CHAPTER III

EXPERIMENTAL

3.1 Materials

In this study, three types of lubricating base oils were from TPI, BP and Castrol, corresponding to product name of lubricating base oil 150 SN (Light), 500 SN (Medium) and 150 BS (Heavy). These lubricating base oils were obtained from both domestic sources and incoming sources. The following data are approximate or typical values of lubricating base oils that were manufactured locally[15]. The basic properties of these three types are shown in Table 3.1.

Table 3.1 : The basic properties of 150 SN, 500 SN and 150 BS

Properties	150 SN	500 SN	150 BS
Distillation range	321-540°C	355-570°C	225-690°C
Molecular weight	350	500	690
Specific gravity	0.8706	0.8850-0.8870	0.9000-0.9010
Pour point	-9°C	-9°C	-9°C
Viscosity @ 40°C	30.0 cSt	96.0 cSt	-
Viscosity @ 100°C	-	-	31.50 cSt
Color	Slightly yellow	Yellow	Yellow to brown
pH	Essentially neutral	Essentially neutral	Essentially neutral
Odour	Neutral odour	Neutral odour	Neutral odour
Physical state	Liquid	Liquid	Liquid
Vapor density (Air =1)	Greater than 5	Greater than 5	Greater than 5
Vapor pressure	Less than 0.1 min Hg @ 20°C		

3.2 Blending and sample preparation

Three types of lubricating base oils were used, corresponding to 150 SN, 500 SN and 150 BS. The blends of these lubricating base oils were performed according to the formulation shown in Table 3.2 using a magnetic stirrer for circulating the oils until homogeneous. From these formulas, the two-component (1-9) and three-component (10-16) blends were prepared by weight. This was carried out by the use of density to calculate the formula D = M/V, to convert weighted quantities in Table 3.2 to volume and then to prepare the sample.

Table 3.2 : Formulation of lubricating base oil blends.

Blend number	Composition (by weight)		
	150 SN	500 SN	150 BS
1	75	25	0
2	50	50	0
3	25	75	0
4	75	0	25
5	50	0	50
6	25	0	75
7	0	75	25
8	0	50	50
9	0	25	75
10	25	50	25
11	50	25	25
12	25	25	50
13	37.5	37.5	25
14	37.5	25	37.5
15	25	37.5	37.5
16	33.3	33.3	33.3

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3.3 Physical characteristics of sample

Lubricant performance is determined by the lubricating base oils and the additives that are used in the formulation. When selecting the appropriate lubricating base oil to use in a formulation, there is a range of properties that can be measured and used to predict performance. Many of these properties are also used as quality control checks in the manufacturing process to ensure uniformity of product quality. Although many of these properties are modified or enhanced by the use of additives, knowledge of the lubricating base oil characteristics, especially any limitations, is vital to effective formulation of any lubricants. There are multitudes of physical tests, which yield useful information on the characteristics of lubricating base oils.

3.3.1 Kinematic viscosity[3,16]

The kinematic viscosity of the lubricating base oils and their blends both obtained by weight and volume methods were determined according to ASTM D-445 within the temperature at 25°C, 40°C and 100°C. The viscometer used was a Cannon-Fenske type for transparent liquids, immersed in a thermostatic oil bath controlled to 0.01C for measurement at 40°C and 100°C, and controlled to 0.05C for testing temperature 25°C. This test method specifies a procedure for the determination of the kinematic viscosity, ν, of liquid petroleum products, both transparent and opaque, by measuring the time for a fixed volume of liquid to flow under gravity through an orifice of calibrated glass capillary viscometer under a reproducible driving head and at a closely controlled and known temperature. The kinematic viscosity is the product of the measured flow time and the calibration constant of the viscometer. To calculate the kinematic viscosity, ν, from the measured flow time, t, and the viscometer constant, C, are used by means of the following equation:

$$\nu = C \times t$$

where :

ν = kinematic viscosity (cSt)

C = calibration constant of the viscometer (cSt/s)

t = mean flow time (s)

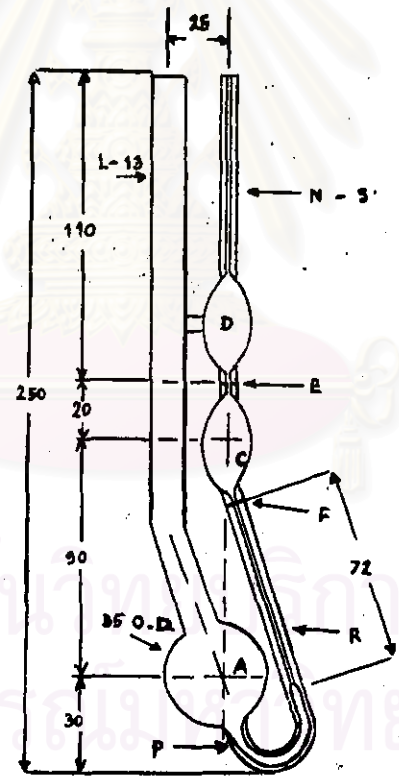

Figure 3.1 : Cannon-Fenske viscometer tube

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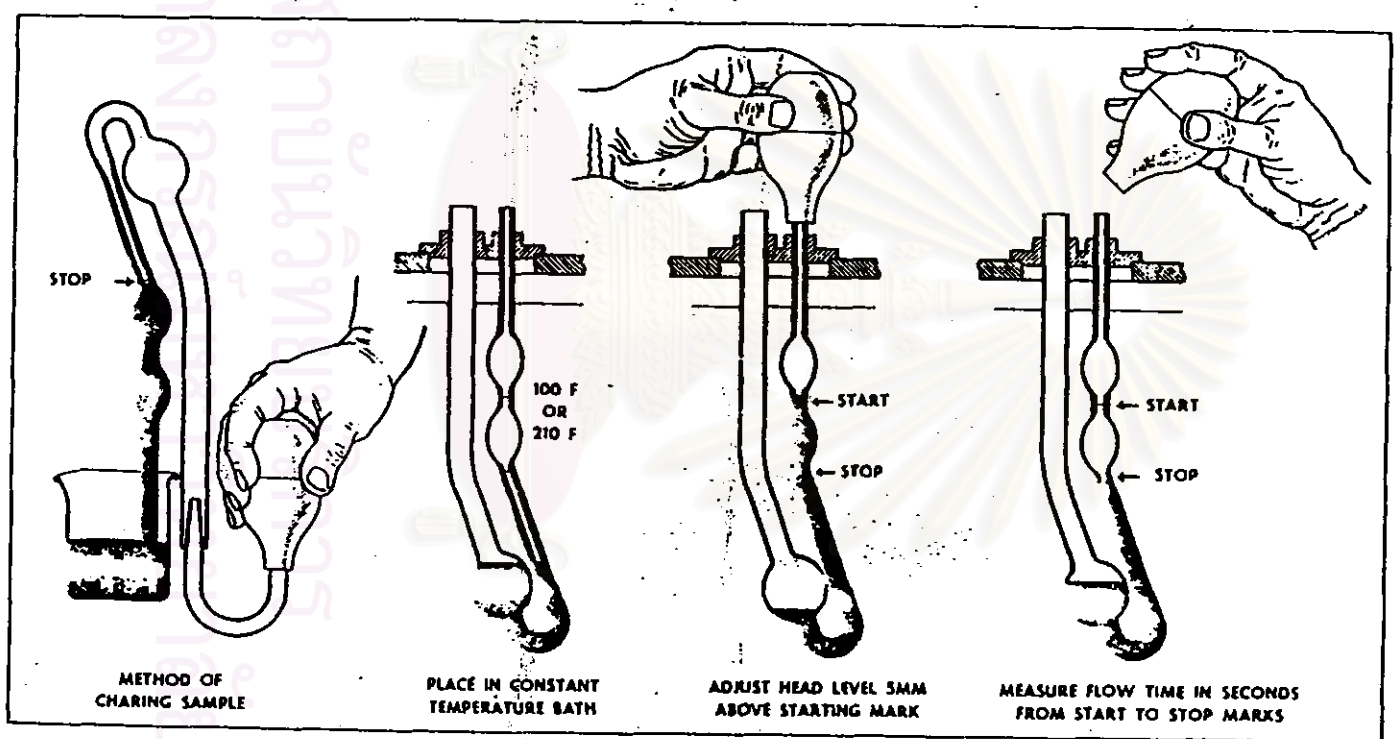

Figure 3.2 : The kinematic viscosity testing

3.3.2 Viscosity index[5,7,17]

The viscosity index (VI) is an empirical number, which defines the behavior of viscosity relative to change of temperatures. The viscosity of high viscosity index oils does not change as much as those of a low viscosity index oils for the same temperature variations.

The viscosity index of an oil is calculated from viscosities determined at two temperatures by means of tables published by ASTM. Tables based on viscosities determined at both 40°C and 100°C are available.

Full definitions of the methods of calculation are given in ASTM D-2270 or IP-226 manuals and a summary is shown in Figure 3.3. In this figure, *L* is the viscosity at 40°C of an oil of 0 VI, which has the same viscosity at 100°C as the sample under test; *H* is the viscosity at 40°C of an oil of 100 VI which has the same viscosity at 100°C as the sample under test; and *U* is the viscosity at 40°C of the oil sample. *L* and *H* are obtained from standard tables. A modified procedure applies to oils of VI above 100 or to oils of high viscosity.

The viscosity index scale is a useful tool in comparing lubricating base oil, but it is vital to recognize that it is arbitrarily based and has limitations. It is also used as a convenient measure of the degree of aromatics removal during the lubricating base oil manufacturing process, but comparison of viscosity index of different oil samples is only realistic if they are derived from the same distillate feedstock. Great care should be exercised in applying a measurement of viscosity index as an indication of lubricating base oil quality.

In calculating the viscosity index, VI of the oil is as follows:

$$VI = (L-U) / (L-H) \times 100$$

where :

L = kinematic viscosity, in cSt, at 40°C of an oil of 0 viscosity index having the same kinematic viscosity at 100°C as the oil whose viscosity index is to be calculated.

H = kinematic viscosity, in cSt, at 40°C of an oil of 100 viscosity index having the same kinematic viscosity at 100°C as the oil whose viscosity index is to be calculated.

U = kinematic viscosity, in cSt, at 40°C of the oil whose viscosity index is to be calculated.

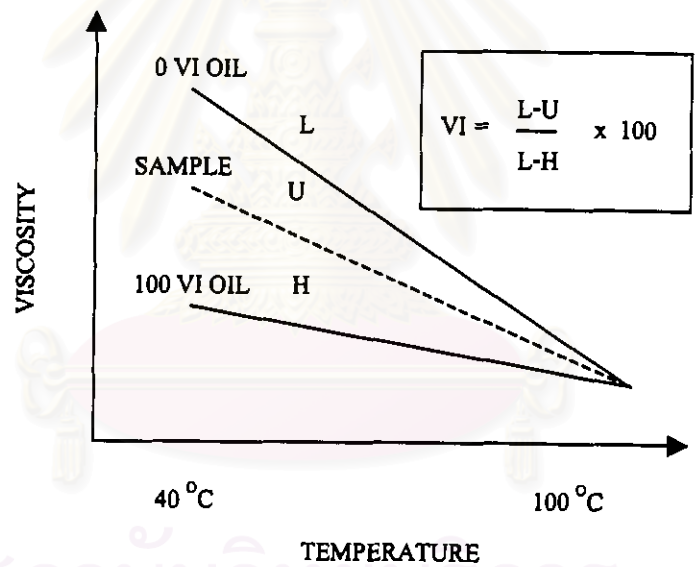

Figure 3.3 : Definition of viscosity index

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3.3.3 Density[6-7,18-19]

The density of a substance is the mass of unit volume at a specified temperature. The accepted units of measure are grams per milliliter or kilograms per cubic meter. Density can be determined by means of hydrometers shown in Figure 3.4 or digital density meter. It was measured according to ASTM D-1298, D-4052. This test method covers the determination of the density or relative density of petroleum distillates and viscous oils.

Density is a fundamental physical property that can be used in conjunction with other properties to characterize both the light and heavy fractions of petroleum products. It is also useful for identifying oils, provided that the distillation range or viscosity of the oils is known. Density is temperature related, and decreases with its increase. Its primary use is to convert weighed quantities to volume and measured volumes to weight. It is important because oils may be formulated by weight, but measured by volume.

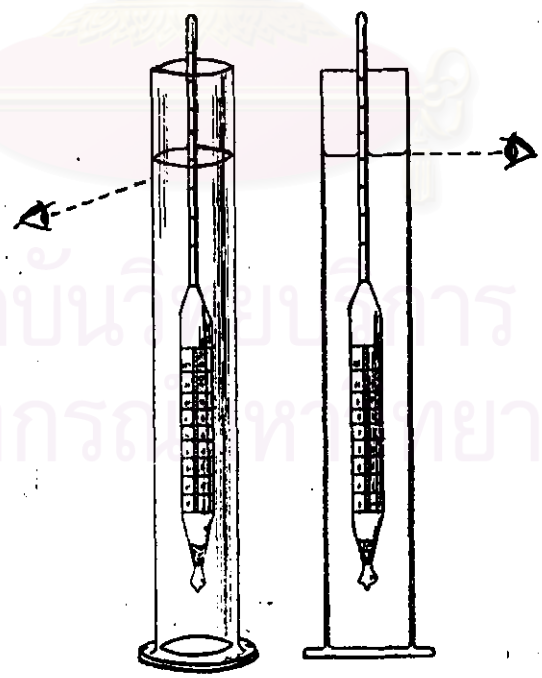

Figure 3.4 : Use of hydrometer to determine density and gravity

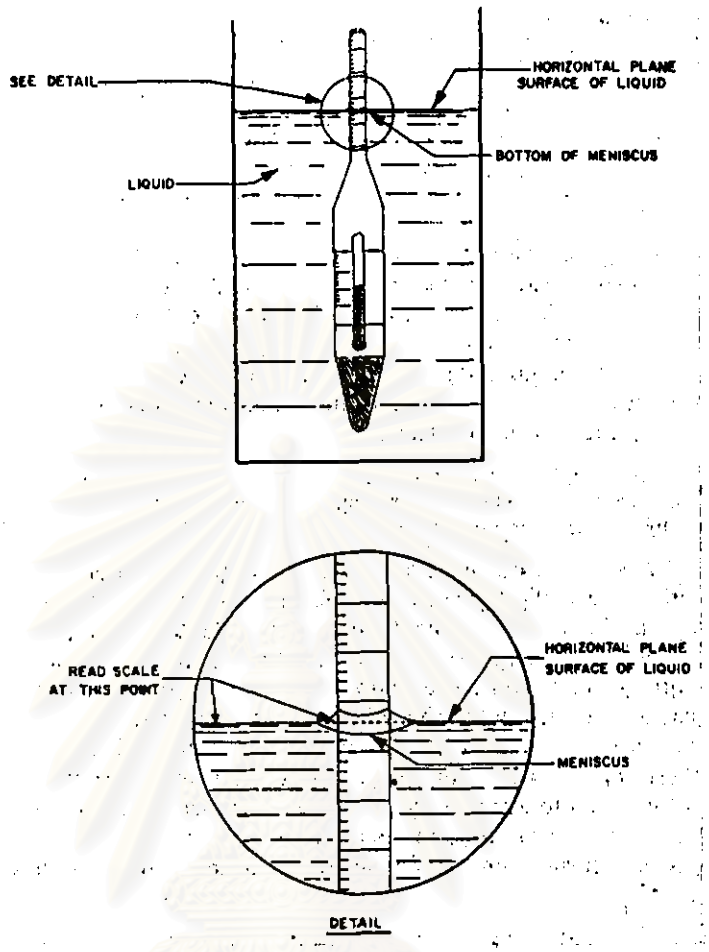

Figure 3.5 : Hydrometer scale reading for transparent liquid

3.3.4 Flash point[5-6,20-21]

The flash point of a petroleum liquid is basically measurement of its flammability. It was measured according to ASTM D-92, D-93. This test method covers determination of the flash and fire points of all petroleum products except fuel oils. Flash point is the lowest temperature corrected to a barometric pressure of 101.3 kPa (760 mm Hg), at which application of a test flame causes the vapor of a specimen to ignite under specified conditions of test. The material is deemed to have flashed when a large flame appears and instantaneously propagates itself over the surface of the specimen.

The flash point of an oil is important from a safety point of view because it is the lowest temperature at which auto-ignition of the vapor occurs above the heated oil sample. Different methods are in use and it is essential to know which type of equipment has been used when comparing results (ASTM D-92, D-93). If lubricating base oil is heated in an open container, ignitable vapors are released in increasing quantities as the temperature rises. When the concentration of vapors at the surface becomes great enough, exposure to an open flame will result in a brief flash as the vapors ignite. When a test of this type is conducted under certain specified conditions, as in the Cleveland Open Cup method (Figure 3.6), the bulk oil temperature at which this happens is reported as the flash point. The release of vapors at this temperature is not sufficiently rapid to sustain combustion, so the flame immediately dies out.

The flash point of new oils varies with viscosity, higher viscosity oils have higher flash points. Flash points are also affected by the type of crude, with naphthenic oils generally having lower flash points than paraffinic oils of similar viscosity.

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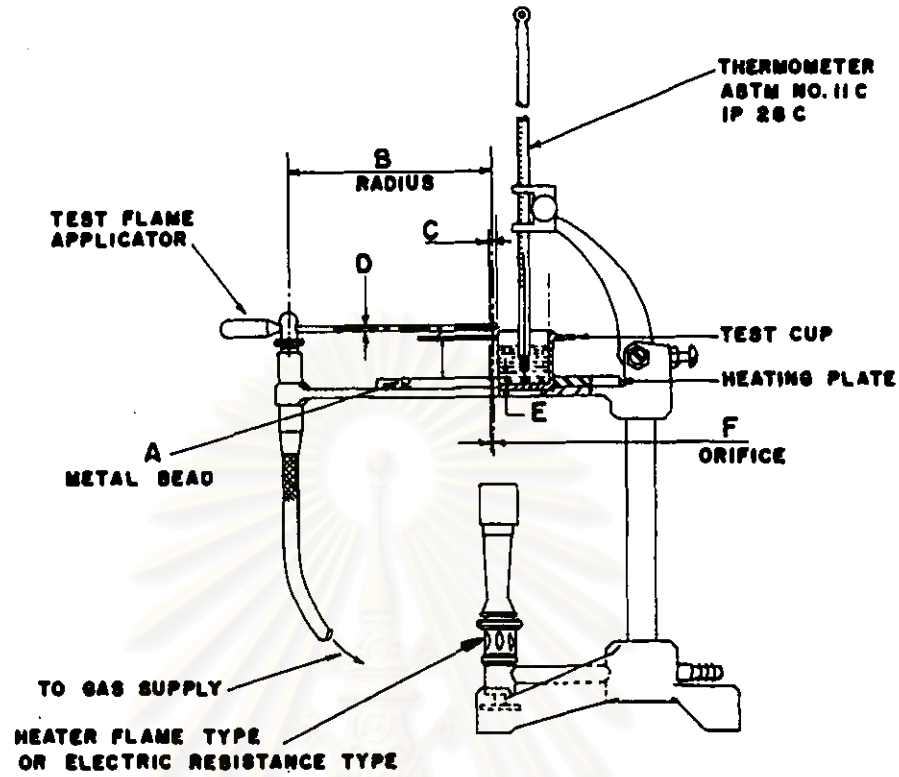

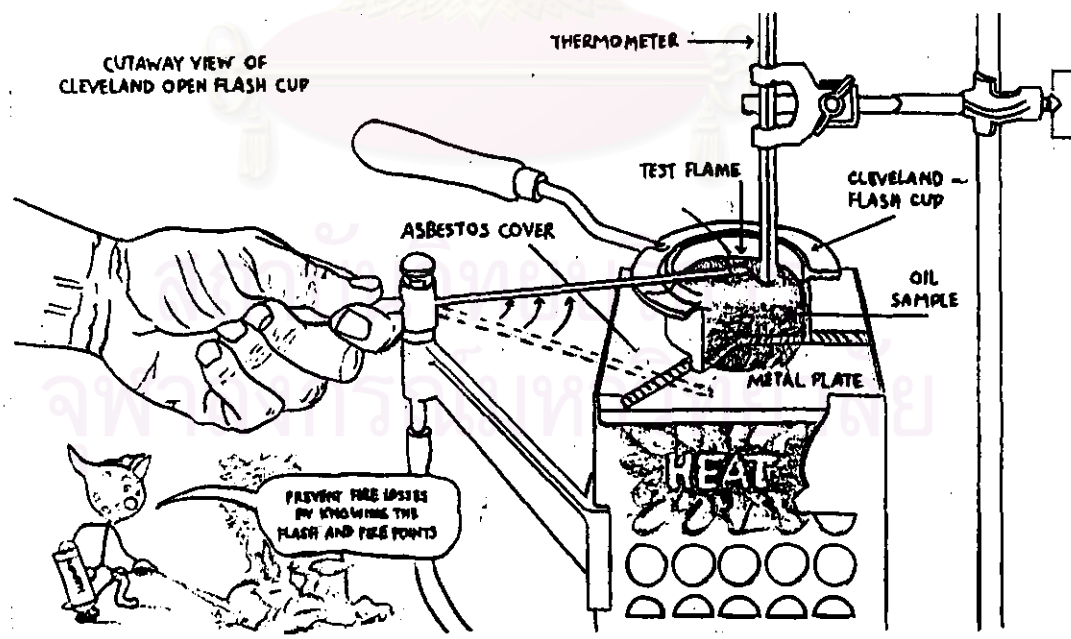

Figure 3.6 : Cleveland Open Cup flash tester

3.3.5 Pour point[5-7,22]

The pour point of an oil is the lowest temperature at which it can be poured without disturbance from a container under prescribed conditions or it can be made to flow by gravity alone. The pour point was measured according to ASTM D-97, this test method is intended for use on any petroleum product. The pour point of a petroleum specimen is an index of the lowest temperature of its utility for certain applications.

The oil is warmed and then cooled at a specified rate and the test jar is removed from the cooling bath and examined at interval of 3°C to see if the sample is still mobile. This procedure is continued until movement does not occur. The pour point is the last temperature before movement ceases, not the temperature at which solidification occurs.

Most oils contain some dissolved wax and, as an oil is chilled, this wax begins to separate as crystals that interlock to form a rigid structure which traps the oil in small pockets in the structure. When this wax crystal structure becomes sufficiently complete, the oil will no longer flow under the conditions of the test. Oils of high viscosity may cease to flow because their viscosity becomes too high at low temperature rather than because of wax formation.

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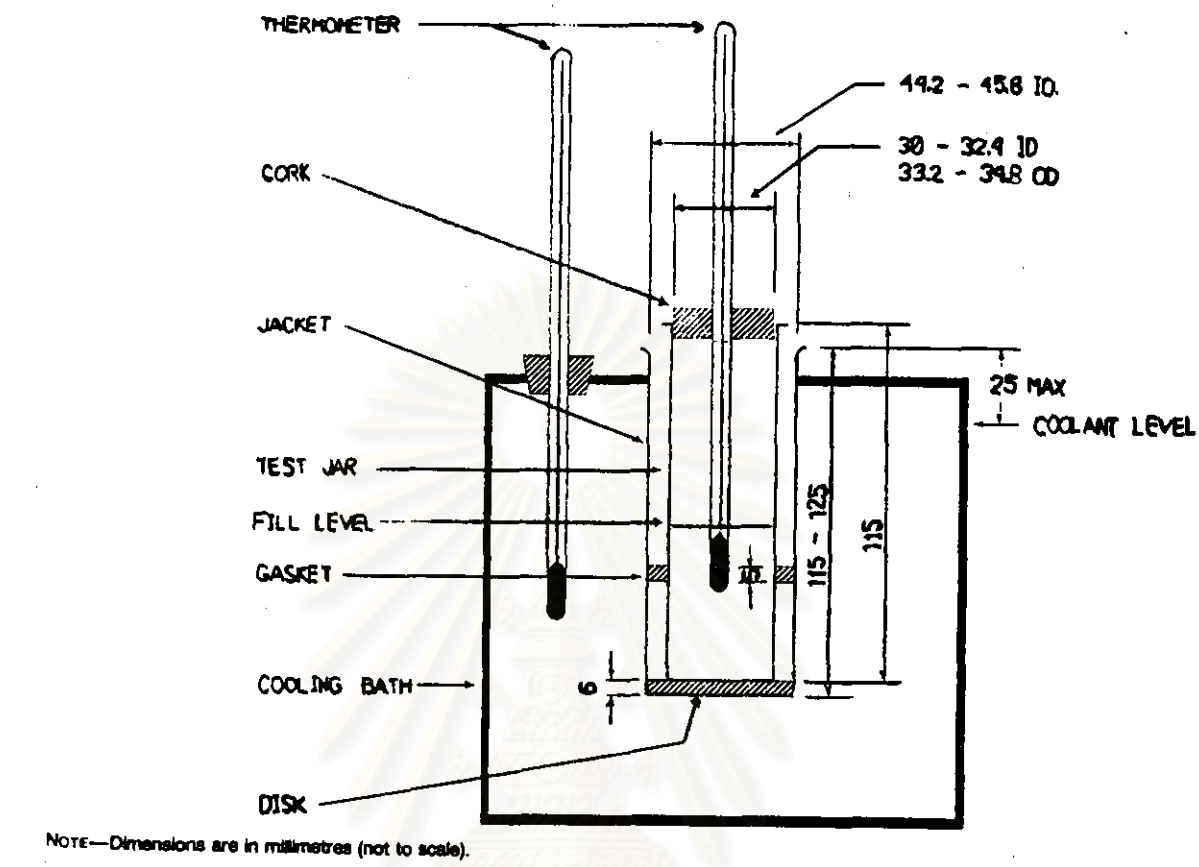

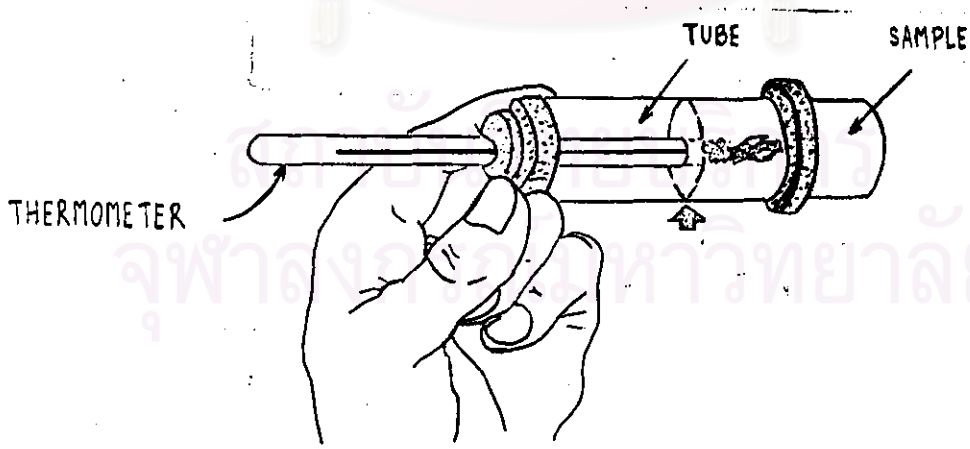

Figure 3.7 : Apparatus for pour point test