Department of Mechanical Engineering

Indian Institute of Technology New Delhi

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MCL 241 Energy systems and Technologies

TESTING OF FUELS : FLASH AND FIRE POINT

1. Introduction

The flash and fire points of a liquid fuel specimen are the indicators of its flammability. In general, **flash point** is the lowest temperature of the test specimen, corrected to a barometric pressure of 101.3 kPa, at which the application of an ignition source causes the vapor of the test specimen to ignite momentarily and the flame to propagate across the surface of the liquid under the specified conditions of test. It is important to realize that the value of the flash point is not a physical constant but is the result of a flash point test and is **dependent** on the apparatus and procedure used. **Fire point** may be considered as the lowest temperature of the liquid at which vapor combustion and burning commences. A fire point happens when an ignition source is applied and the heat produced is self-sustaining, as it supplies enough vapors to combine with air and burn even after the removal of the ignition source.

2. Flash and fire point in engine perspective

Gasoline has a flash point around -43^0 C whereas diesel has flash points higher than 52^0 C. Lower flash points are the indicators of good flammability and volatility. Therefore, gasoline makes faster vapour formation than diesel and instantly catches fire when spark, an external flame source, is provided. However, as its autoignition temperature is high (in low compression ratio gasoline engine perspective), which is in the order of 247-280^0 C, it does not ignite prematurely due to the residual heat generated during compression stroke and heat transfer from wall. On the contrary, the higher flash point of diesel indicates poor vaporization tendencies and lesser tendency to ignite subjected to external flame source. However, as the autoignition temperature of diesel is low (in high compression ratio diesel engine perspective), which is in the order of 210^0 C, diesel autoignites easily with the residual heating during compression stroke and heat transfer from wall without the need of an external flame source such as spark plug. Poor vaporization tendency of diesel is dealt with in-cylinder swirl and high pressure injection.

Vegetable oils have significantly high flash points which are in the order of diesel fuels and higher. Hence their vaporization and mixing are a huge challenge for direct engine

applications. Therefore, vegetable oils are transesterified to produce fatty acid methyl esters or biodiesel which has comparable flash point for direct compression ignited diesel engine application. In the alcohol category, methanol has a flash point of around 12^0 C and autoignition temperature of 470^0 C. Similarly, ethanol has 16^0 C flash point and autoignition temperature around 365^0 C indicating their close proximity to gasoline fuel and potential alternative fuel application in spark ignited engines.

3. Penskey Martens Flash Point Apparatus Laboratory test

3.1 Objective: To determine the flash and fire point of a given sample using Pensky-Martens flash point apparatus and determination of experimental repeatability.

3.2 Apparatus and consumables required:

a) A Pensky-Martens flash point apparatus.
b) Thermometer of suitable range.
c) Test samples.

3.3 Methodology and procedure

3.3.1 Preparation of samples

a) Samples should be in reasonably fluid state before testing. For asphalts and other viscous materials, preheating should be done to ensure fluidity before testing.
b) Samples may be warmed with constant heating rate. However, under no circumstances, should be heated above a temperature that lies 16^0 C below the expected flash point.
c) Samples containing dissolved water may be dehydrated with calcium chloride or by filtering through a suitable filter paper. If the same is not done, its consequence on experimental results and repeatability should be duly inferred.

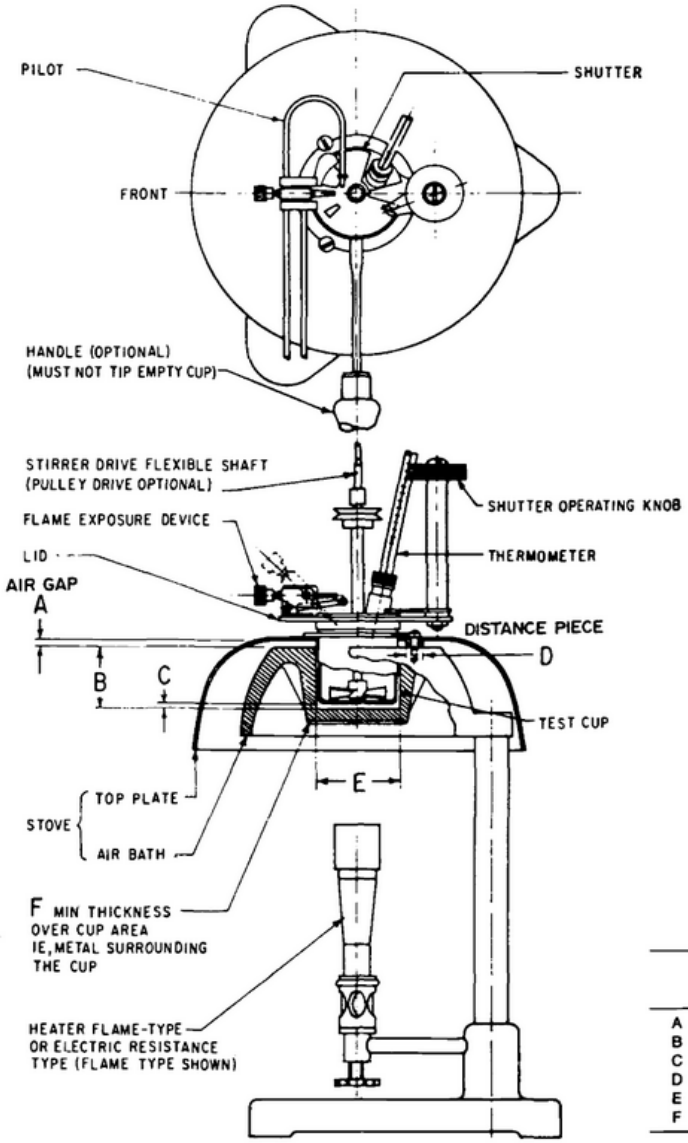
3.3.2 Generalized procedure

a) Clean and dry all parts of the cup thoroughly.
b) Fill the cup with the sample to be tested to the level indicated by the filling mark.
c) Place the lid on the cup and set the latter on the stove.
d) Insert the thermometer and supply heat with the help of the rheostat switch to ensure temperature rise rate not more than 5 to 6^0 C per minute.
e) Turn the stirrer with 90 to 120 rpm in a downward direction.
f) Provide the test flame time to time and start nearly 17^0 C below the expected flash point of the sample with 0.5 to 1^0 C gap.
g) Lower the test flame to the vapour space of the cup for 5s and allow it to be there for 1s. After that move the test flame up as quickly as possible and shut down the lid for vapour build up.
h) Do not stir the sample while providing the test flame.

i) Denote the flash point and fire point accordingly.
j) For **suspension of solids**, follow the procedure as mentioned below.
    - ✓ Bring the materials to be tested to a temperature of 15 ± 5^0 C or 11^0 C lower than estimated flash point.
    - ✓ Completely fill the space between the cup and the interior of the air_bath with water at the temperature of the tester and the sample.
    - ✓ Turn the stirrer at 250±10 rpm in a downward direction.
    - ✓ Raise the temperature throughout the duration of the test at a rate not less than 1^0 C or more than 1.5^0 C per minute.
    - ✓ The rest of the procedures same as the generalized one.

3.4 Results and brainstorming

a) Compare the average of the observations with the known value of the sample.
b) Determine the repeatability of the results of the same sample and compare it to the standard which is 2^0 C for below 105^0 C and 6^0 C for above 105^0 C samples.
c) If the repeatability is not compliant to the standard, provide the reasoning.



	mm		(in.)	
	min	max	(min)	(max)
A	4.37	5.16	(0.172)	(0.203)
B	41.94	42.06	(1.651)	(1.656)
C	1.58	3.18	(0.062)	(0.125)
D	. . .	9.52	(. . .)	(0.375)
E	57.23	57.86	(2.253)	(2.278)
F	6.35	. . .	(0.25)	(. . .)

NOTE—Lid assembly may be positioned either right or left-handed.

Figure 1: Standard sketch for Pensky-Martens flash point apparatus

4. Abel Flash point Apparatus Laboratory test

4.1 Objective: To determine the flash point of a given sample using Abel's flash point apparatus and determination of experimental repeatability.

4.2 Apparatus and consumables required:

a) An Abel flash point apparatus.

b) Suitable thermometer.
c) Test samples.

4.3 Methodology and procedure

Two methods namely, Method A for liquids flashing between -18 to 18.5^0 C and Method B for liquids in19 to 70^0 C are prescribed in the standard. The generalised procedures are accordingly narrated below.

5.3.1 Method A with procedures (-18 to 18.5^0 C)

a) Fill the water bath completely and the air chamber which surrounds the oil cup to a depth of at least 38mm with 50:50 mixture of corrosion inhibiting ethylene glycol and water mixture.
b) Cool the bath to -27^0 C or at least 9^0 C below the expected flash point of the material being tested whichever is higher. Do continuous stirring while cooling the samples.
c) Note**:**
    - ✓ Use an alcohol thermometer to avoid mercury freezing at low temperatures.
    - ✓ Liquid which crystallizes on cooling should not be cooled below crystallization points.
d) Place the cup in bath and replace the thermometer by the oil cup thermometer.
e) Pour the sample till the level reaches the point of the index gauge without agitation avoiding air bubble formation to the extent feasible.
f) Do not move the apparatus after filling and heating rate should be less than 1^0 C per minute.
g) Provide the test flame time to time after 9^0 C less from the expected flash point temperature is met. Apply test flames with every 0.5^0 C after that till flash is realized.

5.3.2 Method B with procedures (19 to 70^0 C)

a) The thermometers need not be taken care of as mercury freezing is no longer an issue.
b) Instead of ethylene glycol water mixture, plane water can be used in the bath.
c) Rest of the procedures are same as method A.

5.4 Results and brainstorming

a) Compare the average of the observations with the known value of the sample.
b) Determine the repeatability of the results of the same sample and compare it to the standard which is 1^0 C.
c) If the repeatability is not compliant to the standard, provide the reasoning.

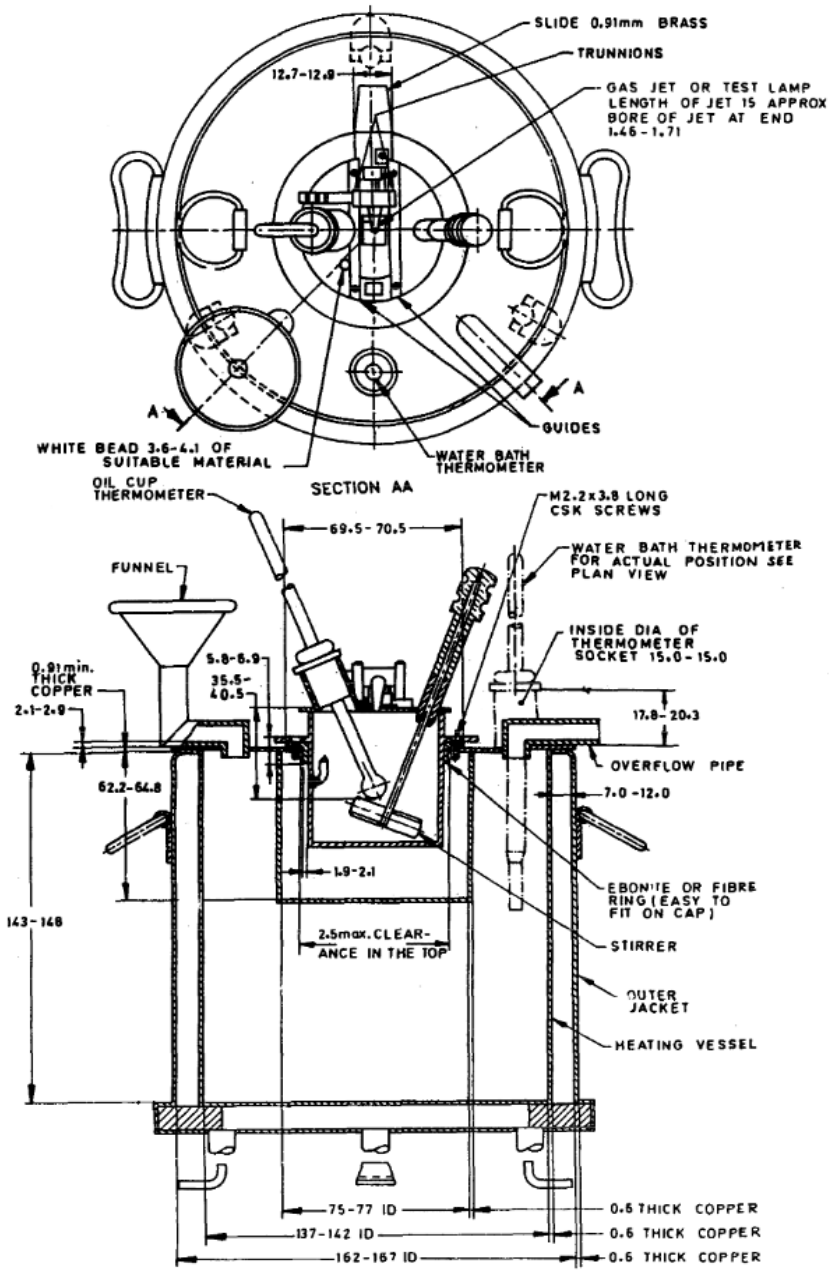


Figure 2: Standard sketch for Abel flash point apparatus (All dimensions in mm)