

BACKGROUND DOCUMENT

RESOURCE CONSERVATION AND RECOVERY ACT
SUBTITLE C - IDENTIFICATION AND LISTING OF
HAZARDOUS WASTE,

§261.21 - Characteristic of Ignitability

May 2, 1980

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF SOLID WASTE

ABBREVIATIONS

ASTM	- American Society of Testing Materials
CFR	- Code of Federal Regulations
CPSC	- U.S. Consumer Product Safety Commission
FR	- Federal Register
DOT	- U.S. Department of Transportation
EPA	- U.S. Environmental Protection Agency
IMCO	- Inter-Government Maritime Consultative Organization
IOTTSG	- International Oil Tanker Terminal Safety Guide
NFPA	- National Fire Protection Agency
RCRA	- Resource Conservation and Recovery Act
°C	- degrees Celcius
°F	- degrees Fahrenheit
\leq	- less than or equal to
\geq	- greater than or equal to
$>$	- greater than
FP	- flash point
%	- percent
psia	- pounds per square inch absolute
(n)	- noun
(adj)	- adjective
m	- meters
s	- seconds
min	- minute
in	- inch
kpa	- kilo Pascal

Ignitability Characterization Background Document

I. Introduction

Subtitle C of the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976 creates a comprehensive "cradle-to-grave" management control system for the disposal of hazardous waste designed to protect the public health and the environment from the improper disposal of such waste. Section 3001 of that Subtitle requires EPA to identify the characteristics of and list hazardous waste. Wastes identified or listed as hazardous will be included in the management control system created by Sections 3002-3006 and 3010. Wastes not identified or listed will be subject to the requirements for non-hazardous waste imposed by the States under Subtitle D. The Agency has determined that ignitability is a hazardous characteristic because improperly managed ignitable wastes pose a substantial present or potential danger to human health and the environment. The purpose of this document is to explain the Agency's definition of ignitable waste, to discuss the comments received on the proposed definition of ignitability (43 FR 58955-58956, December 18, 1978) and the changes subsequently made.

II. Proposed Regulation

Ignitable Waste.

(1) Definition - A solid waste is a hazardous waste if a representative sample of the waste:

- (i) Is a liquid and has a flash point less than 60°C (140°F) determined by the method cited below or an equivalent method, or
- (ii) Is not a liquid and is liable to cause fires through friction, absorption of moisture, spontaneous chemical changes, or retained heat from manufacturing or processing, or when ignited burns so vigorously and persistently as to create a hazard during its management, or
- (iii) Is an ignitable compressed gas as defined in 49 CFR 173.300(b), or
- (iv) Is an oxidizer as defined in 49 CFR 173.151.

(2) Identification method

- (i) Flash point of liquids shall be determined by a Pensky-Martens Closed Cup Tester, using the protocol specified in ASTM standard D-93-72, or the Setaflash Closed Tester using the protocol specified in ASTM standard D-3278-73 or any other equivalent method as defined in this Subpart.
- (ii) Ignitable gases shall be determined by the methods described in 49 CFR 173.300.

III. RATIONALE FOR THE PROPOSED REGULATION

A. Rationale for Proposing an Ignitable Characteristic

Ignitability* was chosen as a characteristic of hazardous waste because ignitable wastes pose a substantial present or potential danger to human health and the environment if improperly managed. Such wastes can cause fires which directly damage the environment by heat and smoke production or indirectly damage the environment by providing a vector through which other hazardous wastes can be dispersed. An example of the latter would be the creation of convection currents that transport toxic particulates. Ignitable wastes may also result in fires which cause otherwise benign wastes to become hazardous. An example of this would be the production of noxious fumes from the burning of plastic waste. Past routine management of ignitable wastes has resulted in death and injury to persons and damage to property. Appendix I lists and discusses some of these damage incidents.

In acknowledgment of the dangers associated with ignitable wastes, Congress designated flammability (ignitability) as a potential hazardous characteristic. At page 25 of the House Report**, the House Committee stated as follows:

* EPA has used the term "ignitability" to avoid confusion with DOT's use of the term "flammability" in its regulations. EPA's definition of ignitability is synonymous with ASTM's definition of flammability. ASTM defines flammability as the capability of a substance/waste to undergo a rapid exothermic oxidation process accompanied by continuous evolution of heat and usually light under normal ambient conditions.

**Report of the Committee on Interstate and Foreign Commerce, U.S. House of Representatives (H.R. 14496)

". . ., the Committee's intention is that EPA, in the development of the characteristics of a hazardous waste take into consideration the toxicity of the waste, its persistence and degradability in nature, its potential for accumulation into tissue and other related factors, such as flammability, corrosiveness or other hazardous characteristics." (emphasis added).

In further acknowledgment of the dangers posed by ignitable wastes, several States regulate or set guidelines for the management of ignitable wastes and public or private organizations often publish suggestions for their safe management. Appendix II lists some of these regulations, guidelines and suggestions. For a detailed discussion on the criteria for determining characteristics, see appropriate background document.

B. Rationale for proposed definition

In formulating the ignitability characteristic, the Agency has sought to identify and employ an indicator or measure of ignitability which best models the hazards associated with ignitable wastes. Unfortunately, no single indicator adequately models the hazards presented by all of the physical states (gas, liquid, semi-solid, or solid) in which ignitable wastes occur. Consequently, the Agency has had to treat the different physical states of ignitable wastes separately in constructing its definition of ignitability. This separate treatment is discussed below.

1. Ignitable Liquids

There are several established measures or indicators of the ignitability of a liquid waste*; for example, flash point, fire point, autoignition, etc. These measures and other terms related to fire phenomenon measurement are presented and defined in Appendix III. The most attractive of these indicators of ignitability is the flash point of the waste. Flash point is defined as the lowest temperature, corrected to a pressure of 101.3 K Pa (1013 millibars), of a substance at which application of an ignition source causes the vapor above the substance to ignite under specified conditions of test¹. The Agency believes that flash point best models the hazards associated with the disposal of ignitable liquid waste streams. Vapor/air mixtures above the liquid waste can be readily ignited by ignition sources that typically are encountered in the transportation, storage, and disposal of such wastes. Such ignition sources include the hot exhaust systems of compaction equipment and trucks used in landfills and for hauling wastes; electrical sparks from the ignition systems of such equipment; electrical sparks from pump motors and other electrical devices; and sparks from friction and lighted cigarettes. Internal temperatures can elevate the temperatures of wastes past ambient temperatures. Such internal heat sources include thermal energy resulting from such things as the heat of decomposition of organic waste or the absorbed heat of the sun on the sometimes dark

*Liquids are defined by the limitation of test standards proposed later in this document.

and broken surface of the landfill. Once ignited, liquid wastes with low flash points can cause fires which result in the damage outlined above. All government agencies and professional associations contacted by the Agency during the early development of these regulations recognized flash point as the primary indicator of the fire hazard of liquids. The primary reasons given for this recommendation were the general industrial acceptance of flash point test standards, the inexpensiveness of flash point testing, and the many years of data compilation. As Appendix II discloses, states and public and private organizations which have promulgated regulations and guidelines regarding ignitable liquids have almost invariably used flash point as the barometer of ignitability.

Another possible indicator of ignitability is the fire point of the waste. Fire point is defined as the minimum temperature to which a material must be heated in an open vessel before the substance will sustain combustion for a specified period of time after ignition by an external source¹. Fire point differs from flash point largely in that it measures the capacity of a substance to sustain combustion when ignited by an external source rather than just the capacity of a substance to flash. The two are thus closely related and the fire point of a substance is generally only a few degrees higher than the flash point. Although fire point models the hazards which accompany the ignition of ignitable liquid

waste streams, the Agency has determined that flash point is the better indicator of ignitability. This is because of the small difference between flash point and fire point, the widespread acceptance of flash point by the regulated community, and the dangers associated with liquids that flash.

Another possible indicator of ignitability is the autoignition temperature of the waste. Autoignition is the spontaneous ignition of a material which occurs not as a result of an external ignition source, but as a result of heat liberation from an exothermic reaction occurring in the material¹. Autoignition temperature is the temperature at which this spontaneous ignition takes place. Autoignition temperatures tend to be much higher than flash point temperatures--generally several hundred degrees higher, as Table 1 illustrates. Consequently, it is very unlikely that wastes would be exposed during their management to energy sources of the magnitude necessary to heat them to their autoignition point. The Agency has rejected autoignition temperatures as a suitable indicator of ignitability because autoignition temperature fails to model the particular hazard the Agency wishes to minimize -- i.e. the external ignition of volatilized liquid wastes. To the extent the autoignition of liquid wastes does pose a hazard, this hazard is likely to be taken care of by the flash point limits.

While most States, agencies, and organizations that define ignitability use flash point as their criterion, there exists

Table 1

Comparison of Flash Point and Autoignition Temperatures

Substance	Flash Point* of °F (°C)	Autoignition* of °F (°C)
Acetaldehyde	36 (2.2)	365 (185)
Acetic Acid (Glacial)	109 (42.8)	800 (426.7)
Allyl Alcohol	70 (21.1)	713 (378.3)
Camphor	150 (65.6)	871 (466.1)
Ethyl Alcohol	55 (12.8)	793 (422.8)
Fuel Oil #1	100 (37.8)	444 (228.9)

*NFPA, Fire Protection Handbook, 12th Edition, Chapter IX, Fire Hazard Properties of Flammable Liquids, Gases and Volatile Solids, Table 6-126.

no consensus on what the limit should be. For example, the Department of Transportation (DOT) defines substances with flash points below 37.9°C (100°F) as flammable and flash points at or above 37.8°C but less than 93.3°C(200°F) as combustible². A number of organizations, responding to the Department of Transportation's effort to standardize its flash point limits, have followed suit. See Appendix II. Ohio, on the other hand, defines liquids with flash points less than 79.4°C (175°F) as flammable and does not recognize the combustible category at all³. Similarly, the National Fire Protection Association (NFPA) has erected a classification system which defines liquids with flash points below 37.8°C (100°F) as Class I (flammable) liquids, liquids with flash points at or above 37.8°C and below 60°C(140°F) as Class II (combustible) liquids and liquids with flash points above 60°C as Class III liquids.

There are persuasive reasons for concluding that these various flash point limits and classification schemes either do not adequately take into account the hazards accompanying the transportation, storage, and disposal of ignitable liquid wastes or are inappropriate for other reasons. For instance, the Department of Transportation's flash point limit of 37.8°C(100°F) for flammable substances appears to have been chosen for the purpose of keeping all of the fuel oils regulated by DOT in the combustible category (i.e., to avoid classifying some fuel oils as flammable and others as combus-

tible). This flash point limit was apparently not designed to take into account all of the heat sources to which ignitable liquids are exposed during transit, storage, and ultimate disposal. J. M. Kuchta, et al., in an early DOT study⁴ recommended as follows:

It is recommended that a flammable liquid be defined as one with a flash point below 140°F, as determined in a Tag Closed Cup, and having a vapor pressure not exceeding 40 psia at 100°F. The 140° break point is suggested because ambient temperatures of this order can be encountered during shipment, particularly in hot climates, this break point is also consistent with the NFPA and IMCO classification systems and that proposed by IOTTSG.

Similiarly, the classification schemes adopted by NFPA and DOT are inappropriate because they would force EPA to adopt a degree of hazard approach to the identification of hazardous waste. EPA's approach has been to classify wastes as either hazardous or not and to rely on the waste management regulations promulgated under Section 3004 and 3005 to inject any needed flexibility into the waste management requirements*.

In selecting a flash point limit for controlling ignitable liquids, the logical choice would be to use that temperature to which wastes are capable of being subjected during routine management. After careful study, the Agency

*One of those who advocated setting up a classification system for defining ignitability was Mr. Harry A. Wray of the American Society for Testing Materials. He advocated a classification system based on a combination of NFPA Code, DOT², DOL⁵ regulations.

has discovered that liquid wastes are exposed to temperatures of up to 140° in the routine handling of such wastes. As noted by J. M. Kuchta in the DOT study referenced above⁴, this upper temperature can occur inside storage tanks, storage containers and transportation tank trailers on hot sunny days. As indicated by the studies referenced in Table 2, this temperature is also frequently encountered in landfill environments. Accordingly, the Agency has elected to use a flash point of 60°C (140°F) as the regulatory limit for defining whether a liquid waste is an ignitable hazardous waste. To use a lower flash point limit would exclude from regulatory coverage many liquid wastes which could, in fact, present a hazard under typical conditions encountered in liquid waste management, that is fires that result from the ignition of these wastes. This flash point limit will include all those liquid wastes which would fall within Class I and Class II of NFPA's classification scheme.

2. Ignitable Solids

Solid materials typically do not volatilize as liquid materials since most solids have lower vapor pressures than do liquids. Consequently, solid wastes rarely have low flash points, that is those less than 60°C (140°F). The hazards that attend the management of liquid wastes and that are modeled by flash point thus do not attend solid wastes. Even if this were not the case, it would be difficult to construct a

Table 2

Typical Landfill Temperatures

Study/References	Temperature/Conditions	Remarks
1. Survival of Fecal Coliforms and Fecal Streptococci in a sanitary landfill ⁶ .	120°F (48.8°C) to 140°F during the first week in the middle-section of the landfill at 2 to 6 foot depths (temperatures were 10 to 15 degrees lower in the periphery.	Landfilling conditions models nicely the conditions of many sanitary landfill disposal sites.
2. Boone County Field Site Interim Report, Test Cells 2A, 2C and 2D ⁷ .	Peak temperature recorded was 51.1°C (124°F)	Highest readings were 4 to 6 days after refuse placement.
3. Sonoma County Solid Waste Stabilization Study ⁸ .	Peak temperature recorded was 43.9°C (111°F)	The seasonal temperature variations for this study shown an annual range of almost 20 (78°F) over the annual cycle. In general there is an apparent temperature response of the upper several feet of the landfill.
4. Management of Gas and Leachate in Landfills ⁹ .	Ambient temperatures during test cell studies peaked at 35°C (95°F) for air and 59°C (138.2°F) for refuse.	
5. Decomposition of Landfills ¹⁰	(1) 71°C (159.8°F) at 0.9m deep. (2) 40°C (104°F) at 3.3m deep.	(1) Aerobic conditions near the surface of landfills resulting in relatively high temperatures. (2) Anaerobic conditions prevail at deeper layers of the landfill thus lower temperatures.

Table 2 (cont.)

Study/Reference	Temperature/Conditions	Remarks
6. Water Pollution Potential of Spent Oil Shale Residues ²⁰ .	Surface temperatures of 77°C (170.6°F) have been measured in small experimental plots due to absorption of solar energy.	Case spent shales were studies in these plots.
7. Evaluation of Emission Control Criteria for Hazardous Waste Management Facilities ²⁶ .		Study recommends that materials with flash points below 62.5°C (150°F) need special disposal considerations.

reproducible flash point testing procedure for solids. Solids are usually poorer conductors of heat than liquids, and vary widely in thermal transport properties. When a solid is heated, heat build-up is intense at the energy source, due to poor conductance. The flash point of a given solid will therefore depend on the duration of heating and the rate of change of heating. For example, if a solid were heated slowly it would register a lower flash point than if it were heated quickly, due to the inability of solids to quickly reach thermal equilibrium. In light of the above, EPA has concluded that flash point is not an appropriate indicator of the hazardousness of solid ignitable wastes.

While solid wastes generally do not present a hazard by virtue of their ability to volatize, some solid wastes do present a hazard by virtue of their capacity to ignite and burn as a result of friction, moisture absorption, or spontaneous reaction under normal temperatures and pressures encountered in waste management. Such wastes, which are closely akin to reactive wastes, can cause direct injury to workers or other persons as a result of fire, induced explosions, or induced generation of toxic gases at almost any point in the waste management process: transportation, storage, treatment or disposal. EPA knows of no available, standardized test methods for measuring the hazards associated with friction, moisture absorption, or spontaneous reaction of solid wastes. J.M. Kuchta and A.F. Smith of the

Bureau of Mines in a report that was done for the Department of Transportation¹¹ established test methods for use in classifying flammable solids. However two independent contractors assigned the work of evaluating the proposed test protocols determined that these test methods were not reproducible^{12,13,14}. These test methods are furthermore quite complex, require special equipment, and are not widely used. In the absence of available test methods which can be used to quantitatively define the ignitability hazard presented by waste, EPA proposed a narrative definition similar to the one used by DOT in its Hazardous Materials Regulation (49 CFR 173.150; see Appendix VII). The proposed narrative definition was as follows:

a solid waste is a hazardous waste if a representative sample of the waste is liable to cause fires through friction, absorption of moisture, spontaneous chemical change or retained heat from manufacturing or processing, or when ignited burns so vigorously and persistently as to create a hazard during its management.

EPA believes that this definition (as amended in accordance with the discussion below), will be sufficiently specific to enable generators to determine, through their knowledge about the waste or its constituents or through their prior observations of and experience with similar types of wastes, whether their solid waste is ignitable. The waste property defined by this definition is that of thermal instability. Solid wastes having this property will, like reactive wastes, be easily detectable by the generator because experiences with handling the waste or similar wastes will most likely have

revealed this instability. Therefore, until the Agency, DOT, or others are able to develop a more quantified definition of ignitable solids, with associated test methods, EPA believes it is justified in using this narrative definition.

3. Ignitable Compressed Gases

Containers of ignitable compressed gases are occasionally, but not frequently, discarded as wastes. The containers are subject to mechanical rupture during transportation, storage and disposal. In addition, they are subject to corrosion and eventual leaking in long-term storage and land disposal. If ruptured or corroded, the escaping gas could be ignited by electrical sparks or other ignition sources, in the same fashion as ignitable liquids. The fires resulting from such ignitions threaten injury to workers, firemen, and other exposed persons. DOT has defined compressed gases in its Hazardous Materials Regulations (49 CFR 173.300). This definition sufficiently embraces the compressed gases which are likely to be hazardous under conditions normally encountered in the management of such wastes. Consequently, EPA has adopted the DOT definition.

4. Ignitable Oxidizers

EPA considered including in its ignitability characteristic wastes which were not easily ignited but which, once ignited, would burn and contribute to an ongoing fire. The Agency has declined to classify such combustible wastes as ignitable in recognition of the fact that virtually all non-

metallic wastes, including paper, waste wood products and other organic wastes might display this particular feature. EPA believes that the waste management requirements imposed under both Subtitle C and D of the Act, (which control open burning and other conditions resulting in strong ignition sources) will be sufficient to protect against any hazards associated with such combustible wastes.

Notwithstanding the foregoing, EPA has determined that strong oxidizing wastes should be classified as hazardous wastes. Once combustion is initiated, these wastes would promote and sustain very aggressive burning or fuming and, therefore, would significantly increase the peril to workers, firemen, and other exposed persons. EPA knows of no widely available, simple, standardized test methods for measuring and defining strong oxidizing wastes. In a DOT funded study to develop a suitable test method,¹⁵ the Bureau of Mines proposed an apparatus for testing oxidizers which is based on the burning rate of a red oak sawdust/oxidizer mixture. In three later studies ^{12,13,14}, two independent contractors were assigned the task of evaluating separately the Bureau of Mines apparatus and classification system. These contractors concluded that the reproducibility of the test protocol was very poor. Consequently, EPA proposed using the same narrative definition used by DOT in its Hazardous Materials Regulations (49 CFR 173.151). EPA believes this definition is sufficiently descriptive to enable waste generators to ascertain whether they have an oxidizing waste.

C. Rationale for Proposed Test Methods

1. Ignitable Liquid Test Protocols

There are two basic methods used for testing the flash point of liquids: open and closed cup testers. Both methods require that the sample be placed in a sample cup and heated at a slow and constant rate. In a closed cup tester, the test flame is inserted into a vapor/air mixture within the closed cup and over the liquid, whereas in an open cup, the test flame is passed over the vapor/air mixture just above the liquid. While liquids will flash at the same concentration of vapor and air in both cups they will flash at a lower temperature in a closed cup. This is because, in the open cup, the temperature must be raised to a greater degree to achieve the same concentration of vapor and air as in the closed cup since the vapor above the liquid is confined in a closed cup but is allowed to diffuse into the atmosphere in an open cup.

The Agency considers the closed cup tester to be more suitable for testing the flash points of liquids. This is because the closed cup tester better replicates the most dangerous type of ignitable liquid waste situation -- that is, the situation where vapor from ignitable wastes collects in a closed space, such as in a storage drum, warehouse, etc. A recent EPA report which lists a large number of accidents involving landfill gas shows that volatile gases emanating from landfills can accumulate in buildings, pipes, excavations,

manholes and soil up to 1000 feet from the fill area¹⁶.

In one such accident, gas emerging from a landfill collected in a barn and caused injury when it exploded¹⁶. The closed cup tester is a more conservative representation of the hazard presented by such confinement of the vapor from volatilized liquids. In addition, the closed cup tester is not as subject to interference from air currents and gives more reproducible results.

Closed cup testers come equipped with different features. There are two types of temperature baths available. (A temperature bath is the heat transport media between the cup of the tester and the heating element). Since the purpose of these temperature baths is to insure uniform temperature around the entire sample, a liquid bath is superior to an air bath because liquids transport heat better than air. Also, there are two types of heating elements; electric and gas. It makes little difference in the test results whether the apparatus has a gas or electric burner. Both are equally accurate at the low temperatures of concern. An optional feature for closed cup testers is a mixing device or stirrer. The stirrer can prevent interference in the operation of the test which results when test samples are very viscous, tend to skin over, tend to stratify, or contain suspended solids. If, for instance, a sludge is stratified, the upper layers will inhibit the volatilization of the lower layers. The evaporation of the lower layers will occur at the normal rate

only when the lower layers are in direct contact with the atmosphere. A mixing device cures this problem. Since the most prevalent forms of waste streams destined for land disposal are sludges and semi-solids, EPA believes that closed cup testers should be equipped with a mixing device.

The closed cup tester which satisfies the above requirements is the Pensky-Martens Closed Cup Tester. Table 3 compares this tester with the Tag Closed Cup tester and demonstrates available options. Table 4-ASTM Specifications and Measured Performance for Several Flash Point Testers - compares data on repeatability and reproducibility⁴. As shown in this table, there are two testers that are fairly reproducible, The Taliague and the Pensky-Martens Closed Cup Testers.

J. Kuchta in his report to DOT⁴ made the following recommendations:

According to the available data in the literature, the Tag closed cup is suitable for determining flash points of liquids over a temperature range from about 220°F down to at least 0°F. Although it is currently recommended for determinations up to only 174°F, ASTM Committee (D-2 and E-27) are presently proposing that the maximum temperature be increased to 200° or 220 °F for use with liquids having a viscosity of 4 centipoise (100°F) or less. For liquids of higher viscosity or higher flash points, the Pensky-Martens closed cup is recommended. However, one can also extend the use of the Tag tester to the higher viscosity liquids by employing a lower heating rate than presently specified. A heating rate

Table 3 - Comparison of Flash Point Tester Types

Type	Sample Cup	Stirrer	Bath	Type of Temperature Control
Pensky-Martens (Fisher)	Closed	No	Air	Electric
Pensky-Martens (Fisher)	Closed	Yes	Air	Electric
Tagliague (Fisher)	Closed	No	Liquid	Electric
Pensky-Martens (Fisher)	Closed	No	Air	Gas
Pensky-Martens (Fisher)	Closed	Yes	Air	Gas

TABLE 4 - ASTM Specifications and Measured
Performance for Several Flash Point Testers

Tester	ASTM Designation	Temp. Range °F	Heating Rate °F/min	Repeatability** °F	Reproducibility
Tagliaque Closed Cup	D 56-64	55 15-175	2 2	2 2	6 4
Pensky-Martens Closed Cup	D 93-66	<220* >220†	9-11 9-11	4 10	6 15

⁴Kuchta, J.M. and D. Burgess. Recommendations of Flash Point Method for Evaluation of Flammability Hazard in the Transportation of Flammable Liquids, Safety Research Center, Bureau of Mines, Report #54131, April 20, 1970.

*Less than

†Greater than

** Duplicate results by the same operator

*** Results submitted by each of two laboratories

of less than 0.5°F/min. or a maximum temperature difference of 5°F between the bath and sample have been found suitable for extending the applicability of this tester to thicker fuels and other highly viscous materials.

These recommendations are in order, except that using the Tag tester for very viscous materials is not standard practice. Agitation of the liquid is necessary if the liquid has a viscosity of 45 S.U.S.* or more at 37.8°C (100°F)⁴, or if it contains suspended solids or has a tendency to form a surface film during testing. Consequently, the Pensky-Martens has been recommended as the tester for ignitable liquids because of the incorporation of a stirring device to handle the testing procedure of sludges and slurries.

Another possible tester is the Setaflash tester, which is an electronic apparatus. The Setaflash tester was investigated and found to be a good means of flash point determination, and thus has also been included in the proposed regulations as a means for determining the flash point of ignitable wastes. The Setaflash closed cup tester determines flash points between 0 and 110°C (32 and 230°F) having a viscosity lower than 150 stokes at 25°C (77°F)[†]. For liquids at or below 45 S.U.S. at 100°F, the average of the duplicate results obtained by the same operator on different days should be

* S.U.S. means Saybolt Universal Seconds as determined by the Standard Method for Saybolt Viscosity (ASTM D88-56 and may be determined by the Use of the S.U.S. conversion tables specified in ASTM test D2161-66 following determination of viscosity in accordance with the procedures specified in the Standard Method for Transparent and Opaque Liquids (ASTM D445-65).

† Data on Setaflash available ASTM D3278-73.

considered suspect if they differ by more than 1.7°C (3°F); each of two laboratories should not differ by 3.3°C(6°F)†. For viscous liquids above 45 S.U.S. at 37.8°C (100°F) or liquids with dispersed solids, duplicate results obtained by each of two laboratories should not differ by more than 5°C (9°F)† Because this tester is relatively new, EPA asked one ASTM Committee for recommendations regarding it. The opinions were very positive from both government and industrial members. It seems the tester can save a laboratory a substantial amount of money if repetitive flash point determinations are needed, although the data for such savings was not attainable.

2. Ignitable Compressed Gas

Since EPA has adopted the DOT definition for ignitable compressed gasses, the test method specified in the DOT regulations has also been adopted. The Agency assumes that this test protocol has undergone the required testing to determine its accuracy, reproducibility, detection limits, etc.

IV. Comments Received on the Proposed Characteristic and the Agency's Response to These Comments

The Agency received over one-hundred comment letters and oral statements* addressing ignitability. Several of the commenters agreed with the Agency's proposed definition. The large majority of comments, however, expressed some concern with the Agency's ignitability characteristic. These comments

* EPA held five public hearings to receive comment on the proposed hazardous waste regulations. The hearings were held in New York City (2/7-9/1979), St. Louis, Mo. (2/14-16/1979), Washington, D.C. (2/20-22/1979), Denver, Co. (3/7-9/1979), San Francisco, Cal. (3/12-14/1979).

have been categorized by either content or the portion of the regulation addressed. A discussion of these follows:

A. Comments on Ignitable Liquids

1. A large majority of the comments objected to the Agency's proposed limit for ignitable liquids (140°F).

° Many of the commenters suggested that EPA amend the proposed regulations and adopt DOT's limit for flammable liquids (100°F). These commenters argued as follows: (1) the higher flash point limit chosen by EPA is not justified since it is doubtful whether higher temperatures will be encountered during the disposal of hazardous wastes than during transportation, (2) past drafts of the ignitability background document list only two landfill fire incidents in which the first material ignited was known and in both incidents the flash point was less than 100°F, (3) the DOT flash point limit is based on experience and has provided adequate protection against ignitable hazards in the past, (4) there is some question whether the 140°F EPA flash point will capture significantly more hazardous waste than the 100°F DOT flash point, (5) EPA's use of a different flash point limit from that employed by DOT will create

confusion in complying with DOT's placarding, containerization and manifest requirements and, (6) EPA's use of a different flash point goes against the stated intent of RCRA to integrate its provisions with those of DOT and other agencies. In none of these comments was any supporting data presented for changing the flash point limit to 100°F.

The Agency disagrees with these comments for several reasons. As noted above, a number of EPA studies indicate that landfill temperatures frequently exceed the limit of 100°F adopted by DOT. Temperatures of as high as 170.6°F(77°C) were experienced at or near the surface of test landfill plots. These recorded temperatures indicate that a flash point limit higher than DOT's is justified by the conditions likely to be encountered during disposal. Furthermore, DOT's 100°F flash point limit does not appear to take into account all of the heat sources available to ignitable materials during transportation and storage. J.M. Kuchta, et al., in an early DOT study ¹⁰, recommended "...that a flammable liquid be defined as one with a flash point below 140°F ...because temperatures of this order can be encountered during shipment ...". Indeed, DOT's adoption of a 130° test temperature in its metal corrosion standard in effect consti-

tutes an acknowledgment that temperatures of greater than 100°F are likely to be encountered during transportation and storage (49 CFR 173.240).

The Agency disagrees with the statement that the DOT requirement has in the past provided adequate protection against fire incidents during transportation and storage. The Agency reviewed the NFPA files and found that 18 percent of the fires in the "storage property" category; 13 percent of the fires in the "transportation vehicle, structure" category; and 18 percent of the fires in the "open-field-dump" category were started by materials or wastes with flash points greater than 100°F (Table 5 and 6). This data¹⁷ tends to demonstrate that liquids with flash points greater than 100°F present a significant ignitability hazard.

The Agency acknowledges that its damage files show only two landfill fires in which the "first material ignited" was known and that, in both cases, the flash points were less than 100°F. However, the Agency considers this irrelevant because it has never studied landfill fires. Similarly, industrial and insurance companies rarely investigate the causes of landfill fires because such fires rarely result in a "large loss." The available data from NFPA, indexed in

Table 3, nevertheless shows that wastes with flash points over 100°F do present a landfill fire problem.

The Agency does not believe that its use of a flash point limit different from that employed by DOT will cause undue confusion to the regulated community or interfere with DOT's placarding, containerization and manifest requirements. The term "ignitability" was selected to minimize any confusion to the regulated community since this community is already familiar with the terms "flammable" and "combustible." EPA's RCRA regulations impose essentially no new placarding or containerization requirements for the transportation and storage of ignitable hazardous wastes other than those already imposed by DOT. The most significant new shipping requirement imposed by the RCRA regulations is that transporters of ignitable wastes comply with the manifest requirement but this requirement is capable of being easily integrated with DOT's own shipping paper requirements. Furthermore, the tests which generators are required to conduct under the RCRA regulations are the same tests required under the DOT regulations.

TABLE 5

NFPA's Report Involving Flammable/Combustible Liquids as the First Material Ignited 17*

Fixed Property Use**	Class I *** Flammable Liquids Number of Fires	Class II *** Combustible Liquid Number of Fires	Class III *** Combustible Liquid Number of Fires
Public Assembly	51	4	1
Educational	17	1	
Institutional	2		1
Residential			
1&2 Family Dwelling	202	48	4
Apartment House, Hotel, etc	129	26	3
Store/Office	151	8	2
Basic Industry, Utility, and Defense	10	7	29

*The data base from which the incidents were selected includes principally the more serious fires which occurs in the United States. Although the sample of incidents included here is sufficient to identify and study significant fire problems, it should not be taken as representative of fires of all severities. The period covered by this report is 1971-1976.

**Defined by NFPA 901-see standard for further explanation.

***Defined by NFPA 30-see standard for further explanation.

TABLE 5 (CONT.)

NFPA's Report Involving Flammable/Combustible Liquids as the First Material Ignited 17*

Fixed Property Use **	Class I *** Flammable Liquids Number of Fires	Class II *** Combustible Liquid Number of Fires	Class III *** Combustible Liq Number of Fires
Manufacturing			
Food	7	3	2
Beverage, Tobacco, Liquor	6	3	
Textile	5	2	1
Footwear, Wearing Apparel (Leather Rubber)	2		2
Wood, Wood Product	30	3	13
Chemical, Plastic, & Petroleum	33	5	12
Metal, Metal Product	21	15	60
Vehicle Assembly	12	3	5
Storage Property	93	11	9
Special Property			
Any unoccupied & under construction	13		
Transportation vehicle, structure	277	28	12
Open field, dump	23	5	

*The data base from which the incidents were selected includes principally the more serious fires which occurs in the United States. Although the sample of incidents included here is sufficient to identify and study significant fire problems, it should not be taken as representative of fires of all severities. The period covered by this report is 1971-1976.

**Defined by NFPA 901-see standard for further explanation.

***Defined by NFPA 30-see standard for further explanation.

TABLE 6

Percent Class II and Class III Fires as First Material Ignited ¹⁷

Fixed Property Use	Class II Combustible Liquids % of Total *	Class III Combustible Liquids % of Total **
Public Assembly	7	2
Educational	6	
Institutional		33
Residential		
1&2 Family Dwelling	19	2
Apartment House, Hotel, etc.	16	2
Store/Office	5	1
Basic Industry, Utility, and Defence	15	63
Manufacturing		
Food	25	17
Beverage, Tobacco, Liquor	33	
Textile	25	12
Footwear, Wearing Apparel (Leather Rubber)	7	50
Wood, Wood Product		28
Chemical, Plastic, & Petroleum	10	24
Metal, Metal Product	16	63
Vehicle Assembly	15	25

*% of Total = #of Class II Fires (Table 1.4.1)/(Class I + Class II + Class III)

**% of Total = #of Class III Fires (Table 1.4.1)/(Class I + Class II + Class III)

TABLE 6 (CONT.)

Percent Class I and Class III Fires as First Material Ignited ¹⁷

Fixed Property Use	Class II Combustibles Liquids % of Total *	Class III Combustible Liquids % of Total **
Storage Property	10	8
Special Property		
Any unoccupied & under construction		
Transporation vehicle, structure	9	4
Open field, dump	18	

* % of Total = # of Class II Fires (Table 1.4.1)/(Class I + Class II + Class III)

** % of Total = # of Class III Fires (Table 1.4.1)/(Class I + Class II + Class III)

While the Agency acknowledges that maintaining consistency between its Section 3001 regulations and those of DOT is a desirable goal, it does not believe that such consistency should be achieved at a sacrifice of environmental protection. Lowering its flash point limit to 100°F would exclude from regulation wastes which present a real hazard. Congress explicitly contemplated such disagreement between EPA and DOT when it provided at Section 3003 of RCRA that the Administrator "is authorized to make recommendations to the Secretary of Transportation respecting the regulation of ...hazardous waste under the Hazardous Materials Transportation Act and for addition of materials to be covered by such Act."

- ° A number of commenters argued that EPA's definition of ignitable waste could be made consistent with DOT's regulations by adopting both DOT's definition of flammables (F.P. 100°F) and DOT's definition of combustibles (F.P. 100°F - 200°F) and including both categories within EPA's ignitable waste classification.

EPA originally considered controlling wastes with a flash point of up to 200°F. However, the Agency concluded that, even though such wastes might present a hazard once ignited, wastes which are easily ignited under conditions encountered

during transportation, storage, and disposal present the greater danger. Therefore the Agency elected not to control wastes with a flash point of up to 200°F under Subtitle C of RCRA and believes that to control such wastes would create an additional burden and expense to the regulated community, which is not justified solely by considerations of consistency.

- ° One commenter suggested that the Agency develop a two-tier system for defining ignitable liquids by adopting the DOT flammable category for wastes with flash points less than 100°F and adding a combustible category for wastes with flash points from 100°F to 140°F. The primary justification given for this two-tier system was the assertion that the 140° temperature specified in the ignitability flash point limit might be applicable to the disposal of wastes in landfills but not to transportation of wastes. No data was presented in support of this assertion.

The Agency disagrees with this comment for two reasons. First, as noted above, the DOT flash point limit of 100°F does not take into account the full range of temperatures likely to be encountered during the transportation of hazardous wastes. J.M. Kuchta, et al., in an early DOT study, recommended that DOT adopt a

flash point limit of 140°F for flammable liquids because temperatures of this order can be encountered during transportation. Second, erecting a two-tier system in which some wastes were regulated for purposes of disposal but not for purposes of transportation would not be compatible with the hazardous waste management system mandated by the Act and the regulations. The Act envisions and the regulations require a comprehensive "cradle-to-grave" management control system which tracks hazardous waste from its point of generation to ultimate disposal. Piecemeal regulation of waste for disposal purposes would be administratively infeasible and not in accordance with this system.

- Several commenters pointed out that under DOT's regulations, "combustible" liquids packed in containers of 110 gallons or less are exempted from DOT's placarding, containerization, etc. requirements. These commenters argued that since EPA intends to regulate 110 gallon quantities of "combustible" liquids with flash points in the range 100°F - 140°F, confusion will result.

The Agency believes that any confusion caused by the Agency's regulation of 110 gallon quantities of DOT defined combustibles will be minimal. Most generators who ship in less than 110 gallon quantities will probably fit within

the Agency's "small generator exemption" and will thus not be subject to any EPA-imposed shipping requirements. It should not cause any undue confusion to require generators who ship in less than 110 gallon quantities but do not fit within the "small generator exemption" to observe DOT placarding, etc. requirements.

- Several commenters proposed that the Agency eliminate the inconsistency between its ignitable standard and DOT's flammable and combustible standards by petitioning DOT to raise its flash point limit for flammable liquids to 140°F. The Agency has requested DOT to change its flash point limit for flammable liquids to 140°F, but DOT refused.
- Some commenters expressed concern that the Agency's ignitability definition would include waste fuel oils which could be burned as fuel oil and thus put to a beneficial re-use. The regulations promulgated today will not include waste oils which are beneficially reused or reclaimed. Waste fuels which are put to beneficial re-use will thus not be regulated as hazardous.
- One commenter argued that the autoignition temperature is a better measure of the hazard presented by liquid waste than the flash point.

This comment has been adequately responded to above and needs no further response here.

2. A number of comments objected to the proposed test protocols for the ignitability flash point limit (140°F).

- ° Several commenters argued that an open cup flash point analysis better simulates landfill conditions and is therefore a better measure of the hazard presented by liquid ignitables than a closed cup flash point analysis.

The Agency does not disagree that an open cup analysis can simulate landfill conditions. However, as noted above, the closed cup tester was selected because it simulates the most dangerous type of hazardous waste situation -- that is, the situation where ignitable liquid vapors collect in a confined space such as a storage area or a structure adjacent to a landfill. Another reason the closed cup tester was selected is that the open cup tester does not give results which are as reproducible as those of the closed cup tester.

- ° Several commenters agreed with the upper flash point limit of 140°F using the closed cup method but also urged the Agency to include an optional limit of 100°F using the open cup method. The basis for this suggestion was that some reference books only present open cup data.

The Agency disagrees with these commenters on two counts. First, most reference books list flash points

only for pure substances and simple mixtures. Waste streams are complex mixtures whose flash points can only be ascertained by testing and not by consulting a reference book. Secondly, a liquid tested in a closed cup tester generally flashes at a lower temperature than the same liquid tested in an open cup. Consequently, if the Agency were to prescribe an optional open cup flash point limit equivalent to its closed cup flash point limit, that limit would of necessity be higher than the closed cup limit. Unfortunately, the Agency has not discovered an appropriate means of equating the two types of testers.

3. A number of commenters argued that the ignitability characteristic improperly includes many liquid wastes such as wine, latex paint and other water borne coatings which contain low concentrations of volatile organics such as alcohol and will consequently exhibit flash points below 100°F but will not sustain combustion because of the high percentage of water present. These commenters urged that the regulations should either specifically exempt such wastes or that the test for ignitability should be expanded to include alternative test methods such as the British Combustibility Test or the ASTM Wick Test which measure the ability of materials to sustain combustion. These commenters pointed out that DOT currently excludes from its flammable category aqueous solutions containing 24 percent or less alcohol by volume.

The Agency generally agrees with the concerns expressed by these commenters. However, problems do exist in formulating an acceptable solution. The Agency has at present no data which identifies the relationship between the concentration levels of volatile organics in aqueous solutions and the established flash point of 140°F. Consequently, the Agency has opted, for the time being, to use an exclusion similar to that prescribed by DOT and exempt from the ignitability characteristic aqueous solutions with alcohol concentrations of less than 24 percent by volume. This exclusion will remove from the ignitability characteristic such things as wine and latex paint which flash at less than 100°F but will not sustain combustion. The Agency will undertake additional work to determine whether this alcohol/water limit is sufficient or whether another limit is more appropriate. Once development of the British Combustibility Test and the ASTM Wick Test is completed, the Agency will also evaluate these two proposed supplemental test methods to determine whether they can be used.

4. One commenter suggested that the Tag Closed-Cup Tester (ASTM method D-56) be included in the regulations as an equivalent methods in testing ignitable liquids. The commenter argued that since this method was allowed by DOT to test ignitable liquids, EPA should also allow this method in order to avoid needless duplicate testing.

The Agency has not designated the Tag Closed Cup Tester as an acceptable tester because the Tag Closed Cup Tester does not incorporate a stirrer and thus is not suitable for testing wastes which are very viscous, skin over, tend to stratify or contain suspended solids. Since most liquid wastes are expected to be in sludge or semi-solid form, the usefulness of the Tagliague Closed Cup Tester was judged to be limited. The regulated community is, however, still free to demonstrate under the procedures provided in §§260.20 and 260.21 that the Tag Tester is equivalent to the specified methods.

5. One commenter argued that an ignitable waste should simply be defined as a waste that is being handled at a temperature greater than its flash point.

The Agency disagrees with the commenter. The commenter's proposed definition would make the hazard-ousness of a given waste entirely dependent on the handling that waste was getting at a particular moment. Such a highly variable definition of hazardous waste would make identification of ignitable wastes and enforcement of the regulations impossible.

B. Comments on Ignitable Solids

1. A large number of commenters disagreed with the proposed definition for solid ignitable wastes. Many commenters argued that the definition as proposed could be construed to include many non-hazardous materials such as bark, wood chips, wastepaper, corrugated boxes, tires, grass, etc. and suggested that the definition be revised

to make clear that this result was not intended. Some of the commenters suggested that the definition be clarified by eliminating the phrase "or when ignited burns so vigorously and persistently as to cause a hazard during management." Others suggested changing "or when ignited burns so vigorously and persistently as to create a hazard during its management" to "and when ignited burns so vigorously ..."

As indicated earlier, the Agency has no intention of designating such things as waste paper, saw dust, etc. as hazardous. It is only interested in designating solids which are liable to cause fires through friction, absorption of moisture, etc as hazardous. Such solids are thermally unstable and will often fit within the reactive classification as well as the ignitable classification. To reflect this intention, the Agency has amended its final regulation by changing "or when ignited burns so vigorously ..." to "and when ignited burns so vigorously ..." This language makes clear that the Agency does not consider materials which simply burn vigorously such as wastepaper to be hazardous.

2. Several commenters argued that the definition as proposed was too vague and did not provide the generator with enough guidance for determining whether or not his waste was ignitable. These commenters went on to recommend that a more specific test be established for solid ignitables.

The Agency considers the prose definition of solid ignitables to be sufficiently specific to enable the generator to determine whether or not his waste is hazardous under the regulations. Most generators whose solid wastes are dangerous due to their ignitability will be well aware of this property since ignitable solid wastes present special problems in handling, storage and transport. It will only be rare instances that a generator would be unsure of the ignitability of his solid waste or unable to assess whether the waste fits the prose definition. Unfortunately, as noted above, no test methods have been adequately developed which adequately measure the ignitability hazard presented by solid wastes. Therefore until an adequate test method is developed, the Agency will continue to use a prose definition for non-liquid ignitables.

3. Several commenters pointed out that the proposed definition classify slags from refining operations as hazardous on the basis of their retained heat. These commenters argued that inclusion of these slags as ignitable was outside the intent of Congress and suggested that the regulation be modified to exclude slags.

In proposing the non-liquid (solid) ignitability definition, the Agency was concerned with wastes such as slags which retain a considerable amount of heat and which, if placed in a landfill, could present

a problem by raising the temperature of other wastes to their flash points. However, in re-evaluating this class of wastes, the Agency believes that these wastes are produced in such high volume that they would never end up in a sanitary landfill and present the problem as described in the above scenario. Therefore, the Agency has amended the regulation by deleting the following phrase "...or retained heat from manufacturing or processing."

C. Comments on Ignitable Gases

1. One commenter suggested that the term "ignitable compressed gases" be changed to "flammable compressed gas" as defined by DOT in 49 CFR 173.300 (b).

The term "ignitable" has been used by the Agency to maintain consistency with the rest of the Agency's ignitability definition. It should be clear from the definition that, insofar as compressed gases are concerned, the Agency's use of "ignitable" and DOT's use of "flammable" are indistinguishable. Therefore, there is no need to modify the final regulation as suggested by the commenter.

2. One commenter recommended that ignitable compressed gases be excluded from the definition of ignitable waste since the main hazard presented by gases occurs during transportation.

The Agency disagrees with this commenter. An ignitable contained gas, with pressure greater than

40 lbs. per sq. inch, could present a danger to human health and the environment through the leaking or rupture of the container during handling or disposal, as well as during transportation.

D. Comments on Ignitable Oxidizers

1. One commenter requested further clarification on the definition of oxidizer.

49 CFR 173.151 defines an oxidizer as "a substance such as chlorate, permananganate, inorganic peroxide, nitro carbo nitrate, or a nitrate, that yields oxygen readily to stimulate the combustion of organic matter." Section 173.151a goes on to define the term organic peroxide. This definition is as good a description of oxidizing compounds as has been developed short of using a test method with a quantitative limit. Unfortunately, as noted above, an appropriate test method has not been developed by the Agency or any other organization and until one is found the proposed definition will be used.

2. One commenter questioned the possible overlap between ignitable oxidizers and reactive oxidizers. The commenter went on to question whether these wastes would have to be recorded as both reactive and ignitable on manifests and reports.

The difference between ignitable oxidizers and reactive oxidizers is largely a matter of degree.

Thus, it is almost impossible to draw a clear line between the two. However, for purposes of these regulations, an oxidizer which reacts violently should be considered a reactive waste; on the other hand, an oxidizer which reacts in a milder manner, should be considered an ignitable oxidizer. In the main, the most important consideration is that these oxidizers be controlled sufficiently to prevent danger to human health and the environment.

E. Summary of Data on the Ignitability Tester Published in the NUS Report* and Response to Comments Received on that Noticed Report

On December 28, 1979 (44 FR 49278), the Agency noticed a report for comment which contained the results of running the PenskyMartens flash point tester to determine the flash points of two selected waste sludges. The flash point determinations were presented at Table 5, (pg.47), and included the following explanation:

The ignitability (flash point) test results obtained by the Pensky-Martens Closed Tester are exhibited in Table 5. The ASTM method states that results submitted by each of two laboratories should be considered suspect if the results differ by more than 3.3°C (6°F) for suspensions of solids having a flash range between 35 to 43.3°C (95 to 110°F). The procedure further states that the reproducibility between the average of duplicate results by two individuals or laboratories would be considered suspect if the results differ by

*"Evaluation of Solid Waste Extraction Procedures and Various Hazard Identification (Final Report)", NUS Corporation, September, 1979.

TABLE 5

ANALYSIS RESULTS FOR IGNITABILITY TESTS

<u>Sample</u>	<u>Laboratory</u>	<u>Flash Point</u>	
		<u>C</u>	<u>F</u>
Refinery Sludge (Tank Bottoms)	J	31.1	88
	K	-5.6	22
Paint, Pigment Sludge	J	33.3	92
	K	43.3	100
Refinery Sludge (Tank Bottoms) ^a	J	>82.2	>180
	K	>93.3	>180*

^aSame sample, repeat analysis; no explanation can be offered for the differences.

*One commenter noted that the F° conversion for >93.3 was incorrect (i.e., the conversion of >93.3°C should be >200°F not 180°F). The Agency agrees with this commenter.

more than 10°C (18°F) for viscous and/or heavily pigmented materials (e.g., paint and pigment sludge). The refinery sludge (tank bottoms) results are definitely not in agreement, whereas the paint and pigment sludge results are considered questionable.

NUS made these conclusions about the Pensky-Martens tester and the two samples:

The Pensky-Martens Closed Cup Tester gave inconsistent results for the refinery sludge (tank bottoms) and marginal results for the paint and pigment sludge. The refinery sludge was an oily mixture containing water, and variable results can be expected for a nonhomogeneous sample of this type. The paint and pigment sludge was highly viscous. The Pensky-Martens Closed Cup Tester or equivalent is acceptable for homogeneous mixtures containing a large fraction of flammable volatiles. However, industrial wastes which are viscous, heavily pigmented, and/or nonhomogeneous are expected to give inconsistent and perhaps conflicting test results. A different method may provide better results with other sample types.

Two commenters stated that the results presented in the NUS report seriously question both the validity and reproducibility of the procedure. One commenter argued that given the contradictory results from the NUS ignitability tests, additional developmental work needs to be conducted to better define the test conditions and parameters of the test. Another commenter stated that, until this was done, the scientific basis for defining ignitable hazardous waste would be inadequate. A third commenter stated that inconsistent and perhaps conflicting test results are expected for other viscous, heavily pigmented wastes. The first commenter noted that, in the refinery sludge sample, the difference in flash point measurements between the two laboratories was 36.6°C or 66°F, and that when the samples were

again run, the results were vastly different. This commenter further noted that in this second run laboratory J, which had initially reported a value of 31.1°, reported a value of >82.2°C, a value which was totally unacceptable since 82.2°C is a temperature that should be determined with precise accuracy by the use of commonly available equipment.

The Agency believes that these commenters may have been somewhat rash in condemning an industrially accepted standard test method (the Pensky-Martens Closed Cup Tester - American Society for Testing Materials Standard D-93-72) based on the review of trial runs performed on two samples. This test method has for a number of years been used successfully by the Department of Transportation in its regulation of hazardous materials. The Agency agrees that the (1) non-homogeneous nature of one sample and (2) the high viscosity of the other may have surpassed the limits of the particular test*. However, the Agency does not agree that the two test results reported in the NUS report are sufficient indication that the test may not be reproducible. A large number of circumstances could have produced this difference in flash points. Difficulty in sampling and splitting oil/water mixtures, insuring that light volatile fractions

*In promulgation of the ignitability standards in today's Federal Register, the most current test standards will be incorporated (i.e., Pensky-Martens Closed Cup Tester D93-78). This updating should improve the applicability of the test methods to sludge because of the incorporation of dewatering techniques and viscosity limits.

do not escape during handling, and sample preservation all could have contributed to false readings. Next, the same samples were run through the flash point test at different times. (The tank bottom sample was first run in the laboratories in November of 1978; these samples were then tested again in February of 1979. The result of which produced the much higher flash points of >180°F. In disagreement with the commenter, this is an acceptable way to present the data, as the samples began to boil around 180°F and the test had to be terminated. The Agency was in error in having the tank bottom sample re-tested after such a delay in time and not reporting so. The other waste stream to be tested (paint and pigment sludge) was a highly viscous homogeneous waste with suspended solids. No viscosity determination was made before the test. The result for this test showing a 18°F difference between the two laboratories is a very good result considering the extreme viscosity of the sample, only one test performed at each laboratory, and lack of a sample preservation technique. Observations made during the test were not reported.

One commenter argued that the additional cited document did not provide validation of the characteristic test method for listing or delisting. The Agency agrees with this commenter. However, the primary objective in running the test was to develop additional baseline data on running wastes in the Pensky-Martens Closed Cup Test, not to validate the test. The Agency assumes that this test method has al-

ready been validated since the test method has been adopted by DOT in their transportation regulations and is commonly accepted by industry as a standard test method.

One commenter presented a rationale that explains the failure of the two laboratories in relating equivalent results. Stating, such results can be obtained in the event that the sampling procedures, subsampling procedures, and finally the individual test sampling procedures are not all representative of the starting material. The commenter goes on to say that what is needed is a method of obtaining a small representative portion of these materials. That is to say, a sample of approximately 100-150 ml which is in turn representative of the original sample, e.g., a lagoon or holding tank. Such materials are, frequently, themselves inhomogeneous and contain lumps and even rubbish so that a truly representative sample from all strata within the holding tank or lagoon and from various locations should be appropriately composited into a large vessel. This large initial vessel, possibly a five gallon container or even a fifty-five gallon drum, itself should be tightly capped during storage and thoroughly homogenized before subsamples are taken. Also, the commenter suggests that after the test samples have been obtained, they should be introduced without delay into the Pensky-Martens apparatus at room temperature. If the sample flashes immediately, another sample aliquot should be cooled and introduced into

a clean cooled Pensky-Martens apparatus. Further, the flash point technician should be thoroughly trained in the sciences of running the Pensky-Martens apparatus. This commenter also relates that in their experience lumps of material and bumping during the stirring process can lead to spuriously high or spuriously low flash points. The commenter recommends that the testing be reported in duplicate (do not average). If values disagree by more than some specified value (pick a number), then run samples in duplicate on another test date. Report all data obtained together with all anecdotal information, e.g., "couldn't stir sample," "sample foamed," "boiled over," "extinguished flame."

The Agency feels that this commenter's suggestions are very much in order. EPA is currently developing a sampling methodology, sample preservation, and sample splitting handbook which will be available to the public. The problem of obtaining a representative sample of a particular waste stream so that appropriate testing can be accomplished has been a concern of the Agency and it's contractors who must sample and analyze waste streams. The Agency agrees that reporting anecdotal information or observations made during a test is necessary. Data collection on very viscous, high solids, and/or nonhomogeneous sludges will be the way the Agency assesses the hazard of sludges which because of some physical restraint are outside the limits of a particular tester. This is not to say that what is not reproducible in one standard is reproducible in another. The Agency

again agrees with this commenter in that more information should be reported concurrently with flash points so that proper hazard evaluation can be made.

V. Promulgated Regulation

As a result of EPA's review of the comments regarding the ignitability characteristic, EPA is promulgating an ignitability characteristic which differs from the proposed regulations in two aspects. First, the definition for liquid ignitables specifically excludes wastes which have a flash point less than 140°F and contain 24 percent or less alcohol by volume; secondly, the definition for non-liquid ignitables has been clarified to better reflect the Agency's regulatory intent.

§261.21 Characteristic of ignitability

(a) A solid waste exhibits the characteristic of ignitability if a representative sample of the waste has any of the following properties:

(1) It is a liquid, other than an aqueous solution containing less than 24 percent alcohol by volume, and has a flash point less than 60°C (140°F), as determined by a Pensky-Martens Closed Cup Tester, using the test method specified in ASTM Standard D-93-79, or a Setaflash Closed Cup Tester, using the test method specified in ASTM standard D-3278-78, or as determined by an equivalent test method approved by the Administrator under the procedures set

forth in §§260.20 and 260.21.*

(2) It is not a liquid and is capable, under standard temperature and pressure, of causing fire through friction, absorption of moisture or spontaneous chemical changes and, when ignited, burns so vigorously and persistently that it creates a hazard.

(3) It is an ignitable compressed gas as defined in 49 CFR 173.300 and as determined by the test methods described in that regulation or equivalent test methods approved by the Administrator under §§260.20 and 260.21.

(4) It is an oxidizer as defined in 49 CFR 173.151.

(b) A solid waste that exhibits the characteristic of ignitability, but is not listed as a hazardous waste in Subpart D, has the EPA Hazardous Waste Number of D001.

*ASTM Standards are available from ASTM, 1916 Race Street, Philadelphia PA 19103.

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Appendix I
Examples of Accidents
Involving Ignitable Waste

East St. Louis, St. Clare County

The Mal-Milam landfill has accepted various industrial wastes for more than ten years. Some of these wastes come from the Chrysler Corporation and Mallinkrodt Chemical Works and include solvents (phenols) and wastes from plastics manufacture. Two serious fires occurred at the site during compaction operations on August 29, 1973 and on April 4, 1974. The fires burned for two days and involved personal danger and much difficulty to extinguish. Only after the second fire when the disposed permits came under review were changes made in the operation. Fire protection handbook lists phenol (C_6H_5OH) with a flash point of 175° . Waste from plastics manufacturing may include a number of ignitable solvents and their still bottoms.

Illinois

Chicago, Dan Ryan Expressway

Several dozen barrels of chemical waste exploded in a truck bin on the Dan Ryan Expressway, spewing barrels and flames over cars and snarling rush-hour traffic on all four Chicago expressways. The explosions occurred at 3:15 p.m. on the elevated portion of the Ryan Expressway. The chemical believed to be sodium nitrate, was part of a load being carried by an industrial garbage truck to a garage in Crestwood from a chemical company on West 18th Street. Barrels which were catapulted into the air landed among the cars or dropped 50 feet to the ground level. Two policeman were treated for eye injuries from the

smoke. Sodium nitrate is a D.O.T. oxidizer and being such is an EPA ignitable oxidizer.

Pennsylvania

Harrisburg, Dauphin County 1/75

An explosion occurred at the Harrisburg City incinerator which resulted in building damage totaling approximately \$95,000. The explosion resulted from the ignition of a drum of spray adhesives delivered by the Rolance and Rolance Supply Co. Proper disposal of these adhesives would of prevented this dangerous situation. Municipal incinerators like municipal landfills are generally not equipped nor permitted to handle ignitable hazardous waste.

Pennsylvania

Whitemarsh Township, Montgomery County

Two explosions and the contamination of residential drinking water resulted from the development of methane gas in a landfill in Deck Quarry, Montgomery County, Pennsylvania. The gas moved through rock fractures. A well-pump spark ignited the gas causing explosions. Residents have evacuated their houses permanently and the contaminated well area has been vented by a trench and holes dug at the landfill in late 1969. The landfill accepted municipal and some industrial wastes until its closure in 1969. The migration of gases from landfills is a problem throughout the country. Organic solvents which volatilize at

ambient temperatures (that is, less than 60° C) join with refuse degradation products causing concentration build-up in nearby structures, manholes, conduits, and in the ground itself. A detail analysis of landfill gas from a different landfill, one in California, showed fifty-some organic contaminants to the methane.²⁴

New Jersey

Toms River, Berkeley Township

1500 or more deteriorating chemical drums buried in Berkeley Township, and considered potentially explosive by the state, could cause the relocation of a major Ocean County Sewerage Authority interceptor lines. The presence of the hazardous drums known to State Department of Environmental Protection since 1974 has resulted in hiring an engineering firm to monitor ground water. One of the substances known to be buried at the site is metallic sodium (825 drums from Union Carbide buried in 1960) which is a ignitable solid. A fire at the dump site in 1974 was put out with dry sand after water made the flames worse. Metallic Sodium is an ignitable solid.

Illinois

Calumet, Cook County 9/75

A landfill operator died from severe burns when the compacter that he was operating struck a 55-gallon drum of ethyl acetate (flash point 24°). The incident occurred after a scavenger/

hauler had deposited a load at the Calumet Industrial Development Landfill in the dark hours of the morning.

Washington

Everett, Snohomish County 9/74

The N.W. Wire Rope Corp., cleaning off debris from the site of a metal reduction plant, sent 200 cubic yards to a landfill near Silver Lake. The debris consisted of aluminum dust, magnesium chips, and two broken drums of concentrated phosphorus. Upon dumping and compaction, the material ignited and developed into a fire. Water could not be applied to the waste and explosions eliminated chances to obtain samples needed for analysis. The fire started after the improper disposal of ignitable solids.

Michigan

Forest Waste Disposal, Genesee County

While burying drums containing an unknown waste, a bulldozer operator at the Forest Waste Disposal Landfill began experiencing dizziness and eye irritations. As a result, he left his bulldozer and upon returning found the machine in flames. Evidently, some of the drums contained ignitable solvents and the waste hauler, Berlin and Farrow, was supposed to incinerate their ignitable waste. The wastes were generated by the Saganough Steering Gear Co. Landfill owner is contemplating legal action against the waste hauler.

Ohio

Elda, Inc. Dump, Cincinnati

An employee of a private dump was burned over 50 percent of his body when several containers of unknown volatile liquid caught fire and enveloped his bulldozer. The employee was attempting to put out a small fire when the bulldozer hit the containers. Firemen were hampered because no hydrants were located at the dump. The problem of unidentified ignitable solvents being placed in municipal landfills keeps cropping up. Danger to landfill personnel and degradation of the environment occur from this waste.

Pennsylvania

Springfield Township, Delaware County

The Mayer landfill of Delaware County, Pennsylvania, formerly accepted various kinds of industrial wastes. At times, tank-car quantities were dumped at the site as well as many barrels of unidentified chemical wastes. During compaction operations in 1971, an explosion occurred which destroyed a bulldozer and caused a fire that burned for several days. Problem disposal sites like this exemplify the need for ignitable waste controls.

Appendix II

Regulation of States, Organizations, Agencies

Regulations of States

California¹⁸

Flammable. (a) "Flammable means:

- (1) A liquid which has a flash point at or below 37.8 degrees centigrade (100 degrees fahrenheit) as defined by procedures described in Title 49, Code of Federal Regulations, Section 173.115.
- (2) A gas for which a mixture of 13 percent or less, by volume, with air forms a flammable mixture at atmospheric pressure or the flammable range with air at atmospheric pressure is wider than 12 percent regardless of the lower limits. Testing methods described in Title 49, Code of Federal Regulations, Section 173.115, shall be used.
- (3) A solid which is likely to cause fires due to friction, retained heat from processing or which can be ignited under normal temperature conditions and when ignited burns so as to create a serious threat to public health and safety. Normal temperature conditions means temperatures normally encountered in the handling, treatment, storage and disposal of hazardous wastes.
- (4) A gas, liquid, sludge or solid which ignites spontaneously in dry or moist air at or below 54.3 degrees centigrade (130 degrees Fahrenheit) or upon exposure to water.
- (5) A strong oxidizer. Section 60415 "Strong Oxidizer" means a substance that can supply oxygen to a reaction and cause a violent reaction, or sustain a fire when in contact with a flammable or combustible material in the absence of air.

Minnesota¹⁹

Flammable material: any material that:

- a. has a flash point below 93.3°C (200°F), except the following:
 - (1) a material comprised of miscible components having one or more components with a flash

point of 93.3°C (200°F), or higher, that make up at least 99% of the total volume of the mixture;

(2) a material that has a flash point greater than 37.8°C (100°F) and that when heated to 93.3°C (200°F) will not support combustion beyond the flash;

(3) an explosive material; or

b. may ignite without application of flame or spark including, but not limited to, nitro cellulose, certain metal hydrides, alkali metals, some oily fabrics, processed metals, and acidic anhydrides.

Flash point: The minimum temperature at which a material gives off vapor within a test vessel in sufficient concentration to form an ignitable mixture with air near the surface of the material.

Oxidative material: Any material with the property to readily supply oxygen to a reaction in the absence of air. Oxidative materials include, but are not limited to, oxides, organic and inorganic peroxides, permanganates, chlorates, perchlorates, persulfates, nitric acid, organic and inorganic nitrates, iodates periodates, bromates, perselenates, perbromates, chromates, dichromates, ozone, and perborates. Bromine, chlorine, fluorine, and iodine react similarly to oxygen under some conditions and are therefore also oxidative materials.

Flammable materials: Whenever the flash point of a waste is to be determined, one of the following test procedures shall be used. The test chosen shall be appropriate for the characteristics of the waste that is tested.

- (a) Standard Method of Test for Flash Point by Tag Closed Tester (ASTM D56-70).
- (b) Standard Method of Test for Flash Point of Aviation Turbine Fuels by Setaflash Tester (ASTM D3243-73).
- (c) Standard Methods of Test for Flash Point of Liquids by Setaflash Closed Tester (ASTM D3278-73).
- (d) Standard Method of Test for Flash Point by Pensky-Martens Closed Tester (ASTM D93-73) or alternate tests authorized in this standard.

For any waste containing components with different volatilities and flash points and having a flash point higher than 93.3°C (200°F) according to the test procedure employed, a second test shall be conducted on a sample of the liquid

portion of the material that remains after evaporation in an open beaker (or similar container), under ambient pressure and temperature (20 to 20°C) conditions, to 90 percent of original volume or for a period of four hours, whichever occurs first, with the lower flash point of the two tests being the flash point of the material.

Oregon²⁰

Flammability is defined as:

- (a) material which is readily ignited under ambient temperatures
- (b) material which on amount of its physical form or environmental conditions can form explosive mixtures with air and which is readily dispersed in air, such as dusts of combustible solids and mists of flammable or combustible liquids
- (c) material which burns with extreme rapidity, usually by reason of self-contained oxygen, materials which ignite spontaneously when exposed to air
- (d) liquids, solids or gaseous material having a flash point below 37.8°C (100°F).

Ohio³

Flash points below 175°F

Very volatile flammable liquids, very flammable liquids and gases, and substances that, in the form of dusts or mists readily form explosive mixtures when dispersed in air.

Washington²¹

Flammable: substances which have a flash point at or below 40°C (100°F), as determined by the Tagliabue open cup tester, or other suitable method.

Agencies and Organizations

Department of Transportation²

- (1) flammable liquids are those having flash points below 37.8°C (100°F).
- (2) combustible liquids are those having flash points at or above 37.8°C (100°F) and below 93.3°C (200°F).
- (3) a flammable solid is any solid material other than one classified as an explosive, which, under conditions normally incidental to transportation is liable to cause fires through friction, retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious transportation hazard.

Consumer Product Safety Commission²²

- (1) the term "extremely flammable" shall apply to any substance which has a flash point at or below 20°F as determined by the Tabliabue Open Cup Tester
- (2) the term "flammable" shall apply to any substance which has a flash point above 20°F, to and including 80°F, as determined by the tester mentioned above
- (3) "Extremely flammable solid" means a solid substance that ignites and burns at an ambient temperature of 80°F or less when subjected to friction, percussion, or electrical spark
- (4) "Flammable solid" means a solid substance that when tested by the method described in Section 1500.44, ignites and burns with a self-sustained flame at a rate greater than one-tenth of an inch per second along its major axis.

Environmental Protection Agency (Title 40 (Pesticides), CFR, Part 162)

The proposed rulemaking includes flammability labeling requirements. "Extremely flammable" and "flammable" categories correspond to those found in Title 15, U.S. Code, Sec. 1261.

- (1) Extremely flammable - a flash point less than 20°F.
- (2) Flammable - a flash point greater than 20°F and less than 80°F.
- (3) Combustible - a flash point greater than 80°F and less than 150°F.

National Academy of Sciences (Ad - 782 476):

<u>Rating</u>	<u>Definition</u>
0 - Insignificant hazard	Not Combustible
1 - Slightly hazardous	Flash point larger than 60°C (140°F)
2 - Hazardous	Flash point from 37.8 to 60°C (100 to 140°F)
3 - Highly hazardous	Flash point less than 37.8°C (100°F) and boiling point greater than 37.8°C (100°F)
4 - Extremely hazardous	Flash point less than 37.8°C (100°F) and boiling point less than 37.8°C (100°F)

National Fire Protection Association²³

Flammable liquid shall mean a liquid having a flash point below 37.8°C (100°F) and having a vapor pressure not exceeding 40 pounds per square inch (absolute) at 37.8°C (100°F) and shall be known as a Class I liquid. Class I liquids shall be subdivided as follows: Class IA shall include those having flash points below 22.8°C (73°F) and having a boiling point at or below 37.8°C (100°F). Class IB shall include those having flash points below 37.8°C (100°F) and having a boiling point at or above 37.8°C (100°F). Class IC shall include those having flash points at or above 22.8°C (73°F) and and below 37.°C (100°F).

Combustible liquids shall be subdivided as follows:

Class II liquids shall include those having flash points at or above 37.8°C (100°F) and below 60°C (140°F).

Class IIIA liquids shall include those having flash points at or above 60°C (140°F) and below 93.3°C (200°F).

Class IIIB liquids shall include those having flash points at or above 93.4°C (200°F).

Booz-Allen Research, Inc., EPA, 1973 (PB 221-464):

A material is flammable if it has a flash point that is less than 37.8°C (100°F) and a boiling point less than 37.8°C (100°F) spontaneous combustion and/or explosive reaction.

Department of the Navy:

<u>Hazard Level</u>	<u>Criteria</u>
4	Flash point less than 100°F and boiling point less than 73°F.
3	Fp less than 100° and Bp greater than 73°F and less than 100°F.
2	Fp greater than 100°F and less than 200°F.
1	Fp greater than 200°F.
0	Material will not burn.

Appendix III

Definitions

These definitions are the working definitions of ASTM's Coordinating Committee on Flashpoint and Related Properties and Interaction with Government Agencies on these Properties.

NOTE: The Agency has used several of the definitions listed below, e.g. flash point in the body of the background document. The remainder are included as a standard for future work.

Autoignition -the spontaneous ignition (without an external ignition source) of a material as the result of heat liberation from an exothermic reaction.

Burning Velocity -fundamental velocity of a combustion wave measured normal to the flame front.

Combustible -capable of undergoing combustion.

Combustion -a rapid exothermic oxidation process accompanied by continuous evolution of heat and usually light.

Deflagration -combustion which propagates into the reacting medium at a subsonic velocity.

Detonability Limits -the maximum and minimum concentrations of a combustible in an oxidant, e.g., air, which will propagate a detonation when initiated at specified temperature and pressure.

Detonation -combustion or other reaction which propagates into the reacting medium at a supersonic velocity.

Fire -the phenomenon of Combustion.

Fire Point -the minimum temperature to which a material must be heated in an open vessel to sustain combustion for a specified period of time after ignition by an external source.

Flame -a zone of gas or particulate matter or both in gaseous suspension that is undergoing combustion, as evidenced by the evolution of both heat and usually light.

Flame Temperature -the temperature of the product species in flaming combustion.

Flame Speed -velocity of a combustion wave measured relative to a stationary observer.

Flash Point -the lowest temperature, corrected to a pressure of 101.3 kPa (1013 millibars), of a substance at which application of an ignition source causes the vapors above the substance to ignite under the specified conditions of test.

Ignite -to initiate combustion.

Lower Flammable Limit -the lowest concentration of a combustible substance that is capable of propagating a flame through a homogenous mixture of combustible substance and a gaseous oxidizer under specified conditions of test.

Lower Temperature Limits -the lowest temperature at which a combustible substance will produce a vapor concentration equal to the lower flammable limit under specified conditions of test.

Minimum Oxygen Concentration -the minimum concentration of oxygen required to sustain burning or flame propagation.

Temperature -the thermal state of matter as measured on a defined scale.

Upper Flammable Limit -the maximum concentration of a combustible substance that is capable of propagating a flame through a homogenous mixture of combustible substance and a gaseous oxidizer under specified conditions of test.

Liquid - (flammability regulations) -a substance that has a definite volume but no definite form except such given by its container. It has a viscosity of 1×10^{-3} stokes (1×10^{-7} to $1 \times 10^{-1} \text{ m}^2 \text{ s}^{-1}$) at 104° F (40° C) or an equivalent viscosity at agreed upon temperature.
(This does not include powders and granular materials).
Liquids are divided into two classes:

CLASS A (low viscosity) a liquid having a viscosity of 1×10^{-3} to 25.00 stokes (1×10^{-7} to $25.00 \times 10^{-4} \text{ m}^2 \text{ s}^{-1}$) at 104° F (40° C) or an equivalent viscosity at an agree upon temperature.

CLASS B (high viscosity) a liquid having a viscosity of 25.01 - 1×10^3 stokes (25.01×10^{-4} to $1 \times 10^{-1} \text{ m}^2 \text{ s}^{-1}$) at 104° F (40° C) or an equivalent viscosity at an agreed upon temperature.

note: The above definition of liquid does not apply to the meaning intended in this document but rather a general definition of ASTM.

Appendix IV

Test Methods for Ignitable Waste

Table of Contents

IV-1, 2-----	Tests to Determine Ignitable Gases (49 CFR 173,300)
IV-3-----	Test to Determine Ignitable Liquids (Pensky-Martens Closed-Cup ASTM)
IV-4-----	Test to Determine Ignitable Liquids (Seta-flash Closed Cup ASTM D3278-73)

IV-1,2 Aerosol Flame Projection Tests

R. R. MANION
Vice-President

R. M. GRAZIANO
Director

AEROSOL FLAME PROJECTION TESTS

Section 173. 300(b) subparagraphs (2), (3), and (4) of Title 49 to the Code of Federal Regulations referenced The Bureau of Explosives' Flame Projection Apparatus, Open Drum Apparatus and Closed Drum Apparatus to be used when examining aerosol products.

The following are descriptions of the equipment and testing procedures to be used when conducting the tests. Any further questions relating to this testing should be addressed to the Director at the above address.

FLAME PROJECTION TEST

EQUIPMENT - The test equipment consists of a base four inches wide and two feet long. A thirty inch rule (with inches marked) is supported horizontally on the side of the base and about six inches above it. A plumber's candle of such height that the top third of the flame is at the height of the horizontal rule is placed at the zero point in the base.

PROCEDURE - The test is conducted in a draft-free area that can be ventilated and the atmosphere cleared between each test. The self-pressurized container is placed at a distance of six inches from the ignition source and the spray jetted into the top third of the flame with valve opened fully for periods of 15 - 20 seconds. The length of the flame projection from the candle position is read on the horizontal scale. Three or more readings are taken on each sample and the average is taken as the result. Samples are also tested with valve in partially open positions to test for "burning back" to valve.

DRUM TESTS

EQUIPMENT- The equipment consists of a 55 - gallon open-head steel drum or similar container which is placed on its side and fitted with a hinged cover over the open end that will open at a pressure of 5 p. s. i.

The closed or solid end is equipped with one shuttered opening at the top. This is for the introduction of the spray. The opening is approximately two inches from the edge of drum head and is two inches in diameter. There is a safety glass or plastic window six inches square in the center of the solid end. A lighted plumber's candle is placed inside the drum on the lower side and midway between the ends.

PROCEDURE - The tests are conducted in the open and when temperature is between 60°F and 80°F.

---- OPEN DRUM TEST ----

This test is conducted with hinged end in a completely open position and with the shutter closed. The spray from the dispenser, with valve opened fully, is directed into the upper half of the open end and above the ignition source for one minute. Any significant propagation of flame through the vapor-air mixture away from the ignition source shall be considered a positive result -- but -- any minor and unsustained burning in the immediate area of the ignition source shall not be considered a positive result.

---- CLOSED DRUM TEST ----

This test is conducted with the hinged cover dropped into position to rest freely against the end and to close the open end of the drum to make a reasonably secure but not necessarily a completely air-tight seal. The shutter is opened and the spray is jetted into the drum through this shutter with valve fully opened for one minute. After clearing the atmosphere in the drum, the jetting is repeated similarly three times. Any explosion or rapid burning of the vapor-air mixture sufficient to cause the hinged cover to move is considered a positive result.

April, 1974

IV-3 ASTM D93-72

Pensky-Martens Closed Cup Tester



Designation: D 93 - 72



IP Designation: 34/71

American National Standard Z11.7 - 1972
Approved May 18, 1972
by American National Standards Institute
Method 1102—Federal Test
Method Standard No. 791b
Federation of Societies for
Paint Technology Standard No. D1-5-68
British Standard 2839

NO: 7 1977

AMERICAN SOCIETY FOR TESTING AND MATERIALS

1916 Race St., Philadelphia, Pa., 19103

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Standard Method of Test for FLASH POINT BY PENSKY-MARTENS CLOSED TESTER¹

ADOPTED (as method GO-7), 1924; LAST REVISED, 1971

This Standard of the American Society for Testing and Materials is issued under the fixed designation D 93; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. This is also a standard of the Institute of Petroleum issued under the fixed designation IP 34. The final number indicates the year of last revision.

This method was adopted as a joint ASTM-IP Standard in 1967.

1. Scope

1.1 This method covers the determination of the flash point by Pensky-Martens Closed Cup Tester of fuel oils, lube oils, suspensions of solids, liquids that tend to form a surface film under test conditions, and other liquids. For the determination of the flash point of drying oils and solvent-type waxes refer to Note 1.

NOTE 1—The flash point of drying oils may be determined using Method D 1393 and the flash point of solvent-type liquid waxes may be determined using Method D 1437.

NOTE 2—This method may be employed for the detection of contamination of lubricating oils by minor amounts of volatile materials.

2. Applicable Documents

2.1 ASTM Standards:

- D 56 Test for Flash Point by Tag Closed Tester²
- D 1310 Test for Flash Point of Liquids by Tag Open-Cup Apparatus³
- D 1393 Test for Flash Point of Drying Oils²
- D 1437 Test for Flash Point of Solvent-Type Liquid Waxes⁴
- E 1 Specification for ASTM Thermometers⁵

3. Summary of Method

3.1 The sample is heated at a slow, constant rate with continual stirring. A small flame is directed into the cup at regular intervals with simultaneous interruption of stirring. The flash point is the lowest temperature at which application of the test flame causes the vapor above the sample to ignite.

4. Apparatus

4.1 Pensky-Martens Closed Flash Tester, as described in Appendix A1.

NOTE 3—There are automatic flash point testers available and in use which may be advantageous in the saving of testing time, permit the use of smaller samples, and have other factors which may merit their use. If automatic testers are used, the user must be sure that all of the manufacturer's instructions for calibrating, adjusting, and operating the instrument are followed. In any cases of dispute, the flash point as determined manually shall be considered the referee test.

4.2 Thermometers—Two standard thermometers shall be used with the ASTM Pensky-Martens tester, as follows:

4.2.1 For tests in which the indicated reading falls within the limits 20 to 200 F (−7 to +93 C), inclusive, an ASTM Pensky-Martens Low Range or Tag Closed Tester Thermometer having a range from 20 to 230 F (−5 to +110 C) and conforming to the requirements for Thermometers 9F (9C) and as prescribed in ASTM Specification E 1 or IP Thermometer 15F (15C) conforming to specifications given in Appendix A3, shall be used.

4.2.2 For tests in which the indicated reading falls within the limits 230 to 700 F (110 to 371 C), an ASTM Pensky-Martens High

¹ This method is under the jurisdiction of ASTM Committee D-2 on Petroleum Products and Lubricants.

Current edition approved Aug. 29, 1972. Published October 1972. Originally published as D 93 - 21 1921. Last previous edition D 93 - 66.

In the IP, this method is under the jurisdiction of the Standardization Committee.

In 1971 the scope was revised.

² Annual Book of ASTM Standards, Part 20.

³ Annual Book of ASTM Standards, Part 11.

⁴ Annual Book of ASTM Standards, Part 22.

⁵ Annual Book of ASTM Standards, Parts 18 and 30.

IV-4 D3278-73

SETAflash Closed Cup Tester



Designation: D 3278 - 73

AMERICAN SOCIETY FOR TESTING AND MATERIALS

1916 Race St., Philadelphia, Pa., 19103

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Standard Methods of Test for FLASH POINT OF LIQUIDS BY SETAFLASH CLOSED TESTER¹

This Standard is issued under the fixed designation D 3278; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 This method covers the determination of the flash point, by Setaflash® Closed Tester, of paints, enamels, lacquers, varnishes, and related products and their components having flash points, between 32 and 230°F (0 to 110°C) having a viscosity lower than 150 stokes at 77°F (25°C).²

NOTE 1—Tests at higher or lower temperatures are possible.

1.2 The procedure may be used to determine whether a material will or will not flash at a specified temperature or to determine the finite temperature at which a material will flash.

1.3 The results from this method are comparable to those obtained by the Tag Closed Tester procedure described in Method D 563 and the Pensky-Martens Tester method described in Method D 93.

2. Applicable Documents

2.1 ASTM Standards:

D 56 Test for Flash Point by Tag Closed Tester²

D 93 Test for Flash Point by Pensky-Martens Closed Tester²

D 850 Test for Distillation of Industrial Aromatic Hydrocarbons and Related Materials²

D 1015 Test for Freezing Points of High-Purity Hydrocarbons³

D 1078 Test for Distillation Range of Volatile Organic Liquids²

3. Summary of Method

3.1 By means of a syringe, 2 ml of sample is introduced through a leakproof entry port into

the tightly closed Setaflash Tester or directly into the cut that has been brought to within 5°F (3°C) below the expected flash point. As a flash/no flash test, the *expected* flash point temperature may be a specification or other operating requirements. The temperature of the apparatus is raised to the precise temperature of the expected flash point by slight adjustment of the temperature dial. After 1 min, a test flame is applied inside the cup and note is taken as to whether the test sample flashes or not. If a repeat test is necessary, a fresh sample should be used.

3.2 For a finite flash measurement, the temperature is sequentially increased through the anticipated range, the test flame being applied at 9°F (5°C) intervals until a flash is observed. A repeat determination is then made using a fresh sample, starting the test at the temperature of the last interval before the flash point of the material and making tests at increasing 1°F (0.5°C) intervals.

4. Apparatus

4.1 *Setaflash Tester*⁴, shown in Fig. X1, and described in Appendix X1.

4.2 *Thermometers*⁵ conforming to specifica-

¹ These methods are under the jurisdiction of ASTM Committee D-1 on Paint, Varnish, Lacquer, and Related Products.

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² 1974 Annual Book of ASTM Standards, Part 29.

³ 1973 Annual Book of ASTM Standards, Part 18.

⁴ Unit shown in Fig. X1 is manufactured by Stanhope-Seta Ltd., Park Close, Egham, Surrey, England. It is available in the USA from Erdeo Engineering Corp., 136 Official Road, Addison, Ill. 60101, or from Paul N. Gardner Co., Station S, P. O. Box 6633, Fort Lauderdale, Fla. 33316.

⁵ Thermometers may be obtained from the suppliers of the Setaflash.