

Petroleum products and other liquids — Guide to flash point testing

ICS 75.080

National foreword

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This document comprises a front cover, an inside front cover, the CEN/TR title page, pages 2 to 16, an inside back cover and a back cover.

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Amendments issued since publication

| Amd. No. | Date | Comments |
|----------|------|----------|
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This Published Document was published under the authority of the Standards Policy and Strategy Committee on 30 December 2005

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ICS 75.080

English Version

Petroleum products and other liquids - Guide to flash point testing

Produits pétroliers et autres liquides - Guide pour
détermination du point d'éclair

Mineralölerzeugnisse und andere Flüssigkeiten - Leitfaden
zur Bestimmung des Flammpunktes

This Technical Report was approved by CEN on 14 May 2005. It has been drawn up by the Technical Committee CEN/TC 19.

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Foreword

This Technical Report (CEN/TR 15138:2005) has been prepared by Technical Committee CEN/TC 19 “Gaseous and liquid fuels, lubricants and related products of petroleum, synthetic and biological origin”, the secretariat of which is held by NEN.

Introduction

This Technical Report has been written under the guidance and with the assistance of the CEN/TC 19 / TC 139 (ISO/TC 28 / TC 35) Joint Working Group for Flash Point Methods and the Energy Institute Flammability Panel ST B 4 with the aim of assisting laboratory managers and technicians, regulators, specification writers and industry in the use, specification and application of flash point tests for liquids and semi-solids.

The work is based on standards produced by the following organizations:

- CEN/TC 19 "Petroleum products, lubricants and related products"
- CEN/TC 139 "Paints and varnishes"
- ISO/TC 28 "Petroleum products"
- ISO/TC 35 "Paints and varnishes"
- ASTM D01.22 "Health and Safety"
- ASTM D02.08 B "Flammability Section"
- DIN Deutsches Institut für Normung
- EI ST B 4 Flammability Panel

1 Scope

This Technical Report is not intended to be a comprehensive manual on flash point tests and the interpretation of test results, however it covers the key aspects on these subjects.

The flash point test can be summarised as a procedure where a test portion is introduced into a temperature controlled test cup and an ignition source is applied to the vapours produced by the test portion to determine if the vapour / air mixture is flammable or at what temperature the vapour / air mixture is flammable.

2 Outline

There are many, slightly different, definitions of flash point, however the following definition is widely used in standard test methods:

The lowest temperature of the test portion, corrected to a barometric pressure of 101,3 kPa, at which the application of an ignition source causes the vapour of the test portion to ignite momentarily and the flame to propagate across the surface of the liquid under the specified conditions of test.

It is important to realise that the value of the flash point is not a physical constant but it is the result of a flash point test and is dependent on the apparatus and procedure used. This fact is so important that a general statement similar to the following will be incorporated into all the main flash point methods:

Flash point values are not a constant physical-chemical property of materials tested. They are a function of the apparatus design, the condition of the apparatus used, and the operational procedure carried out. Flash point can therefore only be defined in terms of a standard test method, and no general valid correlation can be guaranteed between results obtained by different test methods or with test apparatus different from that specified.

Due to the importance of flash point test results for both safety and regulatory purposes, the test method identification should always be included with the test result.

In general specific products specifications indicate which standard test method should be employed.

3 Brief history

The discovery of petroleum and the increased use of flammable distillates in the 19th century, for lighting and heating in place of animal and vegetable oils, led to a large number of explosions and other fire related accidents.

Legislation, such as the UK Petroleum Act in 1862 and the German Petroleum Regulations in 1882, quickly spread around the world and led to the development of many types of test instruments. The following list shows the dates when the major surviving instruments were in a form probably recognisable today:

1870 – 1880 Abel closed cup, Pensky-Martens closed cup

1910 – 1920 Tag closed cup, Cleveland open cup

4 Flash and fire point, and sustained combustion and burning

The flash point is essentially the lowest temperature of the liquid or semi-solid at which vapours from a test portion combine with air to give a flammable mixture and 'flash' when an ignition source is applied. Fire point, combustibility and sustained burning tests all use open cup instruments.

Fire point can be considered as the lowest temperature of the test portion at which vapour combustion and burning commences when an ignition source is applied and thereafter is continuous and where the heat produced is self sustaining and supplies enough vapours to combine with air and burn even after the removal of the ignition source.

Sustained combustion and burning tests are usually carried out with the test portion at a fixed temperature and tests whether vapour combustion and burning commences when an ignition source is applied and thereafter is continuous and where the heat produced is self sustaining and supplies enough vapours to combine with air and burn even after the removal of the ignition source.

5 Why are flash point tests required

The fundamental reason for the requirement of flash point measurements is to assess the safety hazard of a liquid or semi-solid with regard to its flammability and then classify the liquid into a group. The lower the flash point temperature the greater the risk. This classification is then used to warn of a risk and to enable the correct precautions to be taken when using, storing or transporting the liquid.

Specifications quote flash point values for quality control purposes as well as for controlling the flammability risk.

A change in flash point may indicate the presence of potentially dangerous volatile contaminants or the adulteration of one product by another.

6 Which flash point method should be used

6.1 First considerations

Firstly, if a flash point method has been specified in a product specification or regulation, then that method should be the first choice. If a number of alternative methods are specified then the choice will be influenced by availability and other factors such as sample size requirements, speed of testing or precision. In certain circumstances the choice of the stated referee method may be of special importance. Annex A gives an overview of the most common methods and their use in specifications and regulations.

When testing specifically for contamination or contaminants, certain test methods and procedures are more appropriate than others. In general an equilibrium test method is recommended for testing samples that may contain traces of volatile contaminants.

When selecting a flash point method for incorporation into a product specification or regulation, it is important that the product type is included in the scope of the test method and that the temperature range of the product is covered by the test method. If the product is not included in the scope then the test may be unsuitable for the product or the quoted precision does not apply. Where the scope of a test method is general or not suitable it is recommended to contact an appropriate standardization body for advice.

When testing chemicals, mineral products or corrosive materials it is recommended to check that the test cup material is suitable and will not produce flammable gases or be damaged by any possible chemical reaction.

6.2 Open or closed cup

There are two general classes of flash point tests: open cup and closed cup:

The open cup was initially developed to assess the potential hazards of liquid spillage. In this test a test portion is introduced into a cup that is open at the top. An ignition source is passed horizontally over the surface of the liquid, while the cup and liquid are being heated, to test if the vapours 'flash'. If the test is repeated at increasing test portion temperatures a point may be reached when the test portion continues to burn without further application of the ignition source, this is the fire point. The precision of open cup tests is

somewhat poorer than closed cup tests as the vapours produced by heating the test portion are free to escape to the atmosphere and are more affected by local conditions in the laboratory. When open cup tests are made at temperatures above ambient the result is usually higher than a result from a closed cup test due to the reduced concentration of vapours.

The closed cup test contains any vapours produced and essentially simulates the situation where a potential source of ignition is accidentally introduced into a container. In this test a test portion is introduced into a cup and a close fitting lid is fitted to the top of the cup. The cup and test portion is heated and apertures are then opened in the lid to allow air into the cup and the ignition source to be dipped into the vapours to test for a flash.

The closed cup test predominates in specifications and regulations due to its better precision and ability to detect contaminants.

6.3 Non-equilibrium, equilibrium and rapid equilibrium tests

These three types of tests and associated instruments are characterised by the level of temperature stabilisation of the test portion and resultant vapours, and by the test portion size and test time.

Test methods such as Pensky-Martens, Tag, Abel and Cleveland are referred to as non-equilibrium tests as the test temperature of the test portion is increased during the test and the temperature of the vapours is not the same (not in equilibrium) as the test portion temperature when the ignition source is dipped at regular intervals into the cup. This type of test has the advantage that it produces a definitive flash point result. Under normal circumstances the increasing temperature is not a problem, but when volatile contaminants or components are present the short time between each dip of the ignition source, combined with the rate of temperature increase, does not allow enough time for flammable vapours to evolve and this may cause unreliable results. For this reason non-equilibrium tests with lower rates of heating usually perform better than those using higher rates of heating, when volatile contaminants or components are present in the test portion.

Equilibrium tests are preferred for liquids and semi-solids containing volatile components or contaminants and for confirmatory purposes in regulations as the sample temperature is constant or is increased at a very slow rate. This allows enough time for vapours to build up and for the vapours to be in equilibrium with the test portion before the ignition source is dipped into the cup. The ignition source is dipped in the cup at different test portion temperatures thus resulting in a measurement of a flash point, or the ignition source is dipped only once to carry out a flash no flash test to check conformance against specifications and flammability criteria. These equilibrium tests use any type of closed cup in a liquid bath and limits the difference of temperature between the test portion and the liquid bath. The liquid bath is specified because it gives a very even temperature distribution on the outside of the test cup thus ensuring that hot spots are not present on the cup surface that could cause the localised increase of flammable vapours and thus a low flash point. Unfortunately these procedures take a long time to complete.

Rapid equilibrium (small scale) tests are not primarily aimed to give the actual flash point of a test portion. The test is a flash no flash test to determine if the test portion's vapours flash at the test temperature. This is useful for checking conformance against specifications and flammability criteria. The test cup is heated to the test temperature, a small test portion is introduced into the cup, and when the test portion is deemed to be at the test temperature, the ignition source is used to test for a 'flash'. Actual flash point temperature is determined by repeating the flash no flash test at different temperatures with a new test portion. The constant temperature of the test cup ensures that the test portion cannot be overheated and that there is a reasonable time for vapours to build up before the ignition source is applied.

6.4 Flash point automation

For a manual flash point test the operator is in control throughout the test and ensures that the temperature, stirring and ignition requirements are met throughout the test and determines when and if a flash has occurred. Some semi-auto instruments may assist the operator in detecting a flash or controlling the temperature, but the operator is in control. This is why manual tests are the referee in cases of dispute.

Automated flash point testers conform to all the specified requirements of the manual test method such as dimensions, heating rate and flash detection, however the electronics, software and mechanics mimic the manual operations. This may significantly reduce operator time but this does have the disadvantage that more frequent validation of tester operation is required as the instrument operates mainly unattended and is more complex.

Automatic flash point testers are not based on a manual test and often only key dimensions and parameters are defined in a test method written just for this instrument type. A unique type of test may be advantageous to the user but the complexity of the tester makes it difficult for conformance to the test method to be measured. More frequent validation of the tester parameters and operation is required.

Some automated and automatic instruments are available with carousels that allow a number of tests to be carried out unattended. This is particularly advantageous where large numbers of samples are tested. However, accurate and reliable measurements may be compromised if the sample temperature does not meet the recommendations stated in the test method. This is especially relevant to samples that are volatile or contain volatile contaminants.

In general automated instruments are accepted in test methods provided that the instrument shows conformation to the method requirements, including precision.

6.5 Correlation between methods

It is well known that open cup tests usually give higher flash point results than closed cup tests for test temperatures above ambient. Some specifications list equivalent flash point methods and sometimes relative bias information for specific products. However flash point methods employ different apparatus, heating and stirring rates, procedures and sample handling which have an effect on relative biases, especially when the liquid is volatile, or volatile contaminants or components are present. It is therefore not possible and not correct to claim correlation or a fixed relative bias between different test methods for all test samples.

6.6 Precision

The precision of a flash point method is defined by repeatability (r) and reproducibility (R) at a 95 % confidence level such that only 1 test in 20 would be expected to exceed the quoted figure.

The definitions for precision shown below are typical of those used in Flash Point test methods and are based on the definitions given in EN ISO 4259 [1]

Repeatability

r

Difference between two test results obtained by the same operator with the same apparatus under constant operating conditions, on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the given value in only one case in 20

Reproducibility

R

Difference between two single and independent test results obtained by different operators in different laboratories on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the given value in only one case in 20

The precision of the test method is important for assessing the correct operation of flash point instruments and for control of quality in manufacturing and custody transfer of products.

When selecting a flash point test method or testing a new product it is important to check that the product type is covered by the scope of the test method and that the expected flash point temperature is covered by the precision statement.

6.7 Valid temperature ranges

Flash point instruments often have a wider temperature range than the temperatures covered by the precision of the test method. Temperatures outside those covered by the precision may result in different precision or give unpredictable results. The temperature ranges covered by the precision are shown in the test method; otherwise it may be necessary to consult the relevant standardisation body for advice.

Test method procedures include information on the required temperature of the test portion when the flash point test commences and usually defines a temperature band over which a result is valid. It is important to follow the specified procedure as failure to do so may result in an incorrect measurement.

7 Testing environment

The flash point instrument should be located on a flat and stable platform.

It is important to carry flash point tests in a draught free area as draughts may affect the evolution of flammable vapours as well as cooling or extinguishing the ignition source. If there are draughts then a draught screen is recommended.

It is good practice to carry out flash point tests under a fume hood; in these circumstances the airflow should be kept to a minimum.

Visual identification of a flash point may be enhanced by carrying out the test in subdued lighting.

8 Safety

The handling of samples for flash point determinations should be in accordance with local health and safety practices, as the sample could be flammable or toxic.

When handling samples close to a flash point instrument it should be remembered that the flash point apparatus uses a heated hotplate and an ignition source.

Due to the nature of the test the use of safety glasses and the provision of a suitable local fire extinguisher are strongly advised.

Provision should be made (such as a fume hood) to minimise the effects of any toxic or objectionable vapours.

Where the product type is not known it is safer to test using a procedure that uses a smaller volume test portion such as the rapid equilibrium test.

9 Calibration and verification

9.1 General

In general a calibration process leads to either an adjustment of the apparatus or the identification of a correction to be applied to a result.

In general a verification process checks that the apparatus and test procedure gives a result that is within the expected tolerances but no adjustment or corrections are made.

9.2 Calibration

The flash point instrument and its sensors are required to work in accordance with the tolerances stated in the standard method of test. If a sensor such as the thermometer is within the requirement for accuracy then

calibration to a higher level of accuracy is not required. If the sensor is outside the specification it shall either be replaced or calibrated.

Reference materials with a certified flash point are for verification purposes only; they shall not be used to establish an offset, bias or any other form of correction.

9.3 Verification

Verification that an instrument conforms to a standard method of test is implemented by checking that all the physical parameters are within allowable tolerances, by ensuring all key parts are clean and function correctly and by testing using a reference material.

Incorrect dimensions, faulty ignitors, and the use of incorrect heating media and incorrect heating rates or stirring speeds may affect test results.

Using instruments that are damaged, dirty or contaminated with volatile components may affect the test result.

The use of a certified reference material (CRM) that has a certified flash point for the test method being used is the prime verification procedure. This CRM is preferably a pure chemical, but it can be advantageous to use a stable material similar to the product normally tested. Once an instrument has been verified, it can then be used to produce a lower cost secondary working standard (SWS) from a stable material for more frequent use. The test method may include allowable tolerances to judge whether the instrument meets the requirement. If this information is not available the maximum variation from the certified figure is $0,7 \times R$ where R is the reproducibility of the test method for the type of certified fluid at the flash point temperature and the factor 0,7 is a statistically derived constant.

10 Test samples

10.1 Sample handling

All flash point methods give rules for the handling of samples and the preparation of test portions before testing. These rules are mainly intended to help avoid losing any volatile components that are present. Failure to follow these rules results in an incorrect and high flash point measurement that does not correctly define the flammability of the product being tested. Contaminated vessels, beakers or other glassware may also affect the result.

Free water in samples is a problem. If the test method does not give any guidance then this free water should be decanted off.

Samples that contain water as a component, such as water borne or water based paints, shall be tested without any pre-treatment with respect to the water content.

10.2 Samples containing volatile components

Flash point test results are affected by the presence of volatile contaminants. However the scale of the effect on the result will be different depending on the sample handling, test method and procedure, and the amount and type of volatile contaminant present.

The suitability of a test method to detect the presence of volatile contaminants may be described in the test method. In general the presence of volatile contaminants will result in a flash point at a lower temperature, however the use of an equilibrium test method is recommended if very low levels of contamination are present.

10.3 Viscous and semi-solid samples

Not all flash point test methods are suitable for viscous and semi-solid samples. It is therefore important to use a test method that includes such samples in its scope or procedure.

In this context a viscous sample would be one that is difficult to pour or to stir.

In general test methods allow the heating of viscous test samples, before the test, to make them less viscous, provided that the sample temperature is significantly below the expected flash point. Refer to the sample preparation and procedure sections of the test method for detailed requirements.

11 Instrumentation

11.1 Ignition sources

The flash point is dependent upon the position and size of the ignition source and the temperature of the ignition source until it is above about 1 300 °C.

The most proven and accepted ignition source is the gas flame, which burns at a sufficiently high temperature to give reliable results when using natural gases or coal gases. The gas flame does have the disadvantages that it needs to be lit, the size of the flame needs to be set and it can be blown out by draughts, and of course a gas supply is required. These disadvantages should be mainly overcome by using a gas or electric pilot light, an efficient draught screen and a rechargeable gas tank.

A widely used alternative is the hot wire ignitor which can be turned on and off automatically as required and will not be 'blown out' by a strong flash. This approach is not allowed in a number of test methods as difficulties have been encountered when testing products containing traces of volatile contaminants. At present all open cup tests mandate gas flame ignitors. Other disadvantages of hot wire ignitors are the possible change in ignitor temperature over a period of time, and the lifespan of the device.

NOTE Under certain circumstances the use of electric ignition sources may give different results to those obtained using a flame ignition source.

Another approach is the use of an electric spark as the ignition source. This has been successfully adopted in one test instrument and test method.

11.2 Flash detection

The referee and traditional way of observing a flash is by the human eye. However for automated and automatic instruments or for some products, where the flash is not visible, this is not possible. The following two flash detectors are most commonly utilised:

The ionising ring detector operates as organic compounds burn by collecting positive ions and turning them into an electrical current to detect a flash. This type of detector is mechanically robust and is mainly used with open cup instruments as it covers a relatively large area of the test portion's surface. Water vapour may be a problem with this type of detector and hence thermal detectors are becoming more popular for closed cup applications.

The thermal detector measures the increase in temperature caused by a flash. The detector is fragile, as it has to have a small mass to ensure response to the fast increase in temperature caused when the vapours ignite. This detector type is very reliable and is less affected by the presence of water vapours.

The use of a pressure sensor to detect the flash point has been successfully adopted in one closed cup test method.

11.3 Stirring

Stirring of the test portion during the test is specified in many test methods to keep the whole of the test portion at the same temperature and thus avoid incorrect flash points caused by vaporization at the hotter surface of the cup. It also assists the electronics or the operator in heating the test portion at the specified rate or to the required temperature.

Stirring shall be stopped before testing for a flash to allow the vapour space to stabilise.

11.4 Temperature measurement

Some test methods still mandate the use of prescribed mercury in glass thermometers, however most test methods now allow alternative temperature measuring devices provided that their performance is at least equal to the mercury thermometer. The use of mercury thermometers is being phased out in some countries due to safety concerns and alternative liquids are being proposed.

As alternative electronic temperature measuring devices are not specified in detail in test methods this may lead to measurement problems even though the accuracy meets the requirement. This is caused by the differing dynamic performance of the device or the immersion depth being incorrect.

Calibrated thermometers are often used in flash point instruments, but the requirement is that the thermometer conforms to the test method requirement. To reach this requirement, calibration may be required.

11.5 Care of the instrument

Manual instruments are very robust while automated and automatic instruments can be more fragile, but all require careful treatment and servicing to ensure correct operation.

Traces of a material from a previous test on the test cup lid or in the test cup may affect the next test result.

Spilt samples and other debris around the test cup may cause the incorrect opening and closing of lids and shutters as well as being a potential fire or health hazard.

11.6 Sub ambient testing

Samples containing volatile contaminants may have very low flash points. Besides cooling the sample to avoid the loss of these volatile contaminants it is necessary for the instrument to be capable of controlling the test portion at these low temperatures and in conformance with the test method procedure.

Uncontrolled warming of a test portion from a sub ambient temperature, during a test, gives an indication of flash point. However this is unreliable and not in conformance to the test method. In this instance the precision quoted in the test method will not apply.

Many instruments are now available that use an external cryostat or have integral electronic "Peltier" cooling to enable the correct controlled heating rates.

12 Flash point testing effects

The following are the most common effects noticed during flash point testing.

- A halo is seen around the ignition source – this is not a flash point but indicates that a flash point may be detected at the next dip.
- A 'popping' sound is heard – this is only a flash point if a flash is detected. If a flash is not detected then it indicates that a flash point will probably be detected at the next dip.
- The ignitor (flame) is blown out during dipping – this is only a flash point if a flash is detected. If a flash is not detected then it indicates that a flash point will probably be detected at the next dip.
- The sample burns instead of flashing when the ignitor is dipped – this indicates that the flash point is probably at a significantly lower temperature than the current test temperature.

- The measured flash point is much higher than expected – this could be due to the presence of excess volatile components that do not flash due to the lack of enough air (oxygen) in the test cup. A test at a much lower temperature could give a flash point.
- The measured flash point is much lower than expected – this could be due to the presence of volatile components in the test sample or to solvents used to clean the test cup assembly.
- Some halogenated compounds extinguish an ignition flame.
- Non flammable vapours such as water vapour extinguish an ignition flame or do not allow a correct flammable mixture evolve.

13 Test results

13.1 Barometric pressure correction

When the test portion is heated, molecules evaporate to form a vapour. This vapour exerts a pressure, which increases with temperature and depends upon the volatility of the components in the test portion.

If atmospheric pressure is low then the temperature at which the test portion has to be heated to produce a vapour pressure high enough to form a flammable mixture with air will be reduced.

If atmospheric pressure is high then the test portion will have to be at a higher temperature to produce a vapour pressure high enough to form a flammable mixture with air.

In order to neutralise the effects of atmospheric pressure the following standard equation is applied to all flash point results:

$$T_c = T_o + 0,25(101,3 - p) \quad (1)$$

where

T_c is the corrected flash point temperature in °C,
 T_o is the observed flash point temperature in °C, and
 p is the measured atmospheric pressure in kPa.

In the vast majority of instances the correction makes very little difference to the result, however locations at high altitude may cause corrections as large as 4 °C, while severe weather or locations at below normal sea level may also cause significant differences.

13.2 Expression and reporting of results

All flash point methods include instructions on how the test result should be reported. It is important to follow these instructions, given in the test method, regarding rounding of decimals following measurement or barometric corrections. Incorrect use of the rules leads to an incorrect assessment of a test sample's suitability in meeting regulations or specifications.

The requirements to report further details of the test sample, test parameters and any non conformances to the test method are included to enable the history of the test to be documented for traceability or if there should be a dispute or a repeat test requested. The reporting of any unusual occurrences during the test provides further useful information.

Annex A (informative)

Major test methods used in specifications and regulations

Table A.1 gives an overview of the general use of flash point test methods. Due to the large number of specifications and regulations which call up these test methods it is not possible to list the suitability of each method for different product groups. This information is found in the scope of each of the flash point test methods.

Table A.1 — Overview of test methods¹⁾

| Test method | Test type | Closed cup | Open cup |
|--|---|--|-------------------------------------|
| Abel | Flash point | EN ISO 13736 [2] | |
| Abel-Pensky | Flash point | DIN 51755 [3] | |
| Cleveland | Flash and fire point Flash and fire point | | EN ISO 2592 [4] ASTM D92 [5] |
| Pensky-Martens | Flash point Flash point | EN ISO 2719 [6] ASTM D93 [7] | |
| Equilibrium | Flash point Flash point Flash point Flash point | EN ISO 1516 [8] EN ISO 1523 [9] ASTM D3934 [10] ASTM D3941 [11] | |
| Rapid Equilibrium (Small scale) | Flash point Flash point Flash point Flash point Sustained combustion Sustained burning | EN ISO 3679 [12] EN ISO 3680 [13] ASTM D3278 [14] ASTM D3828 [15] | EN ISO 9038 [16] ASTM D4206 [17] |
| Tag | Flash point Flash and fire point | ASTM D56 [18] | ASTM D1310 [19] |
| <p>NOTE The following prefixes are used for standards from the following organizations:</p> <p>EN European Committee for Standardization (CEN)</p> <p>ISO International Standardization Organization (ISO)</p> <p>D ASTM International</p> <p>DIN Deutsches Institut für Normung</p> | | | |

1) The list is not intended to infer equivalence between any of the test methods.

Acknowledgements

CEN/TC 19 acknowledges the following people and organizations for their contribution to this guide:

- a) M.J. Sherratt, Stanhope-Seta and Chairman of the EI Standardization Committee (ST), as author of this guide,
- b) D. Lewis, consultant, for the historical data and background,
- c) the CEN/TC 19 /TC 139 Joint Working Group on Flash Point, for guidance and assistance,
- d) ISO/TC 28 "Petroleum products" and ISO/TC 35 "Paints and varnishes", for the basic standards, and
- e) the Energy Institute (EI) Flammability Panel ST B 4, for guidance and assistance.

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- [13] EN ISO 3680, *Determination of flash / no flash – Rapid equilibrium closed cup method (ISO 3680:2004)*
- [14] ASTM D 3278, *Standard Test Methods for Flash Point of Liquids by Small Scale Closed-Cup Apparatus*
- [15] ASTM D 3828, *Standard Test Methods for Flash Point by Small Scale Closed Cup Tester*
- [16] EN ISO 9038, *Test for sustained combustibility of liquids (ISO 9038:2002)*
- [17] ASTM D 4206, *Standard Test Method for Sustained Burning of Liquid Mixtures Using the Small Scale Open-Cup Apparatus*
- [18] ASTM D 56, *Standard Test Method for Flash Point by Tag Closed Cup Tester*
- [19] ASTM D 1310, *Standard Test Method for Flash Point and Fire Point of Liquids by Tag Open-Cup Apparatus*

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