



Faculty of Engineering and Technology

Civil Engineering Department

Construction Materials Laboratory

ENCE215

Experiment # 8

“Flash point, Fire point and Penetration of Bitumen ”

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Date of performing the experiment: 19-11-2019

Date of submitting the experiment: 28-11-2019

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## - Introduction

### **Background information**

Bitumen is a petroleum substance that possesses great binding and water proofing characteristics that explain its widespread use in roadway and pavement constructions. Same as other petroleum products, bitumen has significant flammability properties, and this is considered a downside of using bituminous materials in the roadway construction as it needs to be heated to sufficiently high temperatures during its manufacturing process and also in site where it is mixed with the aggregates.

To make sure no safety hazards are present during the field work and the manufacturing process, critical temperature limits of the used bitumen should be previously determined. This leads to the determination of the flash point and the fire point of bitumen in order to achieve the awareness of the allowable highest temperature at which the bitumen could be safely heated.

The flash point is defined as the lowest temperature required for the evaporated volatiles from bitumen to instantly catch on fire from the test flame in the form of flashing under standardized conditions of test. On the other hand, the fire point is defined as the lowest temperature at which the bitumen -itself- burns and ignites ( for straight five seconds ) by the affection of the test flame, under specified test conditions. The flash point is considered particularly beneficial as it tells the critical temperature at and above which suitable precautions are required to be taken to eliminate the danger fire during heating. This temperature, however, is well below that at which the bitumen will burn.

Another test made with bituminous materials is the penetration test. Bituminous materials offer wide variations in terms of their properties such as viscosity,

flowability, stability, ductility... etc. Thus, many methods were developed to grade bituminous materials properly. One of which is the penetration, this could be defined as the depth of penetration of the penetrometer's needle in a sample measured in a tenth of a millimeter. This test is used to grade the viscosity of bitumen indirectly based on its consistency. The higher the penetration is, the softer the consistency is. Since the viscosity is very responsive to temperature, it is preferable to use low penetration bitumen in hot areas and vice versa. It is conventional to record the penetration as range of two values separated by the division sign ( / ), for example if a bitumen has a recorded penetration of 30/40 this means that the penetration ranges from 30 to 40.

### **Purpose**

The main aims of the experiment are to determine the temperatures at which the flash and fire point of a bitumen sample occur.

Also, to measure the penetration values of different samples of bitumen using the penetrometer.

### **- Hypotheses**

The minimum value specified by ASTM is 175 C° for the flash point, hence, it is more likely that the results are higher than this value.

For the penetration the specified range is 20 to 225 for various types of bituminous materials, which means that the highest probability is that the obtained penetration values fall within this range.

### **- Procedure**

a) Flash and fire point:

- 1- A sample of bitumen was prepared.
- 2- The bitumen sample was poured in a cup.
- 3- The cup was put on a heater plate, and the heater was turned on.
- 4- A thermometer was put inside the sample.
- 5- The flame source was connected to the gas supply and the flame was lightened using a laighter.
- 6- The flame was repeatedly placed right above the bitumen cup from time to time in search for flash appearance.
- 7- The bitumen was stirred from time to time using a stirring rod.
- 8- At the instant the bituminous vapor started flashing, the temperature was recorded as the flash point.
- 9- The mix continued to heat up until the mix itself started to burn, then the temperature was recorded as the fire point.

b) Penetration test:

- 1) Three bituminous samples were prepared and placed in cups.
- 2) The three samples were placed inside a water bath to maintain a standard temperature of 25 C°.
- 3) The first sample was taken out of water with preserving a layer of water above the bitumen to maintain the temperature and was placed beneath the penetrometer.
- 4) The pointer of the penetrometer was adjusted at zero, and the arm of the device was unlocked.
- 5) The needle was adjusted so as to merely touch the surface of bitumen, this could be done by swinging the needle left and right accompanied with a

very slow downward movement, at the moment the cup barely moves, the arm is locked again.

- 6) The needle is allowed to fall under its own weight and penetrate the sample for five seconds, by pressing the button on the device.
- 7) The penetration was recorded.
- 8) The sample was put again inside water to regain its standard temperature.
- 9) The pointer was adjusted again to read zero, and the needle was raised up to its original elevation.
- 10) The penetration of the second and third sample were obtained following the same procedure of the first sample.
- 11) Each sample was tested for three trials with paying attention to change the orientation of the sample allowing a new region to be penetrated.

## - Instruments

Apparatus and Tools:

The Penetrometer:

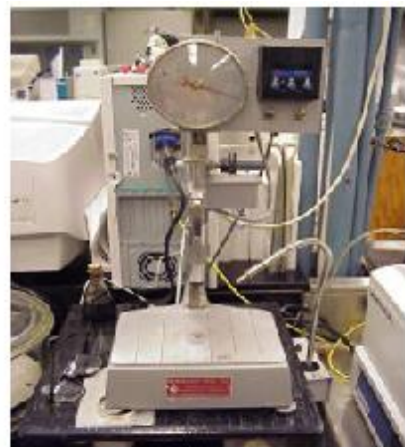
- Consists of a 1mm diameter, 50mm long needle with a pointed end.
- A calibrated dial which reads values of one tenth of a millimeter.
- A shank of 3mm diameter.
- The weight of the needle assembly is 100gm.
- A water bath with 25 C°.
- Builtin timer within the device set for 5 seconds.

The flash-fire point setting:

- Heater
- Flame
- Thermometer
- Stirring rod
- Gas supply
- Matches or lighter



fig(1): fire and flash point settings



fig(2): penetrometer

**- Data & Calculations:**

Table(1): penetration test data				
Sample	Penetration (0.1 mm)			Average Penetration (0.1 mm)
	Trial (1)	Trial (2)	Trial (3)	
1	31	35	52	39
2	40	45	39	41
3	31	53	41	42

Flash point: 320 C°

Flash point: 360 C°

**- Results & Conclusion**

Penetration of Sample(1) = 39

Penetration of Sample(2) = 41

Penetration of Sample(3) = 42

Flash point = 320 C°

Flash point = 360 C°

The flash and fire points are acceptable since they are above the specified minimum value of 175 C°. The results mean that this certain bitumen could be safely heated to 320 C° without any potential hazard, and if it was heated beyond this temperature it will start burning at 360 C°.

The three fall within the specified penetration range ( 20 to 225 ), and thus all are acceptable. Referring to the specification table (table 2) in the references section all



of the three values are suitable for hot temperature with mean annual air temperature >24° C.

However, readings deviated noticeably within each sample, this could result from errors such as:

- Temperature differences.
- A gap between the needle and bitumen ( or deeper than surface ).
- Maladjustment of the penetrometer.
- Incorrect reading of the penetrometer's dial.

- **References**

1. Department of roadway constructions (1997) pavement testing and design: Inspector’s Training Manual. Washington State, Department of Asphalt. Environmental and Engineering Program, Construction office.
2. The constructor (website):  
[https://theconstructor.org/building/pavementdesignpenetrationtest/1358/?fbclid=IwAR0Bm89wilGozpszFhxqQuPuWJ0GCbILwYJPGHOcE\\_mmZ8ZqxZEWibOIP8](https://theconstructor.org/building/pavementdesignpenetrationtest/1358/?fbclid=IwAR0Bm89wilGozpszFhxqQuPuWJ0GCbILwYJPGHOcE_mmZ8ZqxZEWibOIP8).

Table(2): Asphalt's environmental suitability based on penetration grade	
Temperature conditions	Asphalt grade
Cold, mean annual air temperature < 7° C	80/100 penetration
warm, mean annual air temperature 7 to 24° C	60/70 penetration
Hot, mean annual air temperature < 24° C	40/50 penetration

