

CONSTRUCTION AND QUALITY CONTROL OF FLEXIBLE AND RIGID PAVEMENTS

Laboratory Tests on Unmodified Bitumen

National Rural Infrastructure
Development Agency



Ministry of Rural Development

National Institute of Technology



Warangal, Hyderabad

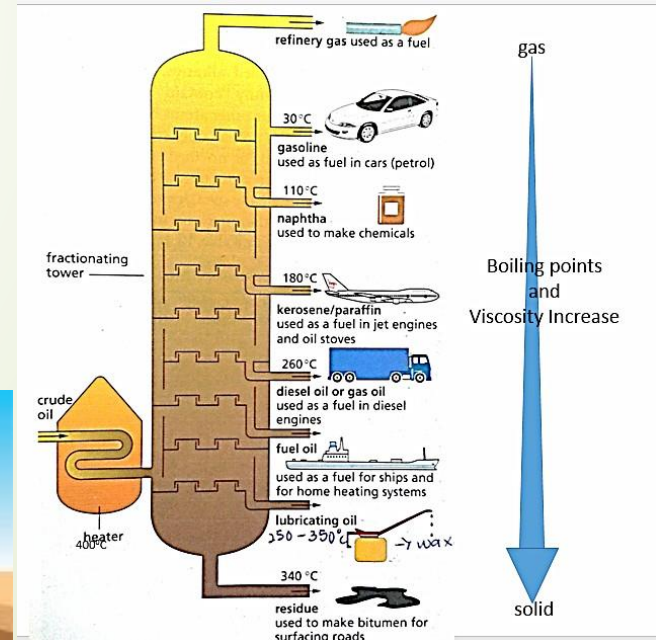


Laboratory Tests on Unmodified Bitumen

Lecture-8

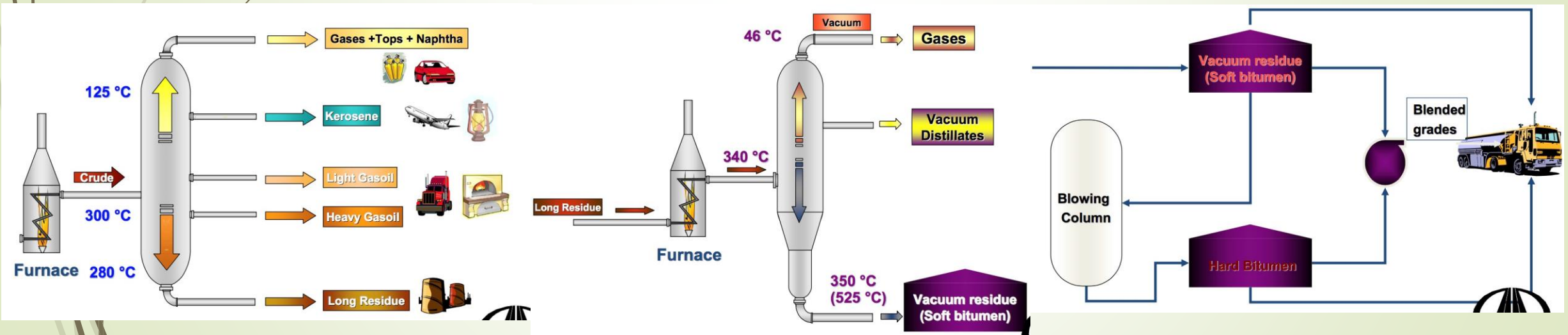
BITUMEN

- Produced in a petroleum refinery through fractional distillation
- Crude oil heated to 400 °C to vapour
- Hydrocarbons of different sizes are condensed and separated at different heights in the fractionating column because they have different boiling points
- Lighter hydrocarbon molecules with lower boiling points condense higher up the column
- Bitumen is a “waste” product from refinery processing of crude oil - sometimes called the “bottom of the barrel”
- 1500 different crudes produced throughout the world
- Few crudes are suitable for manufacture of bitumen



BITUMEN

- Bitumen thus produced does not meet market product quality requirements
- Grade of bitumen depends on amount of volatile material remaining in the bitumen
- Different grades of bitumen can be produced by blowing air through liquid bitumen (in a blowing column) resulting in harder grade of bitumen
- Properties depend on: refinery operations, composition of crude source



GRADING OF BITUMEN

- Penetration grading
- Viscosity grading
- Performance grading

PENETRATION GRADING

- Frass Breaking Point (IS:9381-1979): temperature at which bitumen becomes brittle, indicated by appearance of cracks when a thin film of bitumen is cooled

IS 73 : 1992

Table 1 Requirements for Paving Bitumen Type 1
(Clause 6.2)

Sl No.	Characteristics	Requirements for Grades						Methods of Test, Ref to
		S 35	S 45	S 55	S 65	S 90	S 200	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	Specific gravity at 27°C, <i>Min</i>	0.99	0.99	0.99	0.99	0.99	0.99	IS 1202 : 1978
ii)	Water, percent by mass, <i>Max</i>	0.2	0.2	0.2	0.2	0.2	0.2	IS 1211 : 1978
iii)	Flash point, Cleveland open cup, °C, <i>Min</i>	175	175	175	175	175	175	IS 1448 (P:69) : 1969
iv)	Softening point °C	50 to 65	45 to 60	45 to 60	40 to 55	35 to 50	30 to 45	IS 1205 : 1978
v)	Penetration at 25°C, 100g, 5 Sec., 1/10 mm	30 to 40	40 to 50	50 to 60	60 to 70	80 to 100	175 to 225	IS 1203 : 1978
vi)	Penetration ratio ¹ , <i>Min</i>	35	35	35	35	35	35	—
vii)	Ductility at 27°C, cm, <i>Min</i>	50	75	75	75	75	—	IS 1208 : 1978
viii)	Paraffin wax content, percent by mass, <i>Max</i>	4.5	4.5	4.5	4.5	4.5	4.5	IS 10512 : 1983
ix)	Frass breaking point, °C, <i>Min</i>	—4	—4	—6	—6	—8	—10	IS 9381 : 1979
x)	Loss on heating, thin film oven test, percent by mass, <i>Max</i>	1	1	1	1	1	2	IS 1212 : 1978
xi)	Retained penetration after thin film oven test, 25°C, 100 g, 5 Sec., 1/10 mm, percent of original, <i>Min</i>	55	55	52	52	47	42	IS 9382 : 1979
xii)	Matter soluble in trichloroethylene, percent by mass, <i>Min</i>	99	99	99	99	99	99	IS 1216 : 1978
xiii)	Viscosity at :							
a)	60°C, Poises	2500±500	2000±400	1500±300	1000±200	500±100	250±50	IS 1206 (Part 2) : 1978
b)	135°C, est, <i>Min</i>	220	210	180	150	110	20	IS 1206 (Part 3) : 1978

¹Penetration ratio = $\frac{\text{Penetration at 4°C, 200 g, 60 s}}{\text{Penetration at 25°C, 100 g, 5 s}} \times 100$

PENETRATION GRADING

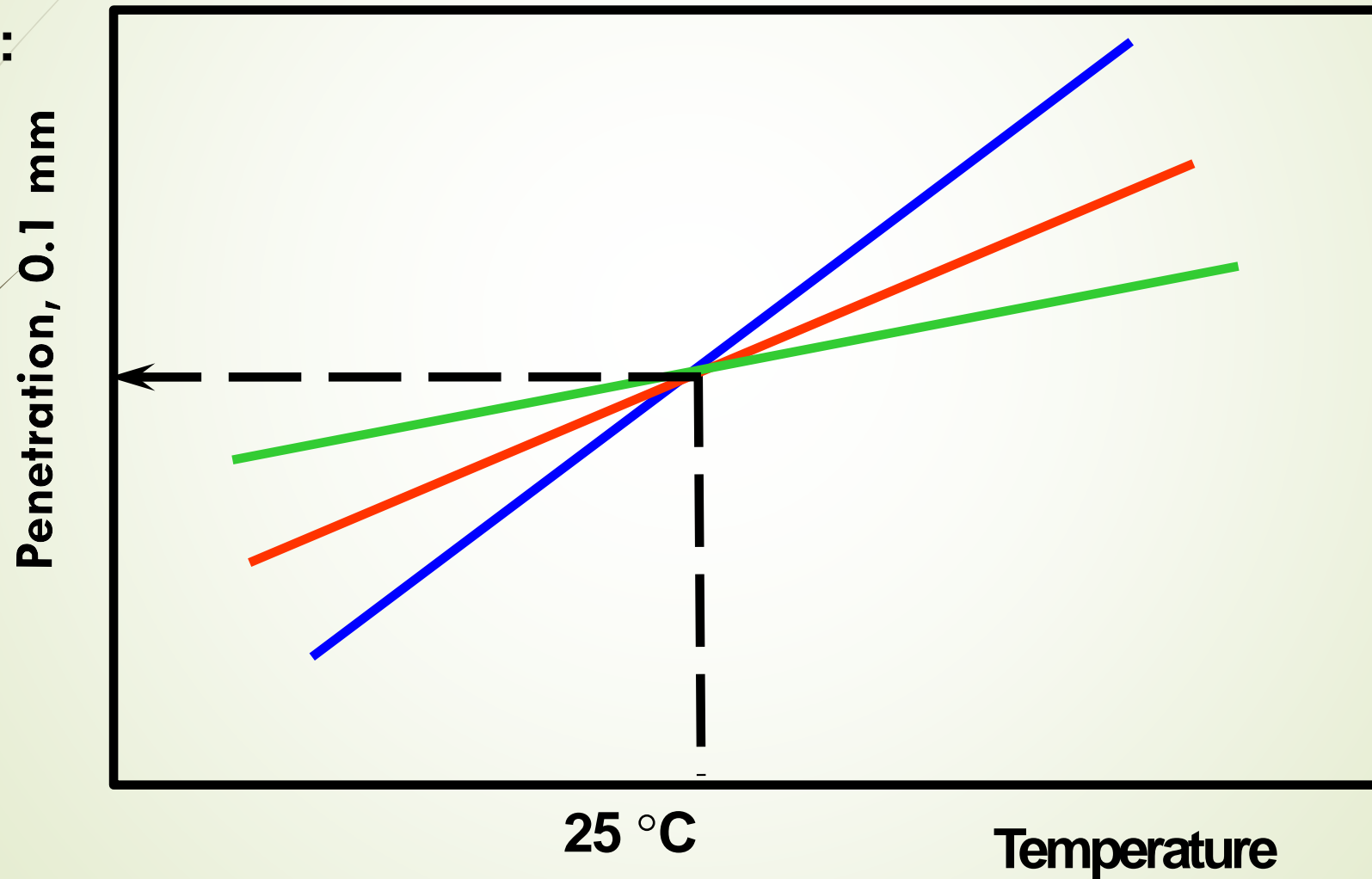
Table 2 Requirements for Paving Bitumen Type 2
(Clause 6.2)

Sl No.	Characteristics	Requirements for Grades				Methods of Test, Ref to
		A 35	A 55	A 65	A 90	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	Specific gravity at 27°C, <i>Min</i>	0.99	0.99	0.99	0.98	IS 1202 : 1978
ii)	Water, percent by mass, <i>Max</i>	0.2	0.2	0.2	0.2	IS 1211 : 1978
iii)	Flash point Cleveland open cup °C, <i>Min</i>	175	175	175	175	IS 1448 (P:69) : 1969
iv)	Softening point, °C	55 to 70	45 to 60	45 to 60	35 to 50	IS 1205 : 1978
v)	Penetration at 25°C, 100 g, 5 Sec., 1/10 mm	30 to 40	50 to 60	60 to 70	80 to 100	IS 1203 : 1978
vi)	Penetration ratio ¹ , <i>Min</i>	5	25	25	25	—
vii)	Ductility at 27°C, cm, <i>Min</i>	10	15	15	15	IS 1208 : 1978
viii)	Paraffin wax content, percent by mass, <i>Max</i>	10	10	10	10	IS 10512 : 1983
ix)	Frass breaking point °C, <i>Min</i>	-4	-6	-8	-10	IS 9381 : 1979
x)	Loss on heating in thin film oven test, percent by mass, <i>Max</i>	1	1	1	1	IS 1212 : 1978
xi)	Retained penetration after thin film oven test at 25°C, 100 g, 5 Sec., 1/10 mm percent of original, <i>Min</i>	57	57	47	42	IS 9382 : 1979
xii)	Matter soluble in trichloroethylene, percent by mass, <i>Min</i>	99	99	99	99	IS 1216 : 1978
xiii)	Viscosity at: (a) 60°C, Poises (b) 135°C, cst, <i>Min</i>	1000±300 250	400±300 100	300±10 70	200±50 50	IS 1206 (Part 2) : 1978 IS 1206 (Part 3) : 1978

¹Penetration ratio = $\frac{\text{Penetration at 4°C, 200 g, 60 s}}{\text{Penetration at 25°C, 100 g, 5 s}} \times 100$

PENETRATION GRADING

Limitation:



VISCOSITY GRADING

- Based on absolute and kinematic viscosities
- Advantages:
 - Viscosity is a fundamental property rather than empirical penetration value
 - Based on viscosity at 60°C which is near the max. pavement surface temperature
 - Wide range of test instruments available
 - Test standards available
 - Temperature susceptibility of bitumen can be determined
- Switched over to Viscosity Grading in India!!!

VISCOSITY GRADING

IS 73 : 2006

Table 1 Requirements for Paving Bitumen
(Clause 6.2)

Sl No.	Characteristics	Paving Grades				Methods of Test, Ref to IS No.
		VG 10 (3)	VG 20 (4)	VG 30 (5)	VG 40 (6)	
(1)	(2)					(7)
i)	Absolute viscosity at 60°C, Poises, <i>Min</i>	800	1 600	2 400	3 200	IS 1206 (Part 2)
ii)	Kinematic viscosity at 135°C, cSt, <i>Min</i>	250	300	350	400	IS 1206 (Part 3)
iii)	Flash point, (Cleveland open cup), °C, <i>Min</i>	220	220	220	220	IS 1209
iv)	Solubility in trichloroethylene, percent, <i>Min</i>	99.0	99.0	99.0	99.0	IS 1216
v)	Penetration at 25°C, 100 g, 5 s, 0.1 mm	80-100	60-80	50-70	40-60	IS 1203
vi)	Softening point (R&B), °C, <i>Min</i>	40	45	47	50	IS 1205
vii)	Tests on residue from thin-film oven tests/RTFOT					
	1) Viscosity ratio at 60°C, <i>Max</i>	4.0	4.0	4.0	4.0	IS 1206 (Part 2)
	2) Ductility at 25°C, cm, <i>Min</i> , after thin-film oven test	75	50	40	25	IS 1208

- MoSRTTH (now MoRTH) issued a circular on Viscosity Grading in Indian Highways, Vol. 36, No. 10, October 2008



सत्यमेव जयते

Government of India
Ministry of Shipping, Road Transport & Highways
Department of Road Transport & Highways

Transport Bhawan,
1, Parliament Street,
New Delhi – 110 001

No.RW/NH-33041/3/2001-S&R(R)-Vol.III

Dated: 04.08.2008

To

Secretaries/Chief Engineer/E-in-C of State PWDs dealing with National Highways.

Subject: Paving Bitumen – Specification (Third Revision) – published by Bureau of Indian Standards in July 2006 – reg. use of viscosity grade bitumen in road construction.

Sir,

Bureau of Indian Standards has revised the specifications of paving bitumen with publication of IS:73-2006 (Paving Bitumen – Specification (Third Revision) in July 2006. This Specification, inter-alia, specifies the Grades of Paving Bitumen, based on viscosity as against the previous grading based on penetration in IS:73-1992.

2. As per IS:73-2006, paving grade bitumen have been classified into 4 types, viz. VG-10, VG-20, VG-30 & VG-40. The minimum absolute viscosity (in Poises) of these 4 grades at 60°C are 800, 1600, 2400 & 3200 respectively when tested in accordance with IS:1206 (Part-2). In other words, index of VG multiplied by 80 gives the minimum absolute viscosity (in Poises) of the particular grade of bitumen at 60°C. From the comparison of the requirements for paving bitumen as per IS:73-2006 with that of IS:73-1992 (as amended in 2002), VG-30 may replace 60-70 penetration grade bitumen; similarly, VG-10 & VG-40 may replace 80-100 and 30-40/40-50 penetration grade bitumen respectively. As regards VG-20, this may be considered for special cases only.

3. The Flexible Pavements Committee of the IRC has since given their recommendation for issuing the corrigendum in this regard to Section 500 of the Ministry's Specifications for Road & Bridge Works – 2001 (Fourth Revision). Considering the above, it has been decided that all future estimates for road projects in central sector shall provide for viscosity grade bitumen as per IS:73-2006. However, during the transition period, for the ongoing projects/projects sanctioned with a particular penetration/viscosity grade of bitumen, the equivalent viscosity/penetration grade of bitumen as per para 2 above may be allowed depending on availability.

Yours faithfully,

Sd/-

(Richhpal Singh)

Assistant Executive Engineer (Roads) Standards & Research,
For Director General (Road Development) & SS

VISCOSITY GRADING

IS:73-2013 (Reaffirmed 2018):

- VG10: $< 30^{\circ}\text{C}$
 - VG20: 30 to 38°C
 - VG30: 38 to 45°C
 - VG40: $> 45^{\circ}\text{C}$
-
- Temperatures correspond to 7-day average maximum air temperature of the hottest week in a year for a period not less than 5 years from the start of the design period

VISCOSITY GRADING

MoRD “Specifications for Rural Roads” 2014:

- Choice of bitumen depends on the maximum and minimum annual temperatures

Annexure-500.2
(Clause 504.2)

**SELECTION CRITERIA FOR VISCOCITY GRADED (VG)
PAVING BITUMEN BASED ON CLIMATIC CONDITIONS**

Lowest Daily Mean Air Temperature, °C	Highest Daily Mean Air Temperature °C		
	Less than 20°C	20 to 30°C	More than 30°C
More than -10°C	VG-10	VG-20	VG-30
-10°C or lower	VG-10	VG-10	VG-20

Source: MoRD, 2014

VISCOSITY GRADING

IS:73-2013 (Reaffirmed 2018):

Sl No.	Characteristics	Paving Grades				Method of Test, Ref to
		VG10	VG20	VG30	VG40	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	Penetration at 25°C, 100 g, 5 s, 0.1 mm, <i>Min</i>	80	60	45	35	IS 1203
ii)	Absolute viscosity at 60°C, Poises	800-1 200	1 600-2400	2 400-3 600	3 200-4 800	IS 1206 (Part 2)
iii)	Kinematic viscosity at 135°C, cSt, <i>Min</i>	250	300	350	400	IS 1206 (Part 3)
iv)	Flash point (Cleveland open cup), °C, <i>Min</i>	220	220	220	220	IS 1448 [P : 69]
v)	Solubility in trichloroethylene, percent, <i>Min</i>	99.0	99.0	99.0	99.0	IS 1216
vi)	Softening point (R&B), °C, <i>Min</i>	40	45	47	50	IS 1205
vii)	Tests on residue from rolling thin film oven test:					
a)	Viscosity ratio at 60°C, <i>Max</i>	4.0	4.0	4.0	4.0	IS 1206 (Part 2)
b)	Ductility at 25°C, cm, <i>Min</i>	75	50	40	25	IS 1208

VISCOSITY GRADING

Sl No.	Characteristics	Paving Grades			
		VG10	VG20	VG30	VG40
(1)	(2)	(3)	(4)	(5)	(6)
i)	Penetration at 25°C, 100 g, 5 s, 0.1 mm, <i>Min</i>	80	60	45	35
ii)	Absolute viscosity at 60°C, Poises	800-1 200	1 600-2400	2 400-3 600	3 200-4 800
iii)	Kinematic viscosity at 135°C, cSt, <i>Min</i>	250	300	350	400
iv)	Flash point (Cleveland open cup), °C, <i>Min</i>	220	220	220	220
v)	Solubility in trichloroethylene, percent, <i>Min</i>	99.0	99.0	99.0	99.0
vi)	Softening point (R&B), °C, <i>Min</i>	40	45	47	50
vii)	Tests on residue from rolling thin film oven test:				
a)	Viscosity ratio at 60°C, <i>Max</i>	4.0	4.0	4.0	4.0
b)	Ductility at 25°C, cm, <i>Min</i>	75	50	40	25

IS 73 : 1992

Table 1 Requirements for Paving Bitumen Type 1
(Clause 6.2)

Sl No.	Characteristics	Requirements for Grades					
		S 35	S 45	S 55	S 65	S 90	S 200
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Specific gravity at 27°C, <i>Min</i>	0.99	0.99	0.99	0.99	0.99	0.99
ii)	Water, percent by mass, <i>Max</i>	0.2	0.2	0.2	0.2	0.2	0.2
iii)	Flash point, Cleveland open cup, °C, <i>Min</i>	175	175	175	175	175	175
iv)	Softening point °C	50 to 65	45 to 60	45 to 60	40 to 55	35 to 50	30 to 45
v)	Penetration at 25°C, 100g, 5 Sec., 1/10 mm	30 to 40	40 to 50	50 to 60	60 to 70	80 to 100	175 to 225
vi)	Penetration ratio ¹ , <i>Min</i>	35	35	35	35	35	35
vii)	Ductility at 27°C, cm, <i>Min</i>	50	75	75	75	75	—
viii)	Paraffin wax content, percent by mass, <i>Max</i>	4.5	4.5	4.5	4.5	4.5	4.5
ix)	Frass breaking point, °C, <i>Min</i>	—4	—4	—6	—6	—8	—10
x)	Loss on heating, thin film oven test, percent by mass, <i>Max</i>	1	1	1	1	1	2
xi)	Retained penetration after thin film oven test, 25°C, 100 g, 5 Sec., 1/10 mm, percent of original, <i>Min</i>	55	55	52	52	47	42
xii)	Matter soluble in trichloroethylene, percent by mass, <i>Min</i>	99	99	99	99	99	99
iii) Viscosity at :							
a)	60°C, Poises	2500±500	2000±400	1500±300	1000±200	500±100	250±50
b)	135°C, est, <i>Min</i>	220	210	180	150	110	20
¹ Penetration ratio = $\frac{\text{Penetration at 4°C, 200 g, 60 s}}{\text{Penetration at 25°C, 100 g, 5 s}} \times 100$							

VISCOSITY GRADING

SI No.	Characteristics	Paving Grades			
		VG10	VG20	VG30	VG40
(1)	(2)	(3)	(4)	(5)	(6)
i)	Penetration at 25°C, 100 g, 5 s, 0.1 mm, <i>Min</i>	80	60	45	35
ii)	Absolute viscosity at 60°C, Poises	800-1 200	1 600-2400	2 400-3 600	3 200-4 800
iii)	Kinematic viscosity at 135°C, cSt, <i>Min</i>	250	300	350	400
iv)	Flash point (Cleveland open cup), °C, <i>Min</i>	220	220	220	220
v)	Solubility in trichloroethylene, percent, <i>Min</i>	99.0	99.0	99.0	99.0
vi)	Softening point (R&B), °C, <i>Min</i>	40	45	47	50
vii)	Tests on residue from rolling thin film oven test:				
a)	Viscosity ratio at 60°C, <i>Max</i>	4.0	4.0	4.0	4.0
b)	Ductility at 25°C, cm, <i>Min</i>	75	50	40	25

Table 2 Requirements for Paving Bitumen Type 2
(Clause 6.2)

SI No.	Characteristics	Requirements for Grades			
		A 35	A 55	A 65	A 90
(1)	(2)	(3)	(4)	(5)	(6)
i)	Specific gravity at 27°C, <i>Min</i>	0.99	0.99	0.99	0.98
ii)	Water, percent by mass, <i>Max</i>	0.2	0.2	0.2	0.2
iii)	Flash point Cleveland open cup °C, <i>Min</i>	175	175	175	175
iv)	Softening point, °C	55 to 70	45 to 60	45 to 60	35 to 50
v)	Penetration at 25°C, 100 g, 5 Sec., 1/10 mm	30 to 40	50 to 60	60 to 70	80 to 100
vi)	Penetration ratio ¹ , <i>Min</i>	5	25	25	25
vii)	Ductility at 27°C, cm, <i>Min</i>	10	15	15	15
viii)	Paraffin wax content, percent by mass, <i>Max</i>	10	10	10	10
ix)	Frass breaking point °C, <i>Min</i>	-4	-6	-8	-10
x)	Loss on heating in thin film oven test, percent by mass, <i>Max</i>	1	1	1	1
xi)	Retained penetration after thin film oven test at 25°C, 100 g, 5 Sec., 1/10 mm percent of original, <i>Min</i>	57	57	47	42
xii)	Matter soluble in trichloroethylene, percent by mass, <i>Min</i>	99	99	99	99
xiii)	Viscosity at: (a) 60°C, Poises (b) 135°C, cst, <i>Min</i>	$\frac{1000 \pm 300}{250}$	$\frac{400 \pm 300}{100}$	$\frac{300 \pm 10}{70}$	$\frac{200 \pm 50}{50}$

¹Penetration ratio = $\frac{\text{Penetration at 4°C, 200 g, 60 s}}{\text{Penetration at 25°C, 100 g, 5 s}} \times 100$

VISCOSITY GRADING

IS:73-2013 (Reaffirmed 2018):

- IS: 1201 to 1220 - 1978 (Reaffirmed in 2019), IS: 1448 Part 69 - 2019

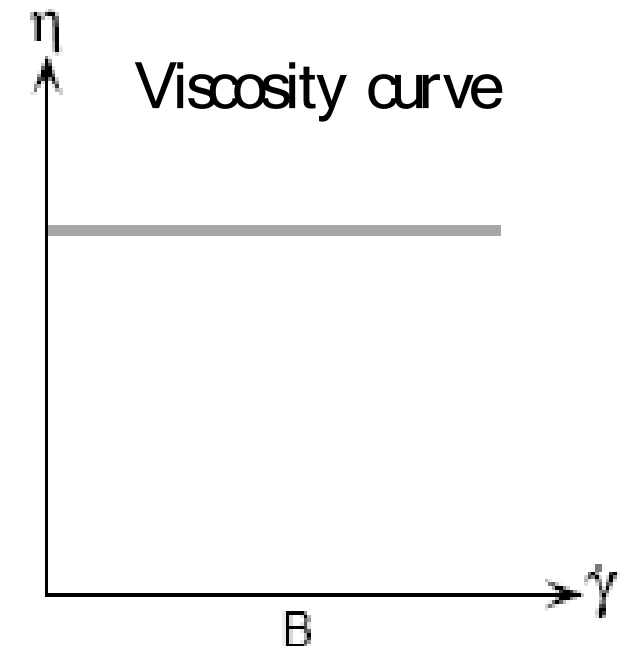
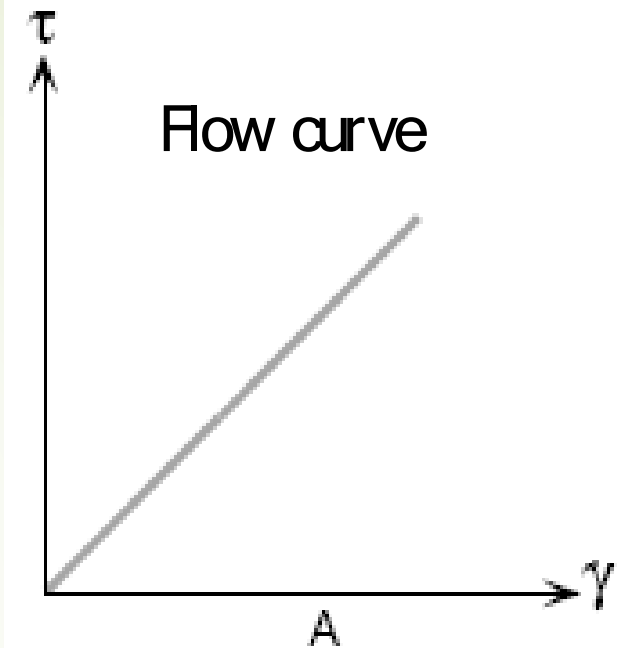
Sl No.	Characteristics	Paving Grades				Method of Test, Ref to
		VG10	VG20	VG30	VG40	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	Penetration at 25°C, 100 g, 5 s, 0.1 mm, <i>Min</i>	80	60	45	35	IS 1203
ii)	Absolute viscosity at 60°C, Poises	800-1 200	1 600-2400	2 400-3 600	3 200-4 800	IS 1206 (Part 2)
iii)	Kinematic viscosity at 135°C, cSt, <i>Min</i>	250	300	350	400	IS 1206 (Part 3)
iv)	Flash point (Cleveland open cup), °C, <i>Min</i>	220	220	220	220	IS 1448 [P : 69]
v)	Solubility in trichloroethylene, percent, <i>Min</i>	99.0	99.0	99.0	99.0	IS 1216
vi)	Softening point (R&B), °C, <i>Min</i>	40	45	47	50	IS 1205
vii)	Tests on residue from rolling thin film oven test:					
a)	Viscosity ratio at 60°C, <i>Max</i>	4.0	4.0	4.0	4.0	IS 1206 (Part 2)
b)	Ductility at 25°C, cm, <i>Min</i>	75	50	40	25	IS 1208

ABSOLUTE VISCOSITY

- Newtonian fluids are those having a constant viscosity dependent on temperature but independent of the applied shear rate
- Newtonian fluids have direct proportionality between shear stress and shear rate in laminar flow

$$\tau = \eta \gamma$$

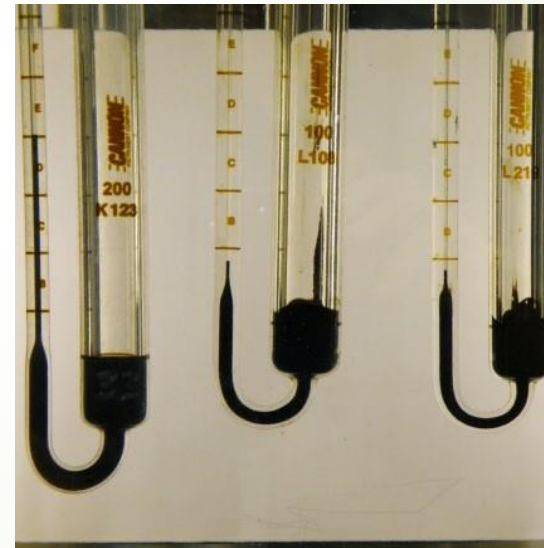
- Newtonian fluid can be defined by a single viscosity value (Absolute Viscosity) at a specified temperature
- Examples: water, mineral & vegetable oils, etc.



ABSOLUTE VISCOSITY

Absolute viscosity testing equipment:

- Absolute viscosity (IS:1206, Part 2) at 60 °C, vacuum of 30 ± 0.05 cm of mercury (Cannon - Manning Vacuum Capillary Viscometer)



- Repeatability: 7% of mean
- Reproducibility: 10% of mean

Source:

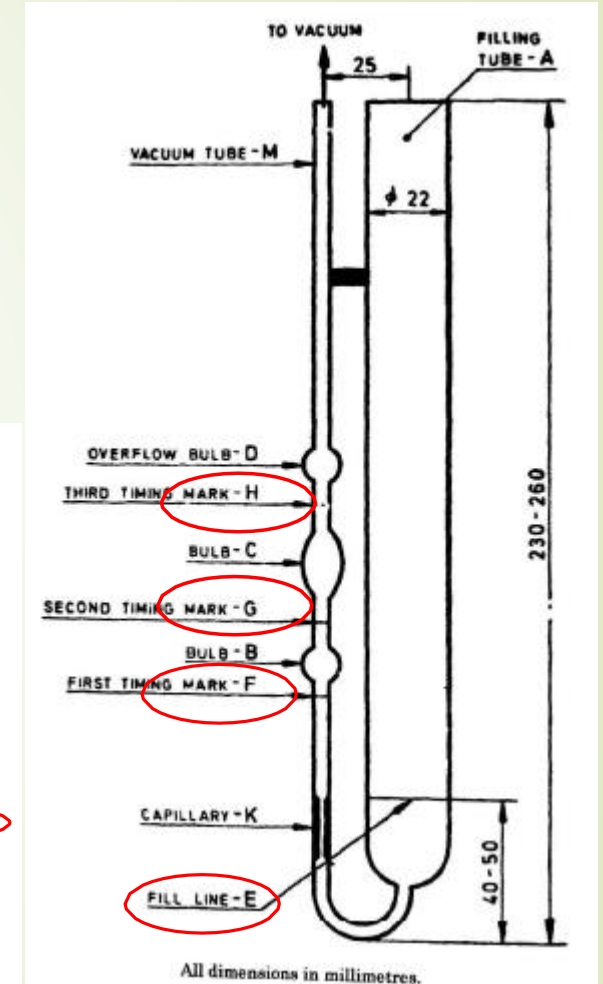
<http://www.priasphalt.com/testingandspecifications.aspx?id=733>



ABSOLUTE VISCOSITY

- Heat bitumen to not more than 90°C above softening point temperature
- 20 ml maintained 135 ± 5.5°C; fill up to line E
- Transfer to water bath maintained at 60°C for 30 ± 5 minutes
- Vacuum: 30 ± 0.05 cm of Hg; note time (± 0.5 s) at F, G, H
- Viscosity (Poises) = calibration factor x flow time

Viscometer Size No.	Approximate Calibration Factor 30 cm Hg Vacuum Poises per s		Viscosity Range Poises	
	Bulb B	Bulb C		
10	2.0	0.6	36	to 800
11	6.0	2.0	120	to 2 400
12	20.0	6.0	360	to 8 000
13	60.0	20.0	1 200	to 24 000
14	200.0	60.0	3 600	to 80 000



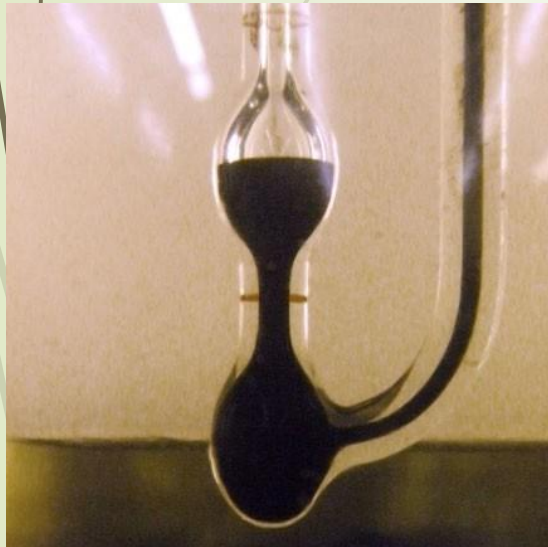
KINEMATIC VISCOSITY

- Kinematic viscosity of a liquid is the quotient of absolute viscosity divided by the density of the liquid
- CGS unit of kinematic viscosity is stoke (St) which has the dimensions cm^2/s
- Kinematic viscosity is expressed in centistokes (cSt)
- Example: An asphalt has a kinematic viscosity of 800 cSt. Its specific gravity is 1.03. What is its absolute viscosity in poises?
- Absolute viscosity in poises = kinematic viscosity in stokes x specific gravity = $8 \times 1.03 = 8.24$

KINEMATIC VISCOSITY

Kinematic viscosity testing equipment:

- Kinematic viscosity (IS:1206, Part 3) at 135 °C (BS U-tube modified reverse flow viscometer)

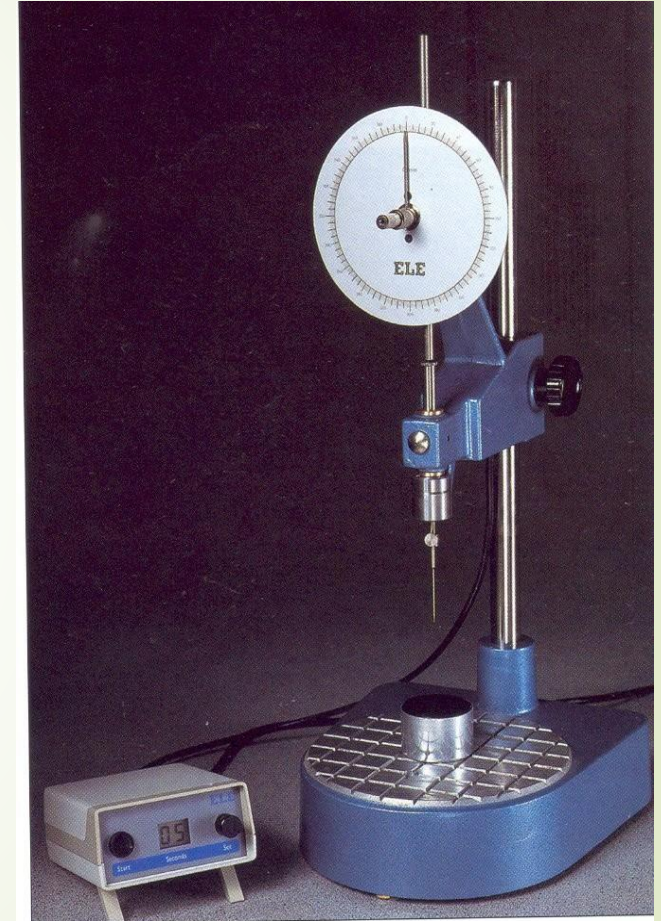


Source:

<http://www.priasphalt.com/testingandspecifications.aspx?id=733>

PENETRATION TEST

- An empirical test used to measure consistency of bitumen
- Penetration of a standard needle into bitumen is measured for:
 - Load = 100 g
 - Temperature = 25 °C
 - Time = 5 s
- Depth of penetration measured in units of 0.1 mm and reported in penetration units
- If needle penetrates 70 (1/10 mm), bitumen penetration number is 70



SOFTENING POINT TEST

- Defined as the temperature (starting from 5°C, heated @ 5°C/minute) at which an bitumen sample can no longer support the weight of a 3.5 g, 9.5 mm ϕ steel ball and starts flowing
- Main purpose is to determine the temperature at which a phase change occurs in bitumen (i.e., “solid-like” behaviour to “fluid-like” behaviour)
- Softening point is reported as mean of temperatures at which two disks soften enough to allow each ball, enveloped in bitumen, to fall a distance of 25 mm
- Glycerine is used for softening point $> 80^{\circ}\text{C}$ (starting from 35°C, heated @ 5°C/minute)



PURITY TEST

- Bitumen, as used for paving should be pure
- Impurities are not active cementing constituents and are detrimental to bitumen performance
- Mineral impurities can be quantified by dissolving a sample of bitumen (2 g) in trichloroethylene (100 ml) and passing through a filter mat (150 mm diameter; grade is Whatman No. 5 or equivalent; particle retention: 2.5 μ m; 200 μ m thick; 100 g/m²) after allowing it to stand loosely corked for 1 h; weight measured to
 - ▶ 0.001 g accuracy
- Anything remaining on the filter mat is considered an impurity

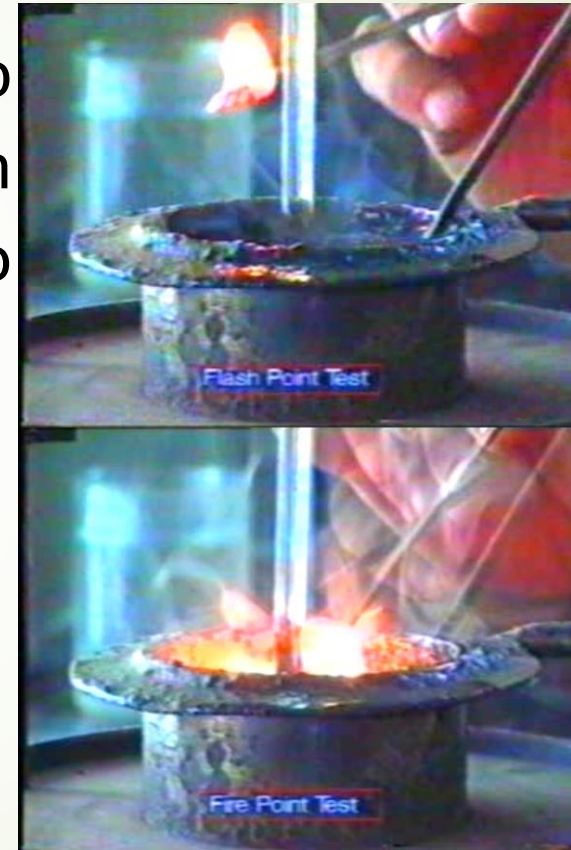
SAFETY TESTS

Flash point:

- A small flame is passed over the surface of the cup periodically and the lowest temperature at which application of test flame causes the vapours to momentarily catch fire in the form of a flash

Fire point:

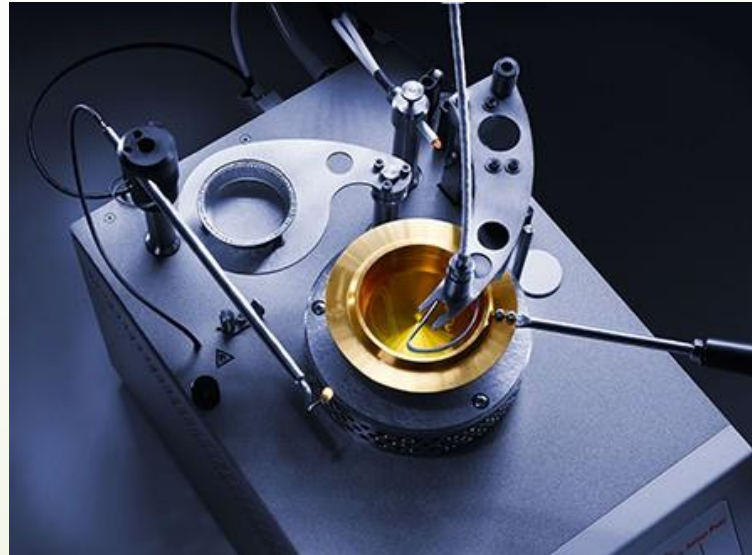
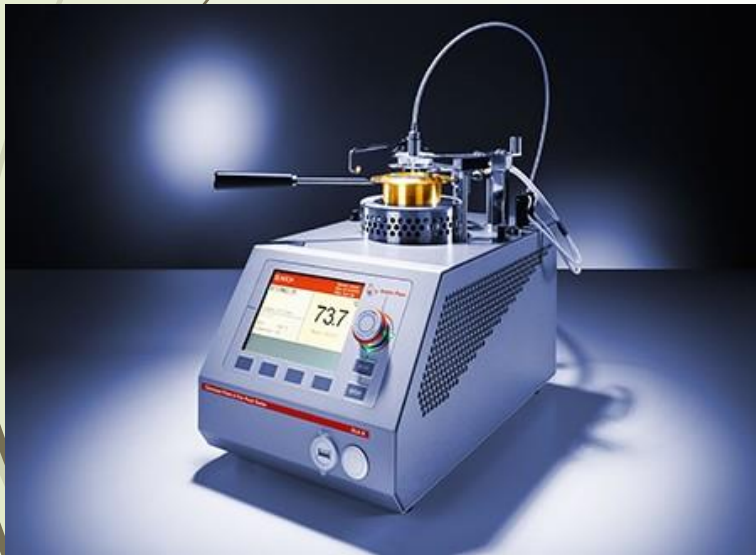
- Lowest temperature at which application of test flame ignites and burns for at least 5 s



SAFETY TESTS

Flash point:

- Cleveland open cup apparatus is used
- Rapid increase in temperature initially @ 5°C/minute to 17°C/minute and then at a slow rate @ 5°C/minute to 6°C/minute



Source: <https://www.anton-paar.com/in-en/products/details/cleveland-flash-fire-point-tester-cla-5/>

AGING OF BITUMINOUS BINDERS

- Through loss of volatiles and oxidation
- Bitumen undergoes aging during:
 - Construction
 - Early age of pavement (initial two years)
 - 8 to 10 years of pavement life
- Aging during construction and initial service: short-term aging (RTFO)
- Aging over pavement life: long-term aging (RTFO+PAV)

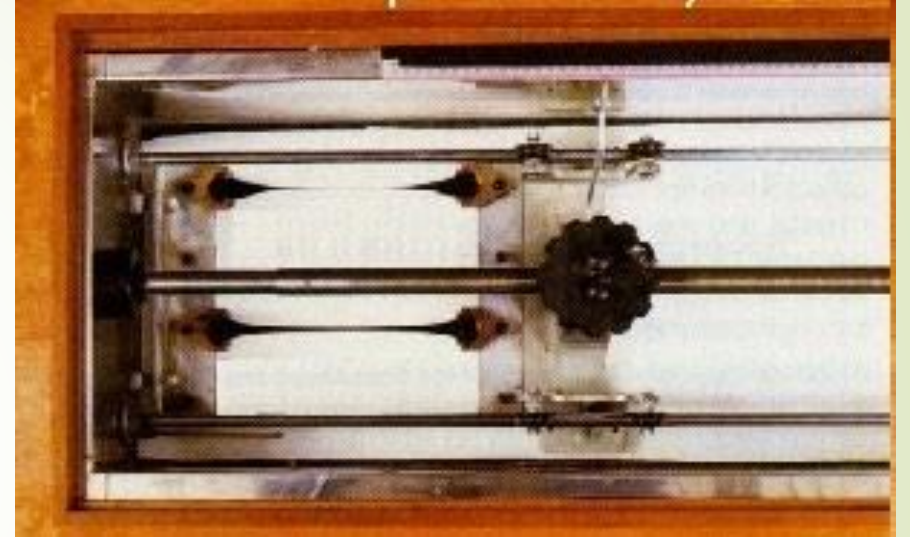
RTFO AGING OF BITUMINOUS BINDERS

- Rolling Thin Film Oven (RTFO) is used to simulate short-term aging in the laboratory
- Test temperature: 163°C
- Test duration: 85 minutes



DUCTILITY TEST

- Test conducted on RTFO bitumen residue
- Ductility test measures bitumen ductility by stretching a standard sized briquette of bitumen to its breaking point @ 50 ± 2.5 mm/minute
- Stretched distance in cm at breaking is reported as ductility
- Conducted at 25°C
- Water must be at same specific gravity as bitumen to prevent floating or sinking of stretched sample
- Sodium chloride or methyl alcohol is added to alter the specific gravity of water



VISCOSITY GRADING

Limitations:

- “A” and “B” have same temperature dependency but different consistency at all temperatures
- “A” and “C” have same consistency at low temperature but not at high temperature
- “B” and “C” have same consistency at 60 °C but are different at other temperatures

