit. For purposes of this definition, finished material means material in its final, packaged form, ready for sale.

(f) "Sample" means a set of five specimens.

(g) "Specimen" means an amount of material to fill the trough for testing as specified in .5(c).

.3 General requirements.

(a) Summary of test method. A specimen is placed in a horizontal trough and exposed to a standard flame on its surface for a specified ignition time under controlled conditions. The horizontal burn time between two trip threads located 15.2 cm (6 in) apart and 0.32 cm (1/8 in) above the surface of the specimen is measured.

(b) Test criterion. When tested in accordance with .5, a material is classified as follows:

(1) Materials with a horizontal burn time greater than the established acceptance criterion shall be considered to pass the test and hence need no labeling under the Federal Hazardous Substances Act.

(2) Materials with a horizontal burn time less than the established acceptance criterion shall be labeled in accordance with the Federal Hazardous Substances Act as flammable.

.4 Sampling and classification procedures.

(a) General. The test procedure of .5(c) shall be used in conjunction with the following plan: The Consumer Product Safety Commission may consider and approve other sampling plans that provide at least the equivalent level of fire safety to the consumer. Alternate sampling plans approved for one manufacturer may be used by other manufacturers without prior approval of the Consumer Product Safety Commission.

(b) A production unit is classified according to the following plan:

(1) Normal classification sampling. Select five specimens, one sample, from at least three different packaged units from a production unit, unless the production unit consists of less than packaged units. Test the sample according to .5. If all five specimens meet the criterion of the test method defined in .3(b), the production unit shall be considered to meet the flammability requirements of the Federal Hazardous Substances Act for fibers, shredded materials, and slit films. If one specimen of the five fails the criterion of the test method defined in .3(b) and the individual responsible for the classification is satisfied to classify the production unit as not having met the requirements, classify the production unit as such. If one specimen of the five fails to meet the criterion specified in .3(b) and the individual

responsible for classification desires to pass the production unit, select 10 additional specimens, two samples from at least three different packaged units other than those selected for the initial sample and test according to .5. If 13 or more of the 15 specimens tested meet the criterion specified in .3(b), the production unit shall be considered to meet the flammability requirements of the Federal Hazardous Substances Act for shredded and slit films. If only 12 or less of the 15 specimens meet the criterion specified in .3(b), the production unit shall not be considered to meet the flammability requirements of the Federal Hazardous Substances Act for fibers, shredded materials, and slit films.

(2) Reduced sampling classification. The level of sampling required to classify shredded and slit films may be reduced provided the previous 15 production units have all met the criteria specified in .3(b).

The reduced classification procedure shall be the same as the normal classification procedure except that the production unit time limit shall be extended to 24 months.

Reduced sampling shall be discontinued and normal sampling resumed if a production unit does not meet the criteria specified in .3(b).

.5 Test procedure.

(a) General. If previous testing indicates that the material under evaluation will not meet the criteria specified in .3(b), the material may, at the tester's option, be considered not to meet the criteria specified in .3(b), and no further testing is necessary.

(b) Apparatus.--(1) Base and specimen holder support. The base and specimen holder support assembly is detailed in engineering drawing 1. It shall consist of a chassis base, nominal 43 x 33 x 10 cm (17 x 13 x 4 in), equipped with trip thread guides and spring loaded microswitches to hold trip threads taut during testing and to allow electronic timing of the horizontal burn time. It shall also be equipped with suitable leveling screws to provide a horizontal, level surface for testing.

(2) Specimen holder. The specimen holder is detailed in engineering drawings 2 and 3. It shall consist of a aluminum trough insert as detailed in the engineering drawings. The insert rests in an aluminum holder that is suspended on spacers above the base assembly.

(3) Ignition source assembly. The ignition source assembly shall consist of a 13-gauge hypodermic needle fastened to a brass tube to supply gas to the burner tip as shown in engineering drawing 4.

(4) Timing device. A stopwatch or suitable electric timer (actuated by trip switches) shall be available to measure horizontal burn time at least to the nearest 0.1 second.

(5) Gas. The gas shall be at least 97 percent pure methane.

(6) Trip threads. The thread used as trip threads shall be #50 white cotton thread.

(7) Trough liners. Aluminum foil, 0.01 ± 0.005 mm (0.39 ± 0.2 mil) thick shall be used to line the trough during testing as described in .5(c)(2).

(8) Balance. A balance shall be available to weigh specimen to the nearest ±0.1 gram.

(c) Test procedure.--(1) General.--(i) All specimens shall be conditioned for at least 8 hours in a room with forced air movement at a temperature 21 ± 3°C (70 ± 5°F) and a relative humidity of 67 percent or less.

(ii) Testing shall be performed in a room under the conditions specified under (c)(1)(i), above, provided with a hood or other smoke removal equipment. It is suggested that the hood be equipped with both a bottom and a top exhaust and be in operation during testing. The maximum airflow in any direction by the test chamber during testing shall not exceed 0.2 m/s (0.65 ft/sec). The airflow may be increased between tests to rapidly remove the gaseous products of combustion.

(2) Test procedure.--(i) Test preparation.--(A) Trough preparation. Prepare trough for testing by leveling trough insert using leveling screws provided. Fit a trough liner of aluminum foil, as specified in .5(b)(7), to conform to the sides and bottom of the trough.

(B) Specimen preparation. Select a specimen, as defined in .4(b)(1) and consisting of 10 ± 0.1 grams of the fiber, shredded material, or slit film, making sure the specimen is as homogeneous as would be representative of the production unit. Insert wire mesh in holder, place specimen on mesh insert in specimen trough, and distribute material evenly over the mesh insert. Lower restraint and clamp at left edge.

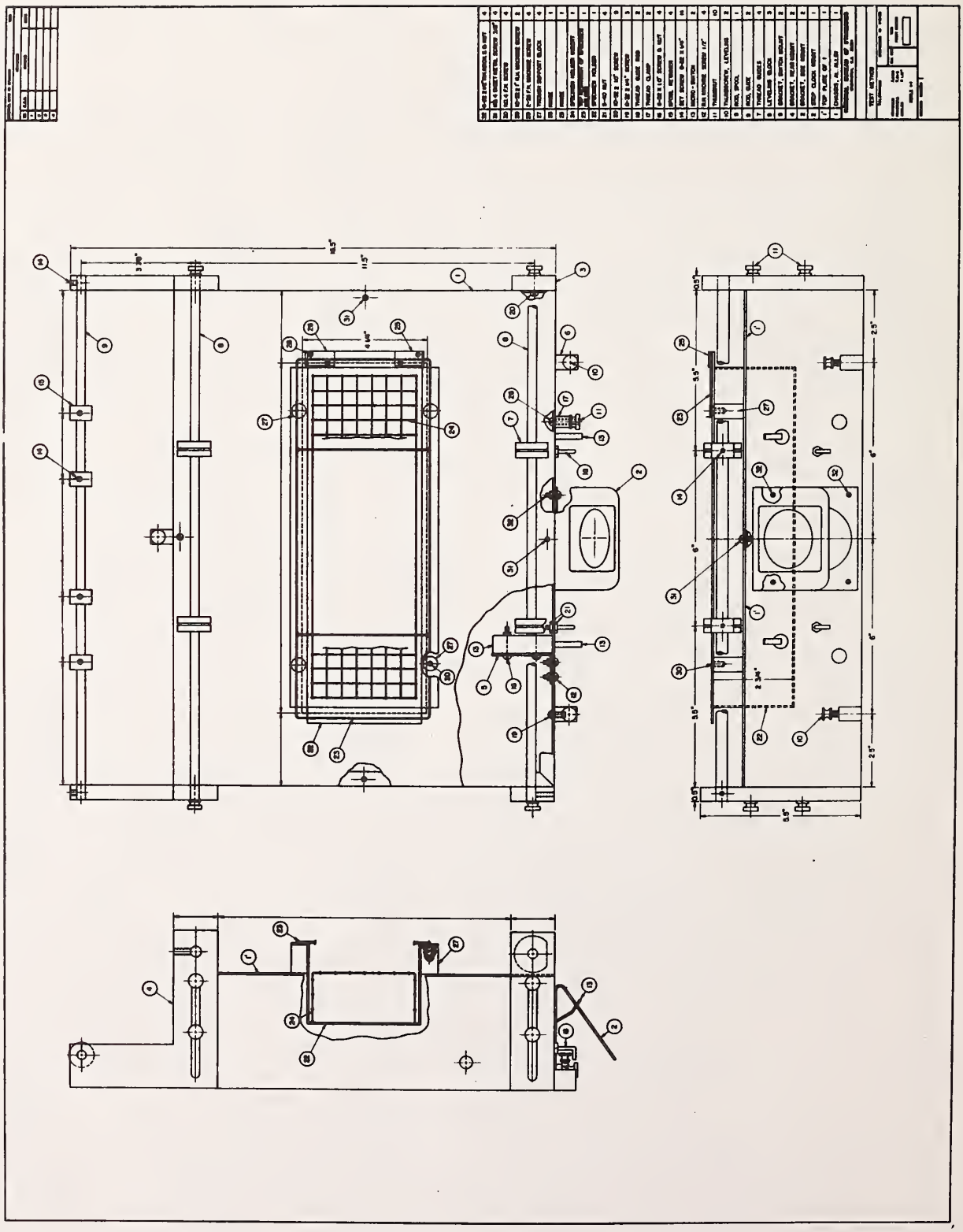
(C) Trip threads. String trip threads, located on spools in back of base specimen holder support, through grooved thread guides in back of specimen trough and across specimen and through grooved thread guides in front of specimen trough; then guide threads around thread switch guide and over thread switch, depressing thread switch completely, and attach thread around bolt, securing it firmly with nut. Make certain that trip threads across specimen are 15.2 cm (6 in) apart.

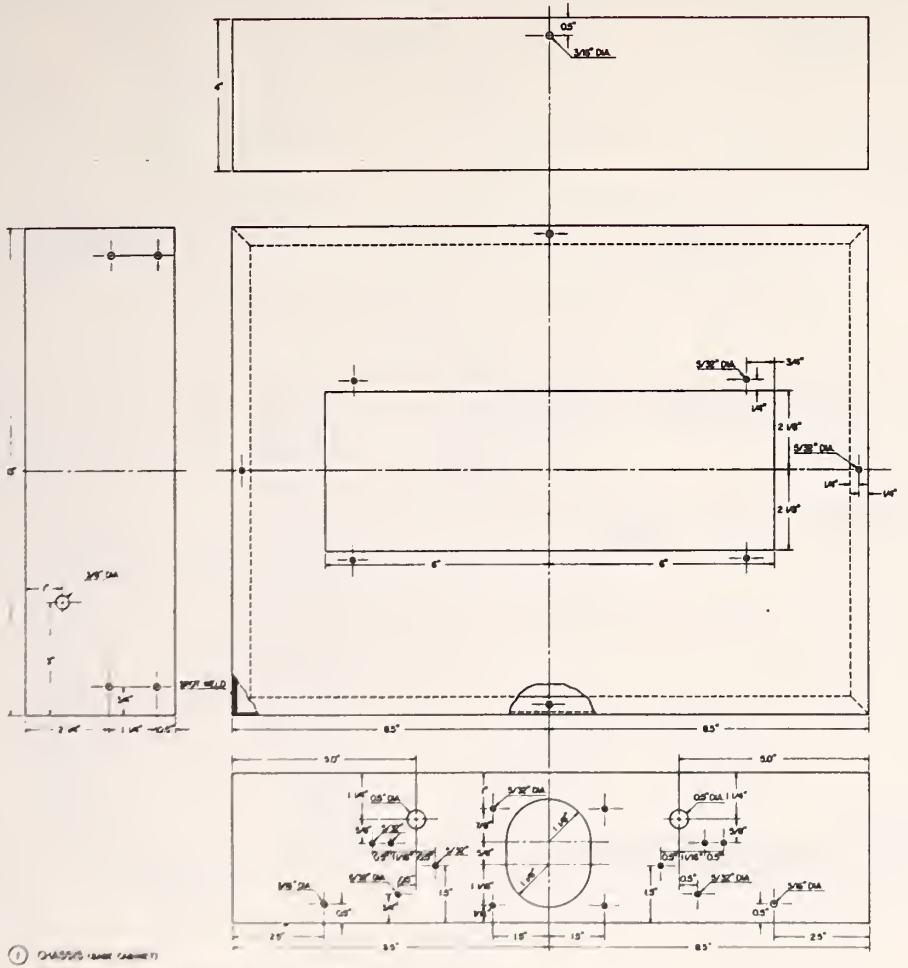
(D) Gas ignition. Light the methane gas ignition source and adjust the flame length so that it is 2.54 ± 0.1 cm (1 ± 0.4 in) when the burner is held in the nearly vertically downward mode.

(ii) Testing. Expose the specimen to the ignition source, for 5 seconds, at a point centered between the front and rear edge of the trough and 1.27 cm (1/2 in) to the left of the right edge of the trough. Allow the material to burn down the trough and begin timing as the first trip thread is burned through. Stop timing when the second trip thread is burned through.

(iii) Test observations. Record the horizontal burn time to the nearest 0.1 second.

(iv) Assembly cleaning and cooling. Dispose of the aluminum trough into a covered metal can. Allow trough to cool before testing next specimen.





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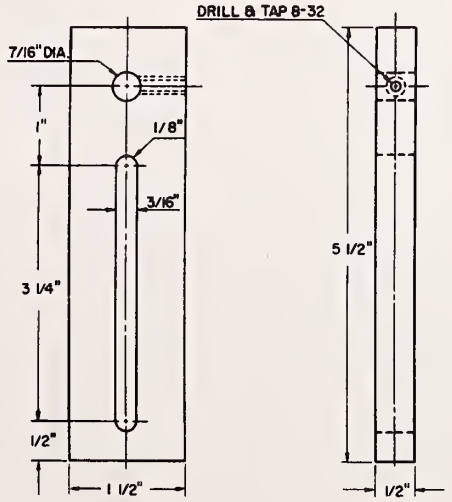
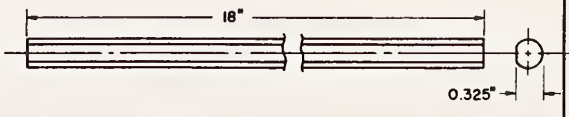


(3) BRACKET SIDE MOUNT
AL. ALY 2024-T4



(8) ROD, GUIDE
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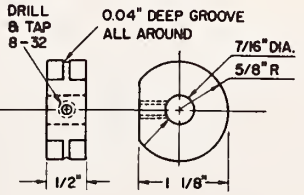
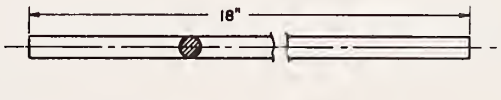
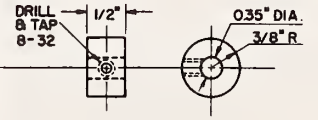


(7) THREAD GUIDE
AL. ALY 2024-T351



(9) ROD, SPOOL
AL. ALY 2024-T4 1/4" DIA.



(15) SPOOL RETAINER
AL. ALY 2024-T351

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TEST METHOD

TOLERANCES		DIMENSIONS IN INCHES	
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FRACTIONS	±.015		
ANGLES	±1/2°		
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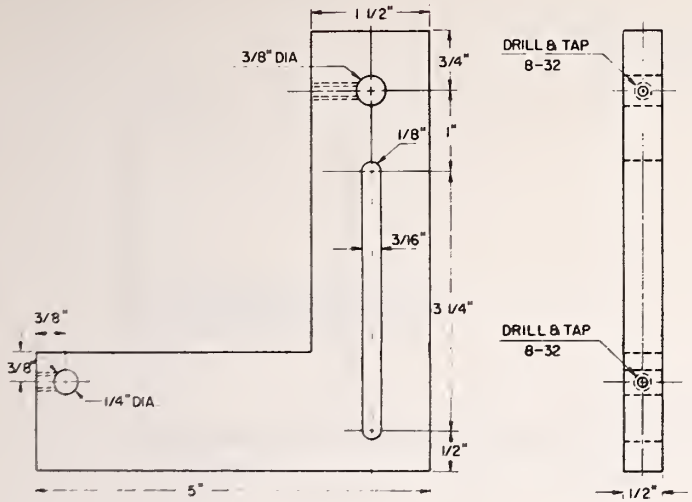
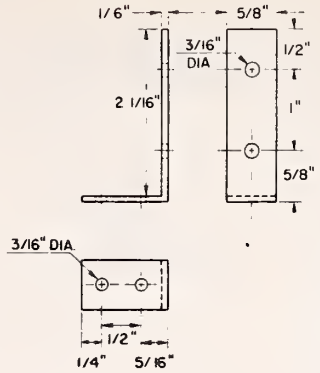
DRAWING NUMBER 18



(4) BRACKET, REAR MOUNT AL ALY 2024-T4



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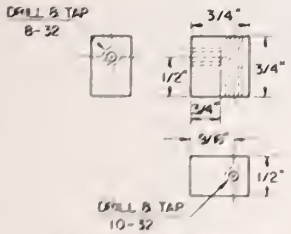

(6) LEVELING BLOCK
AL ALY 2024-T4

(10) LEVELING THUMBSCREW
BRASS 10-32 X 1"

(11) THUMB NUT
10-32

(17) THREAD CLAMP
AL ALY 2024-T4
10-32

ORIGINAL DATE OF DRAWING			1976
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TEST METHOD

TOLERANCES
DECIMALS ± .005
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ANGLES ± 1/2°
SCALE 1:1

DIMENSIONS IN INCHES

DIV SEC | THIS PRINT ISSUED

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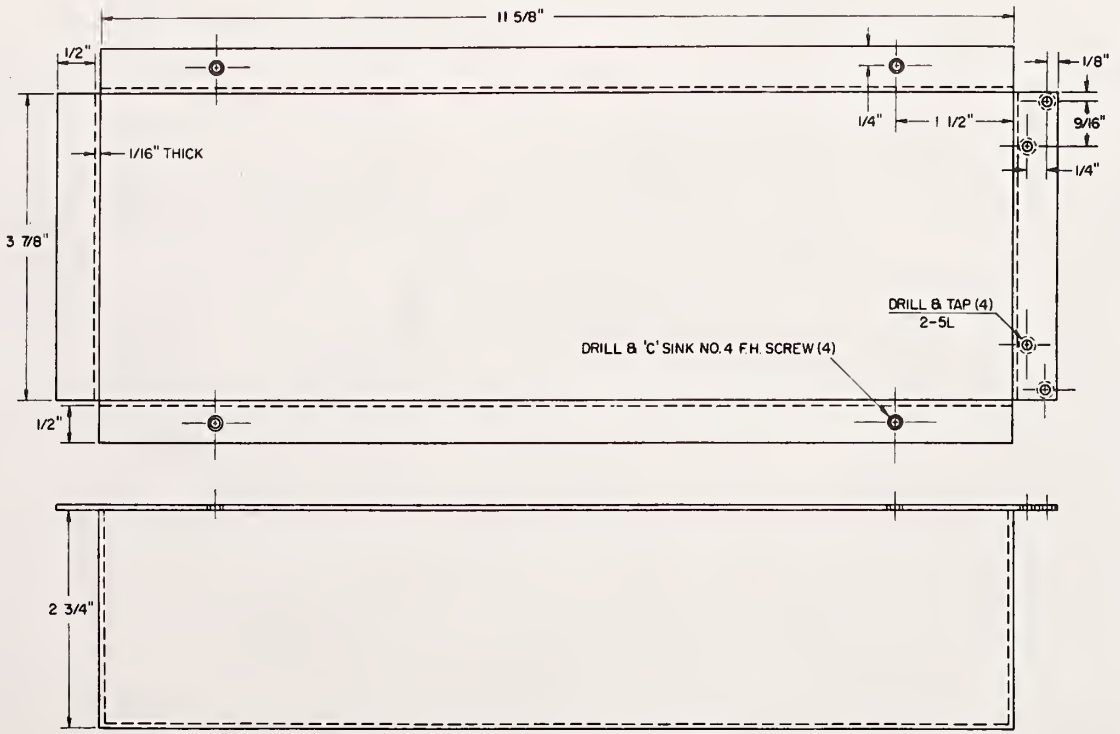
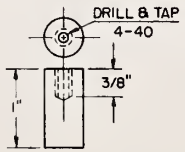
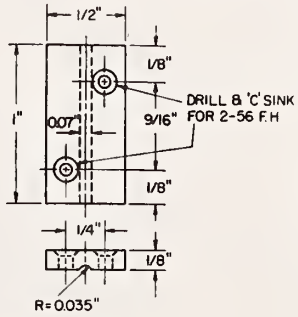
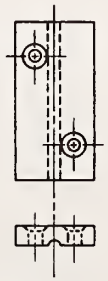


(22) SPECIMEN HOLDER (BASKET)
AL. ALY 5052-H32, 1/16" THICK
WELDED ALL AROUND



(27) TROUGH 1/2" DIA. BLOCK SUPPORT
AL. ALY 2024-T4





(25), (26) HINGES
AL. ALY 2024-T4

SCALE 2:1

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TEST METHOD

TOLERANCES		DIMENSIONS IN INCHES
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FRACTIONS	±.015	THIS PRINT ISSUED
ANGLES	±1/2°	
SCALE 1:1		

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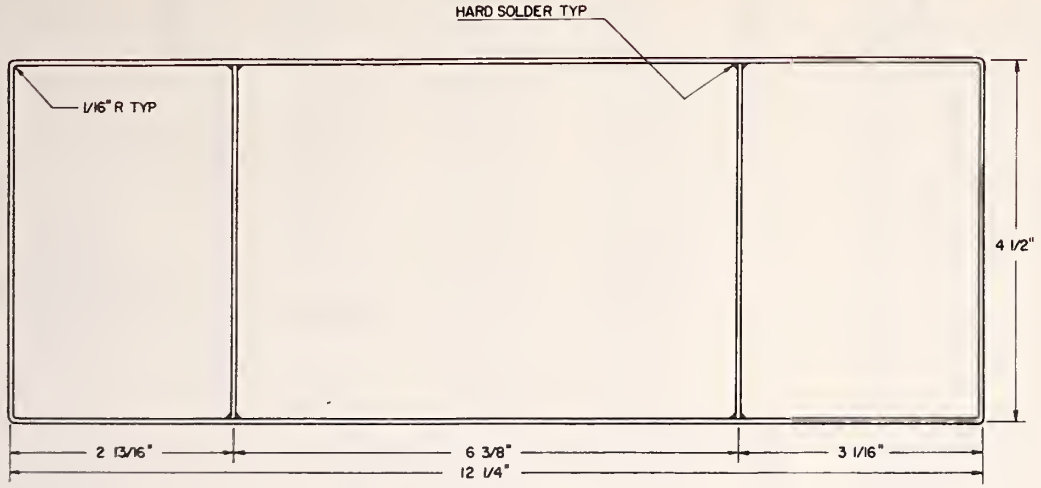
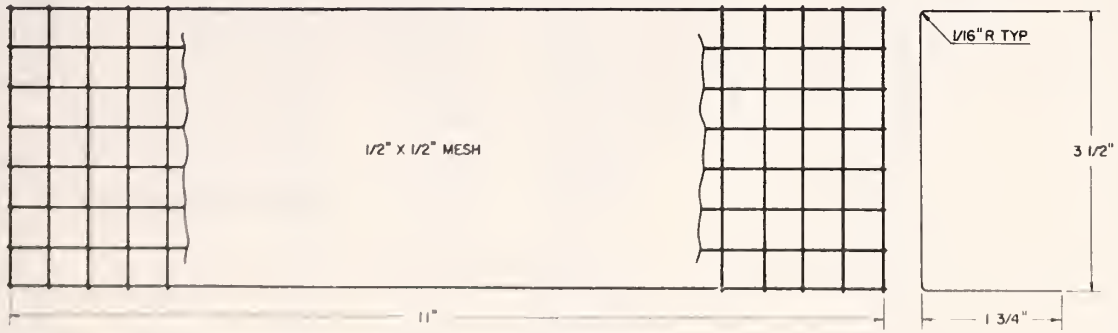


(23) TOP RESTRAINT OF SPECIMEN HOLDER
STAINLESS STEEL WIRE 1/16" THICK



(24) SPECIMEN HOLDER INSERT
COULD BE MANUFACTURED FROM 1/2" X 1/2"
1/32" THICK STAINLESS STEEL WIRE MESH

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TEST METHOD

TOLERANCES		DIMENSIONS IN INCHES
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FRACTIONS	± 015	TNS PRINT ISSUED
ANGLES	± 1/2°	
SCALE 1:1		

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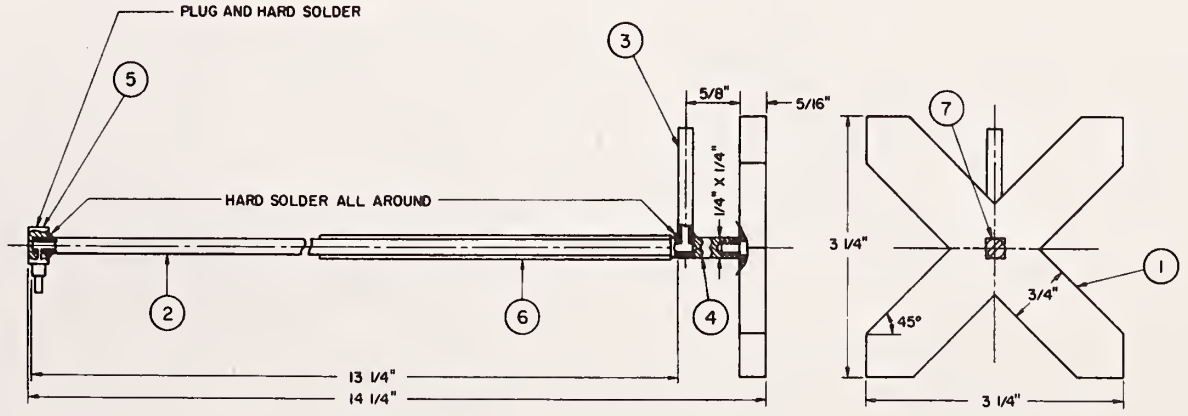

1. DRILL AND TAP ITEM 4 6-32/0.2"DP.
2. DRILL ITEM 1

7	SCREW, FLAT HD. 6-32 5/8" LG.	1
6	TUBE TYGON 3/16" I.D.	A.R.
5	13 GAGE HYPODERMIC	1
4	BASE, BRASS 1/4" SQ., 3/16" I.D.	1
3	TUBE, BRASS 3/16" OD, 1/32" WALL	1
2	TUBE, BRASS 3/16" OD, 1/32" WALL	1
1	BASE, BRASS 5/16" THICK	1

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BURNER

FOR TEST METHOD

TOLERANCES

DECIMALS ±.005
FRACTIONS ±.015
ANGLES ±1/2°

SCALE 1:1

DIMENSIONS IN INCHES

DIV SEC

PRINT ISSUED

DRAWING NUMBER 4

APPENDIX B

Proposed Test Method for the Flammability of Solids Under the Federal Hazardous Substances Act

METHOD II

Powders, Pastes, and Granular Substances

.1 Scope.

This standard provides a test method and sampling plan to determine the flammability classification of powders, pastes, and granular substances under the Federal Hazardous Substances Act.

.2 Definitions.

(a) "Federal Hazardous Substances Act"--the Federal Hazardous Substances Act (1974) and the Federal Hazardous Substances Act Regulations (1973).

(b) "Horizontal burn time" means the time required for a powder, paste, or granular substance to burn 15.2 cm (6 in) from the first trip thread and to the second trip thread as defined in .5(c).

(c) "Ignition source" means the flame produced from the gas, burner, and flame length specified in .5(b).

(d) "Packaged unit" means the smallest primary unit of sale of the substance.

(e) "Powder, paste, and granular" means any solid in paste, powder, or granular form as defined by the Federal Hazardous Substances Act. This definition includes, but is not limited to, paste wax, smokeless gunpowder, bowling alley wax, vinyl top dressing, car wax, boot polish, shoe polish, acoustical tile cement, asphalt tile cement, black gunpowder, etc.

(f) "Production unit" means any quantity of finished material manufactured in 12 calendar months which has a specific identity that remains unchanged

throughout the unit. For purposes of this definition, finished material means material in its final, packaged form, ready for sale.

(g) "Sample" means a set of five specimens.

(h) "Specimen" means an amount of material to fill the trough for testing as specified in .5(c).

.3 General requirements.

(a) Summary of test method. A specimen is placed in a horizontal trough and exposed to a standard flame on its surface for a specified ignition time under controlled conditions. The horizontal burn time between two trip threads located 15.2 cm (6 in) apart and 0.32 cm (1/8 in) above the surface of the specimen is measured.

(b) Test criterion. When tested in accordance with .5, a material is classified as follows:

(1) Materials with a horizontal burn time greater than the established acceptance criterion shall be considered to pass the test and hence need no labeling under the Federal Hazardous Substances Act.

(2) Materials with a horizontal burn time less than the established acceptance criterion shall be labeled in accordance with the Federal Hazardous Substances Act as flammable.

.4 Sampling and classification procedures.

(a) General. The test procedure of .5(c) shall be used in conjunction with the following plan: The Consumer Product Safety Commission may consider and approve other sampling plans that provide at least the equivalent level of fire safety to the consumer. Alternate sampling plans approved for one manufacturer may be used by other manufacturers without prior approval of the Consumer Product Safety Commission.

(b) A production unit is classified according to the following plan:

(1) Normal classification sampling. Select five specimens, one sample, from at least three different packaged units from a production unit, unless

the production unit consists of less than packaged units. Test the sample according to .5. If all five specimens meet the criteria of the test method defined in .3(b), the production unit shall be considered to meet the flammability requirements of the Federal Hazardous Substances Act for powders, pastes, and granular substances. If one specimen of the five fails the criterion of the test method defined in .3(b) and the individual responsible for the classification is satisfied to classify the production unit as not having met the requirements, classify the production unit as such. If one specimen of the five fails to meet the criterion specified in .3(b) and the individual responsible for classification desires to pass the production unit, select 10 additional specimens, two samples from at least three different packaged units other than those selected for the initial sample and test according to .5. If 13 or more of the 15 specimens tested meet the criterion specified in .3(b), the production unit shall be considered to meet the flammability requirements of the Federal Hazardous Substances Act for powders, pastes, and granular substances. If only 12 or less of the 15 specimens meet the criterion specified in .3(b), the production unit shall not be considered to meet the flammability requirements of the Federal Hazardous Substances Act for powders, pastes, and granular substances.

(2) Reduced sampling classification. The level of sampling required to classify powders, pastes, and granular substances may be reduced provided the previous 15 production units have all met the criteria specified in .3(b).

The reduced classification procedure shall be the same as the normal classification procedure except that the production unit time limit shall be extended to 24 hours.

Reduced sampling shall be discontinued and normal sampling resumed if a production unit does not meet the criteria specified in .3(b).

.5 Test procedure.

(a) General. If previous testing indicates that the material under evaluation will not meet the criterion specified in .3(b), the material may, at the tester's option, be considered not to meet the criteria specified in .3(b), and no further testing is necessary.

(b) Apparatus.--(1) Base and specimen holder support. The base and specimen holder support assembly is detailed in engineering drawing 1. It shall consist of a chassis base, nominal 43 x 33 x 10 cm (17 x 13 x 4 in),

equipped with trip thread guides and spring loaded microswitches to hold trip threads taut during testing and to allow electronic timing of the horizontal burn time. It shall also be equipped with suitable leveling screws to provide a horizontal, level surface for testing.

(2) Specimen holder. The specimen holder is detailed in engineering drawings 2 and 3. It shall consist of a Teflon block insert with a 28 x 2.5 x 0.64 cm (11 x 1 x 1/4 in) centrally located trough cut in it. The insert rests in an aluminum holder that is suspended on spacers above the base assembly.

(3) Ignition source assembly. The ignition source assembly shall consist of a 13-gauge hypodermic needle fastened to a brass tube to supply gas to the burner tip.

(4) Timing device. A stopwatch or suitable electric timer (actuated by trip switches) shall be available to measure horizontal burn time at least to the nearest 0.1 second.

(5) Gas. The gas shall be at least 97 percent pure methane.

(6) Trip threads. The thread used as trip threads shall be #50 white cotton thread.

(7) Trough liners. Aluminum foil, 0.01 ± 0.005 mm (0.39 ± 0.2 mil) thick shall be used to line the trough during testing as described in .5(c)(2).

(c) Test procedure.--(1) General.--(i) All specimens shall be conditioned for at least 8 hours in a room with a temperature not less than 15°C (60°F) and a relative humidity of 67 percent or less. However, all containers should be closed at this time and at all times except when samples are withdrawn, etc., to prevent loss of any solvent.

(ii) Testing shall be performed in a room under the conditions specified under (c)(1)(i), above, provided with a hood or other smoke removal equipment. It is suggested that the hood be equipped with both a bottom and a top exhaust and be in operation during testing. The maximum airflow in any direction by the test chamber during testing shall not exceed 0.2 m/s (0.65 ft/sec). The airflow may be increased between tests to rapidly remove the gaseous products of combustion.

(2) Test procedure.--(i) Test preparation.--(A) Trough preparation. Prepare trough for testing by leveling teflon insert using leveling screws provided. Fit a trough liner of aluminum foil, as specified in .5(b)(7), to conform to the sides and bottom of the trough by pulling fingernails gently along bottom edges of trough.

(B) Specimen preparation, pastes. Select a specimen as specified in .4(b)(1) and prepare it for testing in the following manner: Using a spatula, pack substrate into trough firmly, slightly overfilling the trough. Scrape off excess material using a 3-inch putty knife, leveling material to the level of the surrounding tray. Fill in any indentation with additional material and smooth again. Clean putty knife after each use. Wipe excess material from aluminum foil outside the trough and make sure foil liner lies flat against teflon insert.

(C) Specimen preparation, powders, and granulars. Select a specimen as specified in .4(b)(1) and prepare it for testing in the following manner: Pour or scoop substance into trough. Level with putty knife to the level of the surrounding tray. Take care to avoid packing material too densely. Wipe excess material from aluminum foil outside the trough and make sure foil liner lies flat against teflon insert.

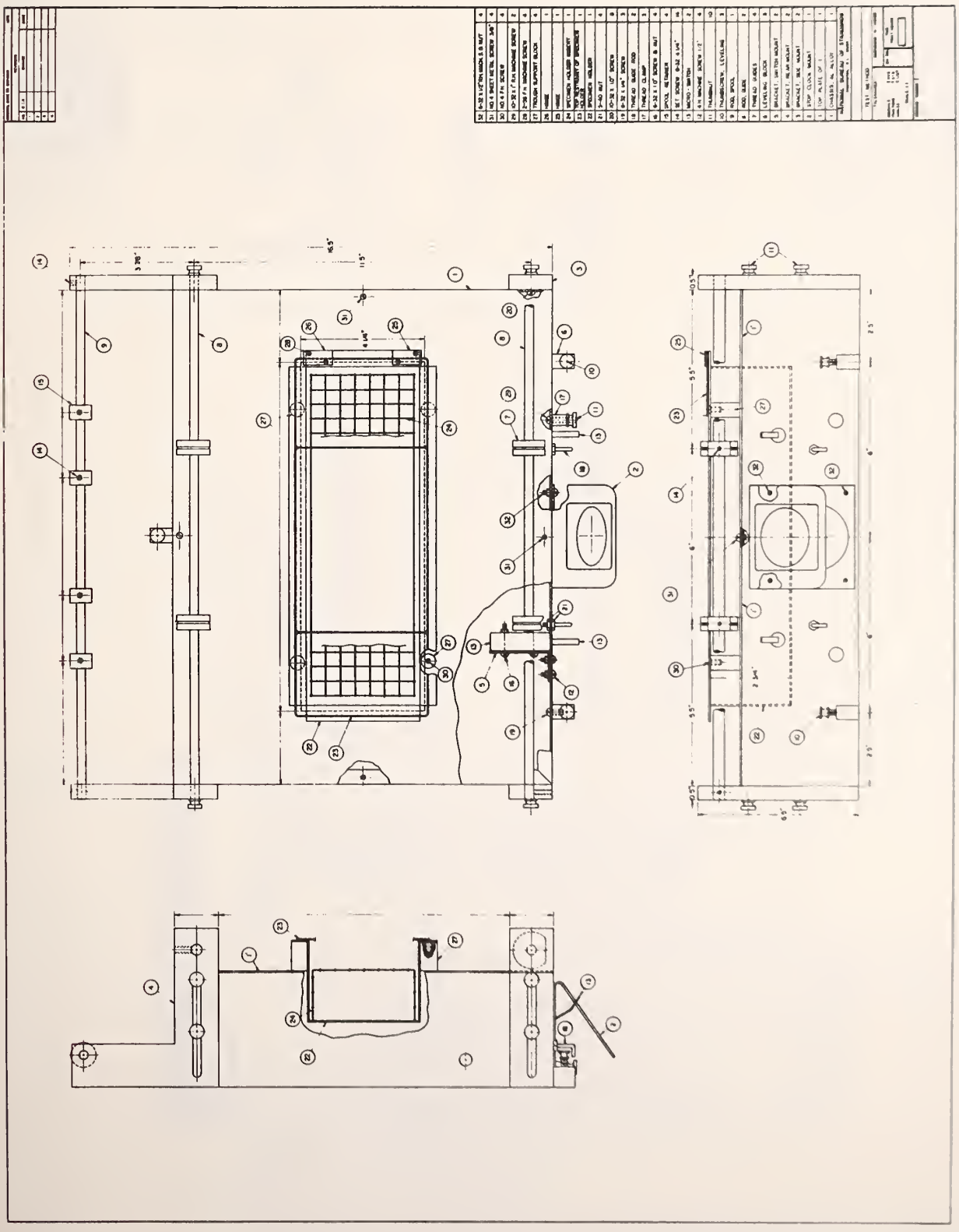
(D) Trip threads. String trip threads, located on spools in back of base specimen holder support, through grooved thread guides in back of specimen trough and across specimen and through grooved thread guides in front of specimen trough; then guide threads around thread switch guide and over thread switch, depressing thread switch completely, and attach thread around bolt, securing it firmly with nut. Make certain that trip threads across specimen are 6 inches apart.

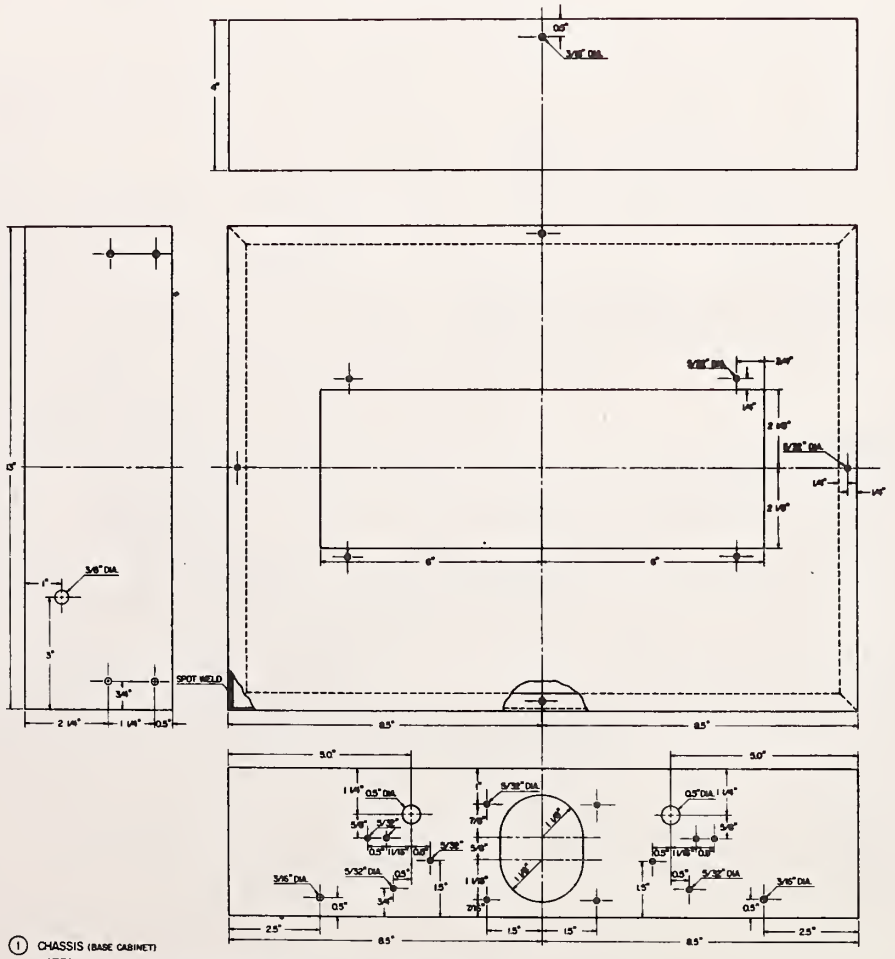
(E) Gas ignition. Light the methane gas ignition source and adjust the flame length so that it is 2.54 ± 0.1 cm (1 ± 0.4 in) when the burner is held in the vertically downward mode.

(ii) Testing. Expose the specimen to the ignition source, for 5 seconds, at a point centered between the front and rear edge of the trough and 1.27 cm (1/2 in) to the left of the right edge of the trough. Allow the material to burn down the trough and begin timing as the first trip thread is burned through. Stop timing when the second trip thread is burned through.

(iii) Test observations. Record the horizontal burn time to the nearest 0.1 second.

(iv) Assembly cleaning and cooling. Dispose of the aluminum trough into a covered metal can. Allow trough to cool before testing next specimen.





(1) CHASSIS (BASE CABINET)

NOTES.

1. THE FOUR SIDES AND THE BOTTOM OF THE BOX COULD BE MANUFACTURED FROM ONE PIECE 1/16" AL. SHEET BY BENDING THE SIDES 90° OVER THE BOTTOM PIECE AND THEN SPOT WELDING EACH SIDE OF THE BOX HAS ALSO 1/2" BENT OVER PARALLEL TO THE BOTTOM TO WHICH THE TOP PLATE IS TO BE SCREWED.
2. THE RIGHT SIDE OF THE BOX IS IDENTICAL TO THE LEFT SIDE EXCEPT WITHOUT THE 3/4" CENTRAL HOLE
3. THE TOP PIECE OF THE BOX IS A 13"X17" FLAT PLATE WITH A 12"X 4 1/4" CENTRAL CUT-OFF, THE FOUR HOLES NEAR THE EDGES ARE USED TO FASTEN THE TOP PLATE TO THE SIDE PLATES.

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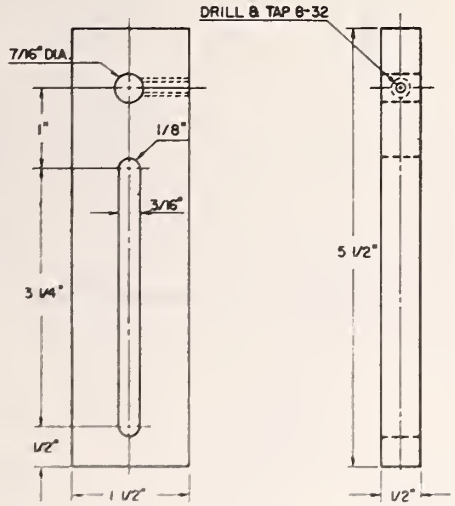
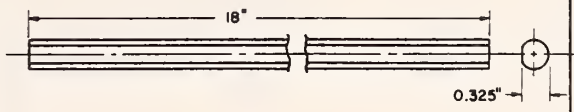
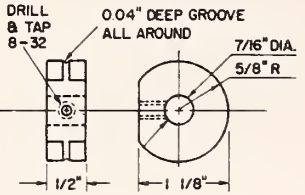


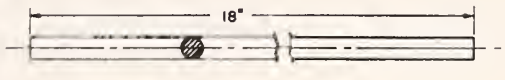
(3) BRACKET SIDE MOUNT
AL. ALY 2024-T4



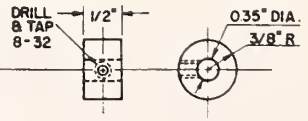
(8) ROD, GUIDE
AL. ALY 2024-T4 3/8" DIA.



(7) THREAD GUIDE
AL. ALY 2024-T351



(9) ROD, SPOOL
AL. ALY 2024-T4 1/4" DIA



(15) SPOOL RETAINER
AL. ALY 2024-T351

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TEST METHOD

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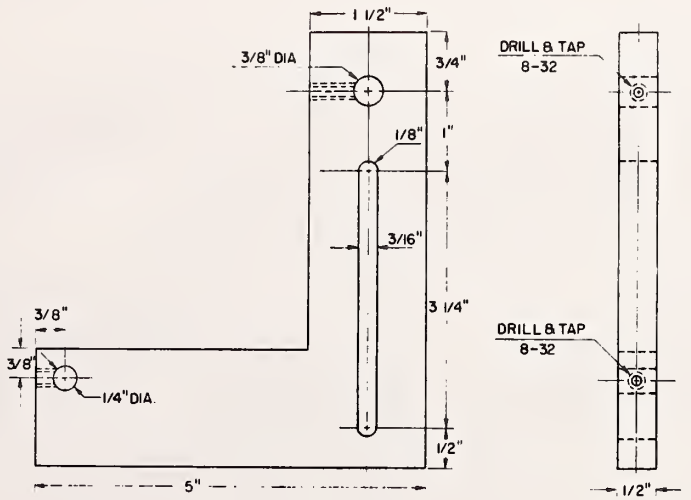
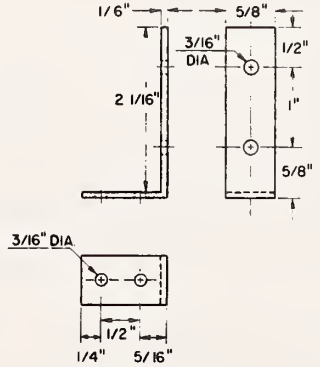


(4) BRACKET, REAR MOUNT AL. ALY 2024-T4



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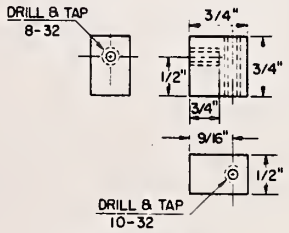
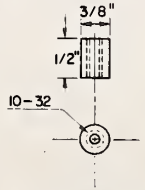


(6) LEVELING BLOCK
AL. ALY 2024-T4

(10) LEVELING THUMBSCREW
BRASS 10-32 X 1"

(11) THUMB NUT
10-32



(17) THREAD CLAMP
AL. ALY 2024-T4
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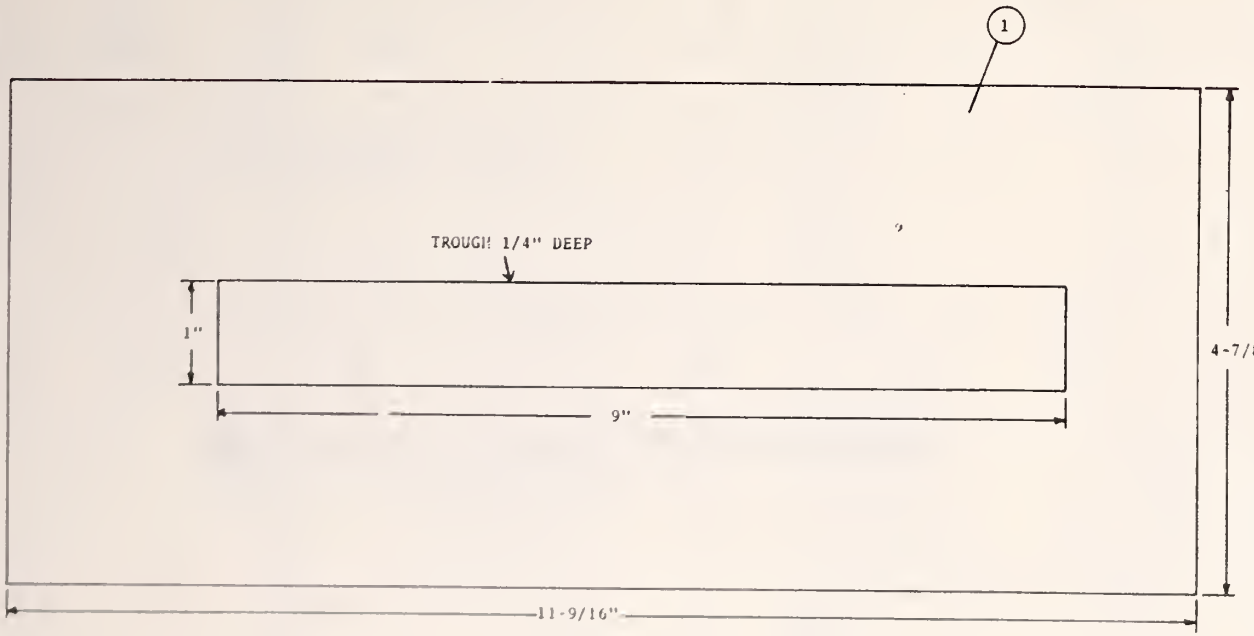

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WASHINGTON, D.C. 20234

FOR TEST METHOD II

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DO NOT SCALE THIS PRINT	EXAMINED BY CHIEF ENGINEER	
DIV. 00C — THIS PRINT ISSUED	APPROVED BY CHIEF, DIV	
	DRAWING #3	

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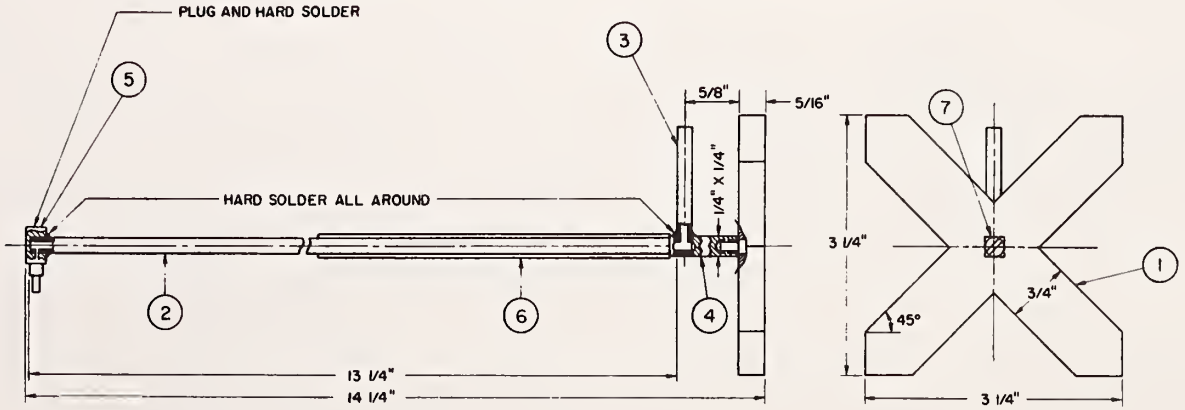


1 DRILL AND TAP ITEM 4 6-32/0.2" DP.
2 DRILL ITEM 1

7	SCREW, FLAT HD. 6-32 5/8" LG	1
6	TUBE TYGON 3/16" I.D.	A.R.
5	13 GAGE HYPODERMIC	1
4	BASE, BRASS 1/4" SQ., 3/16" I.D.	1
3	TUBE, BRASS 3/16" O.D., 1/32" WALL	1
2	TUBE, BRASS 3/16" O.D., 1/32" WALL	1
1	BASE, BRASS 5/16" THICK	1

NATIONAL BUREAU OF STANDARDS
WASHINGTON, D C 20234

BURNER

FOR TEST METHOD

TOLERANCES
DECIMALS ± .005
FRACTIONS ± 1/5
ANGLES ± 1/2°
SCALE 1:1

DIMENSIONS IN INCHES

DIV SEC

PRINT ISSUED

DRAWING NUMBER 4

APPENDIX C

Proposed Test Method for the Flammability of Solids
Under the Federal Hazardous Substances Act

METHOD III

Electric Sparking Ignition

.1 Scope.

A test method and sampling plan is provided to determine the flammability classification of solids when exposed to an electric spark under the Federal Hazardous Substances Act.

.2 Definitions.

(a) "Federal Hazardous Substances Act"--the Federal Hazardous Substances Act (1974) and the Federal Hazardous Substances Act Regulations (1973).

(b) "Packaged unit" means the smallest primary unit of sale of the substance.

(c) "Production unit" means any quantity of finished material manufactured in 12 calendar months which has a specific identity that remains unchanged throughout the unit. For purposes of this definition, finished material means material in its final, packaged form, ready for sale.

(d) "Sample" means a set of five specimens.

(e) "Specimen" means an amount of material necessary to conduct a test as defined in .5(c).

.3 General requirements.

(a) Summary of test method. A specimen is placed on a specimen holder and exposed to a standard electric spark on its surface for a specified

ignition time under controlled conditions. The ignition/nonignition of the material is measured.

(b) Test criterion. When tested in accordance with .5, a material is classified as follows:

(1) Materials that do not ignite when exposed to the standard spark discharge shall be considered to pass this test and hence need no labeling as extremely flammable under the Federal Hazardous Substances Act.

(2) Materials that do ignite when exposed to the standard spark discharge shall be labeled in accordance with the Federal Hazardous Substances Act as extremely flammable.

.4 Sampling and classification procedures.

(a) General. The test procedure of .5(c) shall be used in conjunction with the following plan: The Consumer Product Safety Commission may consider and approve other sampling plans that provide at least the equivalent level of fire safety to the consumer. Alternate sampling plans approved for one manufacturer may be used by other manufacturers without prior approval of the Consumer Product Safety Commission.

(b) A production unit is classified according to the following plan:

(1) Normal classification sampling. Select five specimens, one sample, from at least three different packaged units from a production unit, unless the production unit consists of less than three packaged units. Test the sample according to .5. If all five specimens meet the criteria of the test method defined in .3(b), the production unit shall be considered to meet the flammability requirements of the Federal Hazardous Substances Act for extremely flammable solids. If one specimen of the five fails the criterion of the test method defined in .3(b) and the individual responsible for the classification is satisfied to classify the production unit as not having met the requirements, classify the production unit as such. If one specimen of the five fails to meet the criterion specified in .3(b) and the individual responsible for classification desires to pass the production unit, select 10 additional specimens, two samples from at least three different packaged units other than those selected for the initial sample and test according to .5. If 13 or more of the 15 specimens tested meet the criterion specified in .3(b), the production unit shall be considered to meet the flammability requirements of the Federal

Hazardous Substances Act for extremely flammable solids. If only 12 or less of the 15 specimens meet the criterion specified in .3(b), the production unit shall not be considered to meet the flammability requirements of the Federal Hazardous Substances Act for extremely flammable solids.

(2) Reduced sampling classification. The level of sampling required to classify materials may be reduced provided the previous 15 production units have all met the criteria specified in .3(b).

The reduced classification procedure shall be the same as the normal classification procedure except that the production unit time limit shall be extended to 24 months.

Reduced sampling shall be discontinued and normal sampling resumed if a production unit does not meet the criteria specified in .3(b).

.5 Test procedure.

(a) General. If previous testing indicates that the material under evaluation will not meet the criteria specified in .3(b), the material may, at the tester's option, be considered not to meet the criteria specified in .3(b), and no further testing is necessary.

(b) Apparatus.--(1) Specimen holder and electrode assembly. The specimen holder and electrode assembly is detailed in engineering drawings 1 and 2. It shall consist of two replaceable copper electrode tips mounted to copper electrode holders, and supported by nylon support assemblies, as detailed in engineering drawing 1. The horizontal distance between the two tips shall be 0.5 cm (0.2 in). The specimen holder shall be constructed with a teflon top plate with an electromagnet mounted under it, as detailed in engineering drawing 2. In addition, it shall be equipped with suitable vertical height adjustment on the specimen holder to allow adjustment of the specimen to electrode distance. It shall also be equipped with suitable leveling screws to provide a horizontal, level surface for testing.

(2) Power supply and timing circuitry. The power supply and timing circuitry is detailed in engineering drawing 3. It shall consist of a high voltage transformer and an electronic clock, as detailed in engineering drawing 3, to provide power to the electrodes and timing of the spark duration.

(c) Test procedure.--(1) General.--(i) All specimens shall be conditioned for at least 8 hours in a room with a temperature not less than 15°C (60°F) and a relative humidity of 65 ± 2 percent. However, all containers should be closed at this time and at all times except when samples are withdrawn, etc., to prevent loss of any solvent.

(ii) Testing shall be performed in a room under the conditions specified under (c)(1)(i), above, provided with a hood or other smoke removal equipment. It is suggested that the hood be equipped with both a bottom and a top exhaust. The hood should not be in operation during testing. However, the airflow in the hood should be turned on between tests to rapidly remove the gaseous products of combustion.

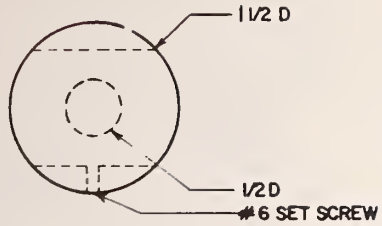
(2) Test procedure.--(i) Test preparation.--(A) Specimen holder preparation. If there is any visible residue on the electrode tips, the tips should be cleaned or replaced, and the electrode tip spacing should be checked (0.5 cm).

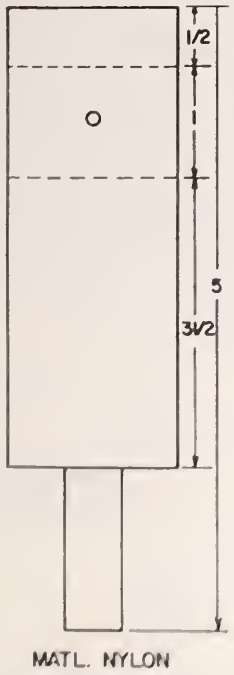
(B) Specimen preparation. Select a specimen, as specified in .4(b)(1), and prepare it for testing in the following manner: Place a small amount of the material to be tested on the specimen holder directly underneath and centered between the two electrode tips. Using the vertical adjustment provided, adjust the specimen holder so that the top surface of the material is 0.3 ± 0.05 cm (0.12 ± 0.02 in) from the bottom of the electrode tips.

(ii) Testing. Expose the specimen to the spark for the established duration of time.

(iii) Test observations. Record whether the specimen ignites or not. For purposes of this test method, ignition shall be defined as sustained burning of specimen that would lead to complete consumption of the material.

(iv) Assembly cleaning and cooling. Any residue that is present on the specimen holder or the electrode tips should be cleaned and the assembly allowed to cool before testing the next specimen.





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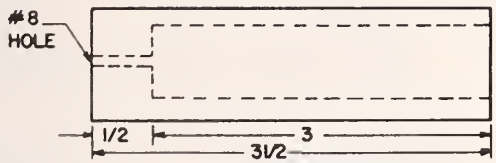

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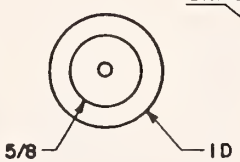
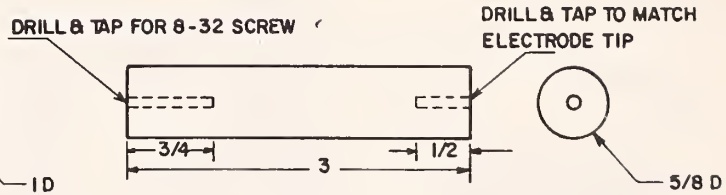


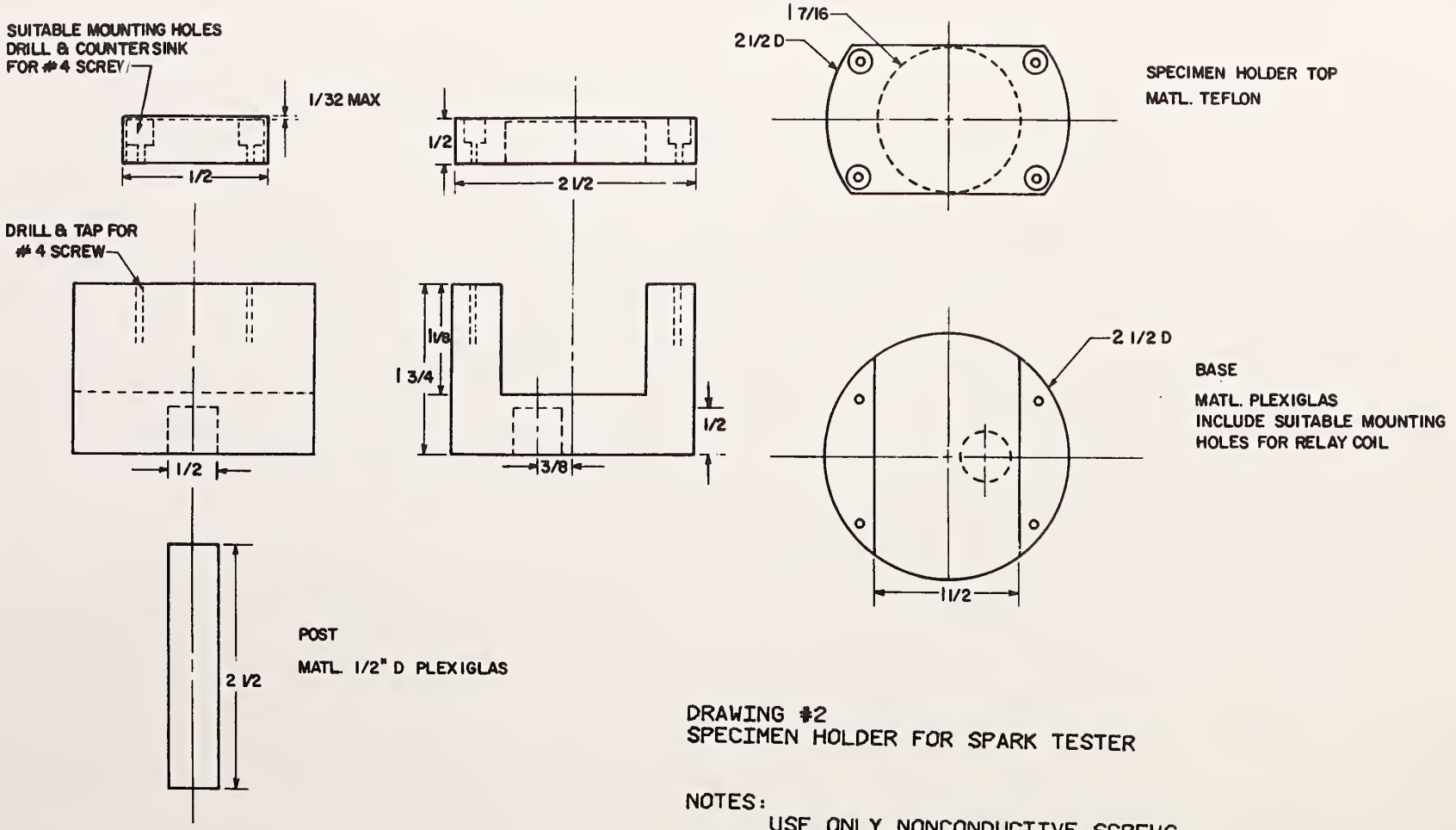


MATL. COPPER

DRAWING #1
ELECTRODES FOR SPARK TESTER

NOTES:

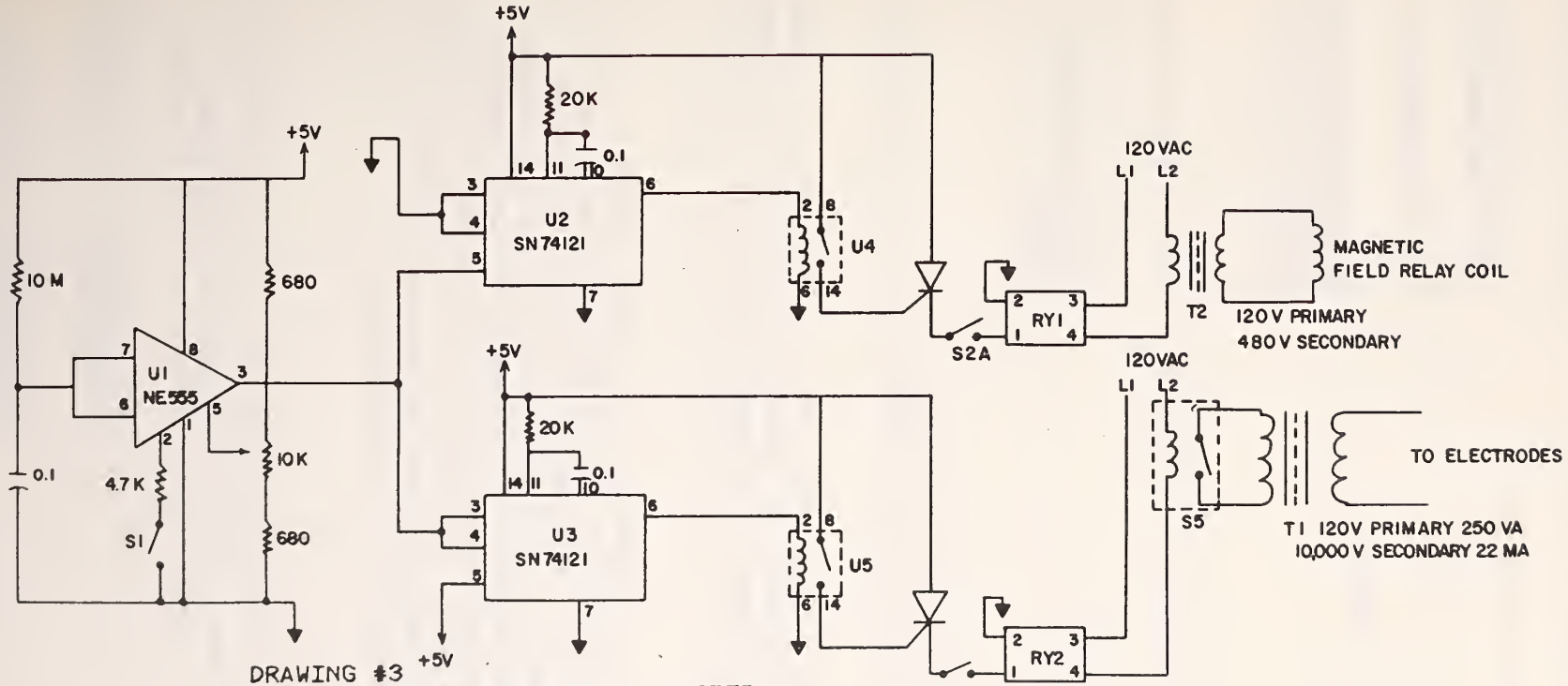
ELECTRODE TIPS ARE UNGAR #332 COPPER OR EQUIVALENT.
LEADS USED TO CONNECT ELECTRODES TO VOLTAGE SUPPLY SHALL BE 20 GAUGE, 1200WV, STRANDED, KINKLESS
ELECTRODES ARE MOUNTED ON OPTICAL BENCH, EALING CORPORATION PART NUMBERS -- 22-4881, 22-4071, 22-6886, 22-4170, 22-4634, 22-4063 OR EQUIVALENT.



DRAWING #2
SPECIMEN HOLDER FOR SPARK TESTER

NOTES:

USE ONLY NONCONDUCTIVE SCREWS
MOUNT RELAY COIL SO THAT MAGNETIC FIELD
IS CENTERED OVER POST



DRAWING #3
TIMING CIRCUITRY FOR SPARK TESTER

NOTES:

ALL RESISTORS VALUES ARE IN OHMS, ±5%, 1/4 WATT.
ALL CAPACITORS VALUES ARE IN f, ±20%, 25 WVDC.
TRANSFORMER T1 -- DONGAN ELECTRONICS #1725CR OR EQUIVALENT.
RY1, RY2 -- CRYDOM SOLID STATE RELAY #D1210 OR EQUIVALENT.
S5 -- SHAWNEE MODEL 333B SOLID STATE TIMER OR EQUIVALENT,
0-99.99 SECONDS, ±0.01 SECOND ACCURACY.
U4, U5 -- SIGMA REED RELAY #191TE2A1-5G OR EQUIVALENT.
S1 -- START SWITCH.
S2 -- RESET.
T2 -- TRIAD #R104A OR EQUIVALENT.
MAGNETIC FIELD RELAY COIL -- COIL REMOVED FROM POTTER &
BRUMFIELD #PR11AY0-DPDT-480V OR EQUIVALENT.

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15. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

The objective of the Federal Hazardous Substances Act is to protect the consumer from hazards that arise from a large variety of products. The Act and its regulations have several provisions pertaining to the measurement of the flammability of substances. Some are detailed and explicit; others provide only general guidelines.

This report presents the results of a program to provide improvements to particular provisions of the Act and includes test methods that may be used for the testing of various solid materials. An extensive review of the Federal Hazardous Substances Act, its predecessor, and the legislative history provides the basis for some specific recommendations for improvement or clarification. Experimental work performed for the improvement of test methods for shredded or slit films, powders, pastes, and granular substances, and for extremely flammable solids is discussed. This report is based on work sponsored by the Consumer Product Safety Commission and performed from 1974 through 1976.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Federal Hazardous Substances Act; flammability; granulars; hazardous substances; pastes; powders; shredded and slit films; solids; sparks; test methods.

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