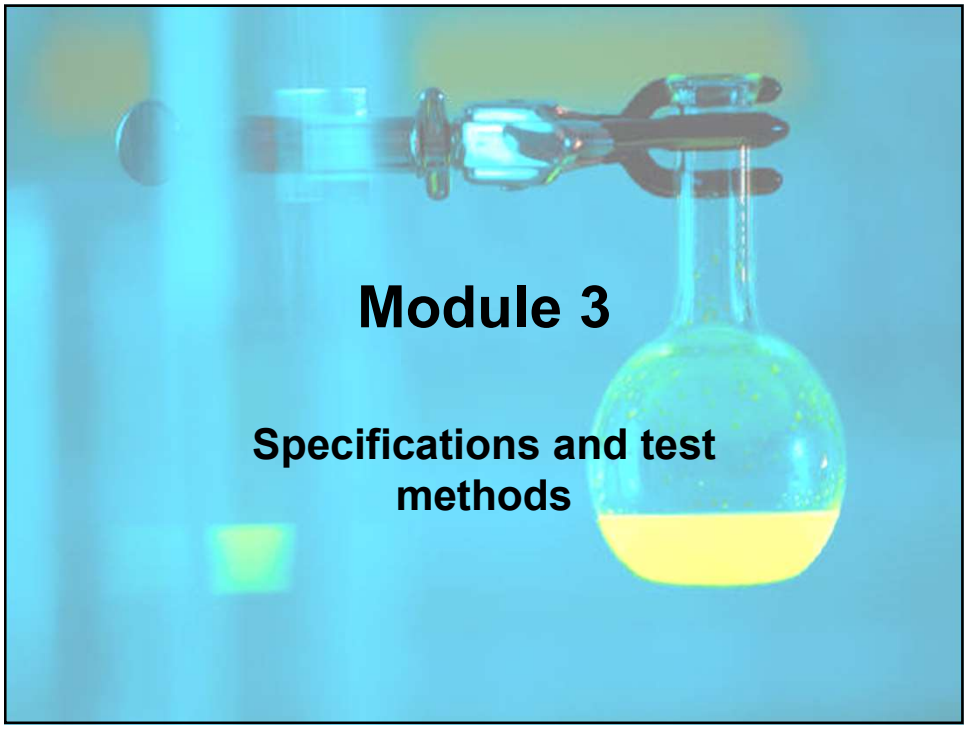


Module 3

Specifications and test methods

Purpose of Specifications for bituminous binders

To ensure that:

- Binders are manufactured to accepted, uniform standards that will ensure satisfactory performance;
- Binders will not be adversely affected during normal handling, transport and storage, even when heated
- Changes in binder properties during correctly controlled application will not exceed certain limits.

Type of specification

- Chemical composition of a particular bitumen will determine its physical properties and performance characteristics
- Complex and variable chemical and molecular structure of bitumen makes it extremely ***difficult to define chemical composition*** to characterise performance.
- General practice, worldwide, to make use of ***performance-related physical properties*** as the primary means for specifying and selecting bituminous binders.

Specification types in SA

- SANS 4001-BT1: Bitumen graded in terms of consistency (viscosity)
  - Empirical evidence on some performance characteristics
- Supplemented by TG1
  - *Technical Guideline: The use of modified bituminous binder in road construction*
- SATS 3028 (Technical Specification)
  - *Performance grade bitumen*
  - Forerunner to standard specification
  - Implemented on trial basis

Specifications for binders

Specification No	Title	Grade
Bitumen		
SANS 4001-BT1	Penetration grade	35/50 50/70 70/100 150/200
SANS 4001-BT2	Cutback bitumen	MC-10 MC-30 MC-3000
SATS 3208	Bitumen	All grades
Bitumen emulsion		
SANS 4001-BT3	Anionic bitumen emulsion	Spray grade Stable mix grade
SANS 4001-BT4	Cationic emulsion	Spray grade Premix grade Stable mix grade
SANS 4001-BT5	Invert bitumen emulsion	Prime

Specification for penetration grade bitumen

1	2	3	4	5	6
Property	**Penetration grade**				**Test method**
	35/50	**50/70**	**70/100**	**150/200**	
	Requirements				
Penetration at 25 °C/100 g/5 s, 1/10 mm	**35 - 50**	**50 - 70**	**70 - 100**	**150 - 200**	**EN 1426**
Softening point (ring and ball), °C	49 – 59	46 - 56	42 - 51	36 - 43	ASTM D36*
Viscosity at 60 °C, Pa.s	220 - 400	140 - 250	75 - 150	30 – 60	ASTM D4402+
Viscosity at 135 °C, Pa.s	0,27-0,65	0,22-0,45	0,15-0,40	0,12-0,30	ASTM D4402+
Performance when subjected to RTFOT					ASTM D2872
mass change, % (by mass fraction), max.	0,3	0,3	0,3	0,3	ASTM D2872
viscosity at 60 °C, % of original, max.	300	300	300	300	ASTM D4402+
softening point (ring and ball), °C, min.	52	48	44	37	ASTM D36*
increase in softening point, °C, max.	7	7	7	7	ASTM D36*
retained penetration, % of original, min.	60	55	50	50	**EN 1426**
Spot test#, % xylene, max.	30	30	30	30	AASHTO T102

Specifications for modified binders

The requirements for modified binders when are set out in TG1 (Tables 5 – 11). The tests incorporated in these requirements are intended to ensure that:

- The consistency and rheological properties are appropriate for a range of in-service conditions
- The binder can be safely handled and is stable during storage and handling.
- The performance characteristics are not unduly compromised during hot applications

Requirements for modified binders

Table number in TG1 setting out the property requirements

APPLICATION	BINDER CLASS	TABLE IN TG1
Hot applied polymer modified binders for spray seals	S-E1, S-E2	5
Polymer modified emulsions for spray seals	SC-E1, SC-E2	6
Polymer modified binders for hot mix asphalt	A-E1, A-E2, AP-1	7
Bitumen rubber for spray seals and asphalt	S-R1,2 A-R1,2	8
Hydrocarbon modified binders for hot mix asphalt	A-H1, A-H2	9
Modified binder crack sealants	C-E1, CC-E1,C-R1	10
Polymer modified emulsions for machine-applied microsurfacing	AC-E1 (overlays) AC-E2 (rut filling)	11

Proposed draft SA PG Binder spec with DSR

Test Property	Note	South African Performance Grades												Test Method
		58S-22	64S-16	70S-10	58H-22	64H-16	70H-10	58V-22	64V-16	70V-10	58E-22	64E-16	70E-10	
Max pavement design temperature (°C)		58	64	70	58	64	70	58	64	70	58	64	70	
Minimum grading temperature (°C)		-22	-16	-10	-22	-16	-10	-22	-16	-10	-22	-16	-10	
G* and δ at [(T_{max} + T_{min})/2+4]°C	1.1	Compulsory report only – see detail description of report only item												ASTM D7175
G*/sinδ @10rad/s (kPa) @ T = T_{max}	1.2	> 1.0												ASTM D7175
Viscosity at 165°C (Pa.s) ≥ 30 sec^{-1}	1.3	≤0.90												ASTM D4402
Storage Stability at 180°C (% diff in G* at T_{max})	1.4	< 10												ASTM D7175
Flash Point (°C)		230												ASTM D92b
	1.5	**After RTFO Ageing**												ASTM D2872 / TG1 MB3
G* and δ at [(T_{max} + T_{min})/2+4]°C,	1.1	Compulsory report only – see detail description of report only item												ASTM D7175
Mass Change (% m/m)		< 0.3		< 1.0										ASTM D2872 / TG1 MB3
J_{nr} at T_{max} (kPa^{-1})		< 4.5	< 4.5	< 4.5	< 2.0	< 2.0	< 2.0	< 1.0	< 1.0	< 1.0	< 0.5	< 0.5	< 0.5	ASTM D7405
Ageing ratio [G^*_{RTFO} / $G^*_{Original}$]	1.8	< 3.0												ASTM D7175
		After RTFO plus PAV Ageing												ASTM D6521
G* and δ at [(T_{max} + T_{min})/2+4]°C,	1.1	Compulsory report only – see detail description of report only item												ASTM D7175
S (60s) at T_{min} + 10°C , MPa		< 300 MPa												ASTM D6648
m (60s) at T_{min} + 10°C		> 0.300												
ΔT_c (°C) = $T_{c,S}$ – $T_{c,m}$	1.7	> -5												ASTM D7643
Ageing ratio [G^*_{PAV} / $G^*_{Original}$]	1.8	< 6.0												ASTM D7175

Traffic & binder classification systems

Design ESALs[a] (million)	Traffic Load Rate		
	Standing[b]	Slow[c]	Standard[d]
0.3 to < 3	H	S	S
3 to < 10	V	H	H
10 to < 30	E	V	V
≥ 30	E	E	E

Classification	58S -22	64S -16	58H -22	64H -16	58V -22	64V -16	58E -22	64E -16
Maximum pavement design temperature, T_{max} (° C)	58	64	58	64	58	64	58	64
Minimum grading temperature, T_{min} (° C)	-22	-16	-22	-16	-22	-16	-22	-16

HiMA – EME
High Modulus Asphalt

Property	Test Method	Unit	Penetration Grade	
			10/20	15/25
Before RTFOT				
Penetration @ 25 ºC	EN1426	0.1 mm	10 - 20	15 – 25
Softening point	EN 1427	ºC	58 - 78	55 - 71
Viscosity @ 60 ºC	EN 12596	Pa.s	> 700	> 550
After RTFOT				
Increase in Softening Point	EN1427	ºC	< 10	< 8
Retained Penetration	EN 1426	%	-	> 55
Mass change		%		< 0.5

Precoating fluids

In the absence of a national standards specification, the following is recommended (Sabita Manual 26)

Property	Requirement	Test method
Density @ 25ºC, kg/l	0.85 – 0.95	-
Saybolt Furol viscosity @ 50ºC, SFs	10 – 30	ASTM D244
Distillation comparison to 360ºC, v/v %		
to 190ºC	0 – 15	ASTM D402
225ºC	10 – 55	
260ºC	45 – 75	
316ºC	70 – 95	
Residue from distillation to 360ºC, v/v %	45 – 60	ASTM D402
Dynamic viscosity @25ºC of residue distilled to 360 ºC, cps	300 - 500	ASTM D4402
Stripping number	Report	Riedel & Weber

Tests on bituminous binders

- Sampling
- Properties tested
- Standard test methods
- Performance grade tests

Tests on bituminous binders

- The tests listed are routinely carried out to ensure compliance with the relevant specification
- Tests required for bituminous binders vary according to the type of binder
- Other properties of bitumen not necessarily specified are often monitored to provide users with information (E.g. density determination for conversion of mass to volume in calculations)

Sampling

- Testing – to determine whether a lot complies with a specification based on the tests of samples of the lot
- SANS specifications - sampling of bitumen and bitumen emulsions according to ASTM D140
- The procedures for sampling at various operational situations are comprehensively covered in Sabita Manual 25
- All modified binders should be sampled and prepared in accordance with the procedures set out in Method MB-1: *Sampling of modified binders* and MB-2: *Sample preparation*, covered in TG1

Notes on sampling

- Samples are normally subjected to testing for *compliance with a specification*
- Compliance or non-compliance has significant *contractual* implications
- Since the entire product (or batch) can not be sampled nor tested it should be ensured that *samples* taken for testing are *representative of the batch* being assessed.
- Immediately after sample has been packed:
  - Container (not lid) should be labelled (indelibly)
  - Labels should be securely fixed to containers

Notes on sampling/cont…

- All apparatus and containers should be thoroughly clean
- All appropriate safety precautions should be taken
  – Sabita manual 8

Sampling at a refinery

- Taken from in-line sampling valves while loading 2nd third of the load
- Numbered sample containers should display:
  – Grade of bitumen
  – Date and time of sampling
  – Batch number
  – Registration number of tanker/trailer
  – Tank number
  – Temperature of product
  – Person responsible for sampling

Sampling at off-loading point

- Samples taken from sampling valve during offload of 2nd third of load
- Sampling valve position:
  - Between discharge pump and receiving tank or
  - On the tanker
- ***Samples should NOT be taken from the top of the tank or delivery hoses***

Sampling at off-loading point/cont…

Numbered sample containers to display:

- Grade of bituminous binder
- Date and time of sampling
- Refinery or supplier
- Batch number
- Transporter
- Registration numbers of tanker/trailer
- Delivery note number
- Temperature of product
- Name of person taking sample

Sampling at producer

Penetration grade bitumen, emulsions or modified binders

- Modified binders and emulsions - samples of both base bitumen and processed binder to be taken
- Sampling of base bitumen to be in accordance with procedure described at “off-loading point”

Sample size

• Bulk storage or road tankers	4 litre
• Liquid binder from drums	1 litre
• Solid binder from drums	1 kg

Tests on bituminous binders

- Sampling
- Properties tested
- Standard test methods
- Performance grade tests

Conventional binders

BINDER TYPE	PROPERTY TESTED	TEST STANDARD
Penetration grade bitumen	Penetration Softening Point (Dynamic) Viscosity (at 60ºC and 135ºC) Rolling Thin Film Oven Test (RTFOT) n-Heptane/Xylene Spot test	EN 1426 ASTM D36 ASTM D4402 ASTM D2872 AASHTO T102
Cutback bitumen	Kinematic viscosity Distillation test Penetration (on residue of distillation) Flash point Viscosity (Dynamic)	ASTM D2170 ASTM D402 ASTM D5 ASTM D92 ASTM D4402

Emulsions

BINDER TYPE	PROPERTY TESTED	TEST STANDARD
Bitumen emulsions	Water content	ASTM D244
	Particle charge (anionic)	SANS 4001-BT2
	(cationic)	SANS 4001-BT3
	(Saybolt Furol) viscosity	ASTM D244
	Coagulation value test	SANS 4001-BT2 & BT3
	Sieve test	SANS 4001-BT2 & BT3
	Sedimentation test	SANS 4001-BT2 & BT3

Modified binders

BINDER TYPE	PROPERTY TESTED	TEST STANDARD
Modified Binders	Flash Point	ASTM D93
	Modified rolling thin film oven test	MB-3
	Elastic recovery of polymer modified binders by ductilometer	MB-4
	~~Torsional recovery of polymer modified binders~~	~~MB-5~~
	Storage stability of polymer modified binders	MB-6
	~~Modified Vialit adhesion test~~	~~MB-7~~
	Pull out test method for surfacing aggregate	MB-8
	~~Pliers test for assessment of adhesion properties~~	~~MB-9~~
	Ball penetration and resilience of bitumen-rubber blends	MB-10
	Compression recovery of bitumen-rubber binders	MB-11
	Flow test for bitumen-rubber binders	MB-12
	Dynamic viscosity of bitumen-rubber binders	MB-13
	Particle size distribution & loose fibre content of rubber crumb	MB-14
	Bulk density of rubber crumb	MB-16
	Softening point of modified binders by ring and ball method	MB-17
	Dynamic (apparent) viscosity of polymer modified binders	MB-18
	Recovery of residue of modified bitumen emulsions	MB-20
	Viscosity of modified bitumen emulsions by means of the Saybolt- Furol viscometer	MB-21
	Water content of modified bitumen emulsions	MB-22
	Residue on sieving of modified bitumen emulsions	MB-23
	Particle charge of modified bitumen emulsions	MB-24

Precoating fluids

BINDER TYPE	PROPERTY TESTED	TEST STANDARD
Precoating fluids	Density Saybolt Furol viscosity Distillation test Dynamic viscosity Stripping test	 ASTM D244 ASTM D402 ASTM D4402 Riedel & Weber

Tests on bituminous binders

- Sampling
- Properties tested
- Standard test methods
- Performance grade tests

Standard test methods

- In SA test standards used are published by:
  - American Society for Testing and Materials (ASTM)
  - American Association for State Highway and Transportation Officials (AASHTO)
  - South African Bureau of Standards (SABS)
  - TG1 (for modified binders)
- Tests should be carried out strictly in accordance with the test standard
  - ***Small deviations from the method – significant differences in results***
- Test methods are not covered in detail

  Purpose is to develop an understanding
  - reasons for conducting the test
  - brief description of the method

Uncertainty/precision of test results

- Expressed quantitatively as a dispersion of results likely to contain 99% of measurements
- Variation in test results not suspect unless they differ by more than these values
- Tolerance limits allow for slight differences between equipment and human error

Criteria

- Criteria for acceptability of test results are defined in terms of:
  - Repeatability
  - Reproducibility
- All ASTM and AASHTO methods have published values of these

Repeatability

Variation in measurements by:

- Single operator or instrument
- On same items
- Under same conditions of
  - Procedure
  - Instrument
  - Location
  - Repetitions over a short period of time

Reproducibility

Variation in measurements by:

- Two or more operators
- In different locations
- On the same items
- Using same measurement techniques

Tests on penetration grade bitumen

Specified in SANS 4001-BT1

BINDER TYPE	PROPERTY TESTED	TEST STANDARD
Penetration grade bitumen	Penetration	EN 1426
	Softening Point	ASTM D36
	(Dynamic) Viscosity (at 60°C and 135°C)	ASTM D4402
	Rolling Thin Film Oven Test (RTFOT)	ASTM D2872
	n-Heptane/Xylene Spot test	AASHTO T102

Penetration test (EN 1426)

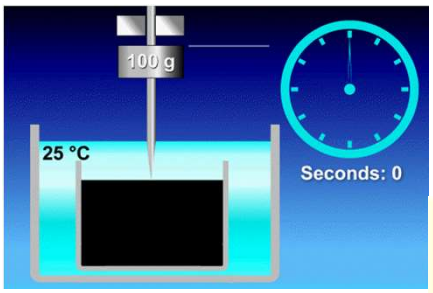
Significance and use:

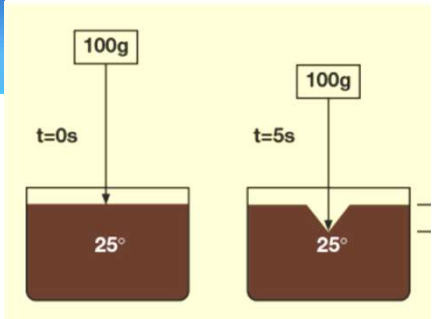
- Measure of the relative hardness or consistency of bitumen at 25 °C (an average in-service temperature)
- Value used to classify the bitumen into standard penetration ranges in accordance with SANS 307.
- Selection of bitumen grades is made on the basis of climate, traffic volumes and speed and aggregate shape.

Method:

- The penetration value of a bitumen is the distance in dmm that a standard needle, pre-treated in oleic acid will penetrate into the bitumen under a load of 100 g applied for 5 seconds at 25 ºC
- Higher values of penetration indicate softer consistency.

Penetration test





Softening point (ASTM D36)

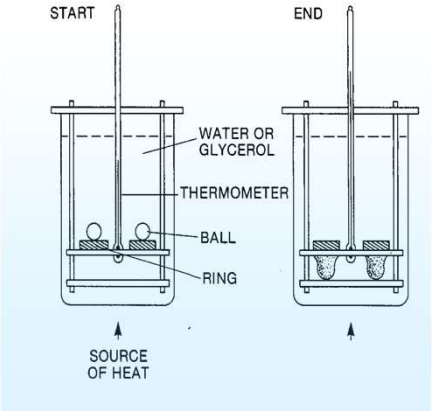
Significance and use:

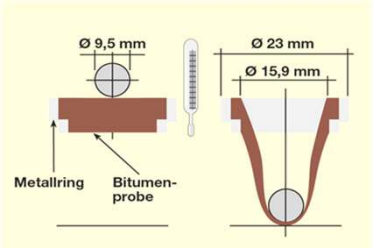
- Determines the temperature at which the bitumen is transformed from a solid to liquid phase
- For the majority of bitumens this viscosity value is in the region of 1200 Pa.s
- Indication of the capacity of a particular bitumen to perform adequately at high in-service temperatures

Method:

- Also referred to as the Ring-and-Ball Softening Point test
- Measures the temperature at which a bitumen disc softens sufficiently to allow a steel ball, placed on the surface, to sink through the disc to a further prescribed distance

Ring and ball softening point





Viscosity test (ASTM D4402)

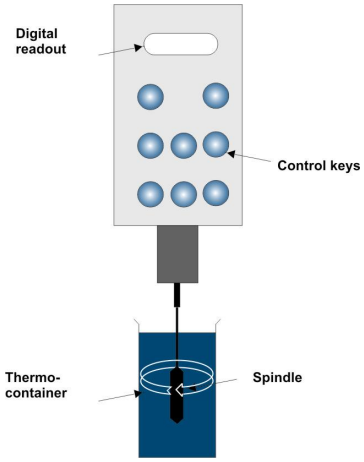
Significance and use:

- Measures resistance to flow (or shear stress)
- Assesses consistency at temperatures representing:
  - In-service conditions (60° C – high end)
  - Processing and application temperatures (135° C)
- Relationship of viscosity and temperature used to determine the correct temperatures for pumping, spraying, mixing and compaction of asphalt mixes.

Method:

- Measures the torque required to rotate a spindle immersed in bitumen.
- Viscometer used in SA - Brookfield model RV with Thermosel system using SC-4 type spindles.
- The SI unit of dynamic viscosity is the Pascal second (Pa.s).

Viscosity (dynamic)



Viscosity (dynamic)

Rolling thin film oven test (ASTM D2872)

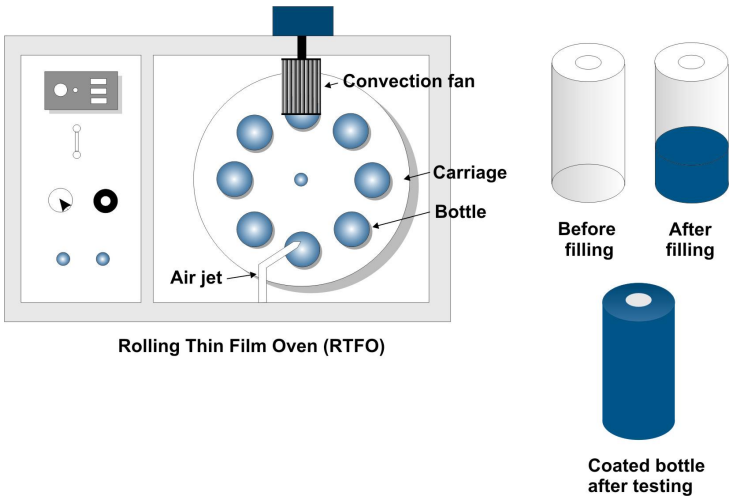
Significance and use:

- RTFOT subjects bitumen to ageing and hardening due to the effect of heat and oxidisation in the presence of air
- Simulates conditions in a hot-mix asphalt manufacturing plant.
- The aged material is tested to gauge its resistance to age-hardening.
- Does not simulate long term in-service ageing

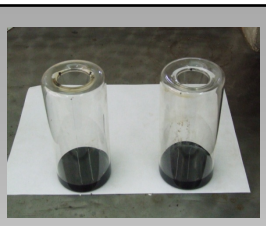
Method:

- Glass containers rotate in a vertical plane so that a fresh surface of bitumen is continuously being exposed to air (at 163°C) for 75 minutes
- Flow of air is blown over the surface of the bitumen from a single nozzle.
- At the end of the test, the change in mass, viscosity, softening point and penetration is assessed

RTFOT


Convection fan
Carriage
Bottle
Air jet
Rolling Thin Film Oven (RTFO)
Before filling
After filling
Coated bottle after testing

RTFOT

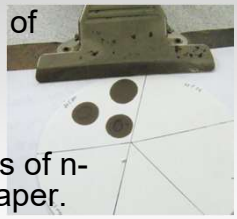


NORMALAB ANALIS

n-Heptane/Xylene Spot test (AASHTO T102)

Significance and use:

- Assesses the potential for a binder to be susceptible to oxidation thereby having an adverse effect on the durability of the bitumen during service on the road
- Not relevant for modified binders.
- Useful in identifying overheated or bitumen of unbalanced composition



Method:

- A solution of bitumen in prescribed mixtures of n-heptane and xylene dropped onto a filter paper.
- The test is negative when a uniformly brown stain is formed. Otherwise the test is positive.

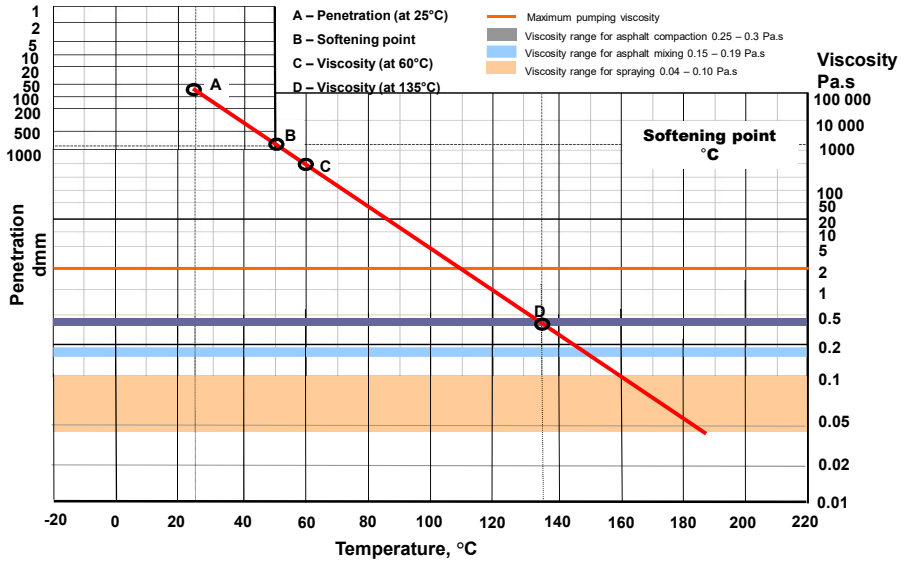
Bitumen test data chart (BTDC)

- Requirements for pen grade bitumen based on empirical measurements
- They DO ensure consistent rheological properties over temperature range:
  - Ambient
  - Application
  - 25 – 135° C

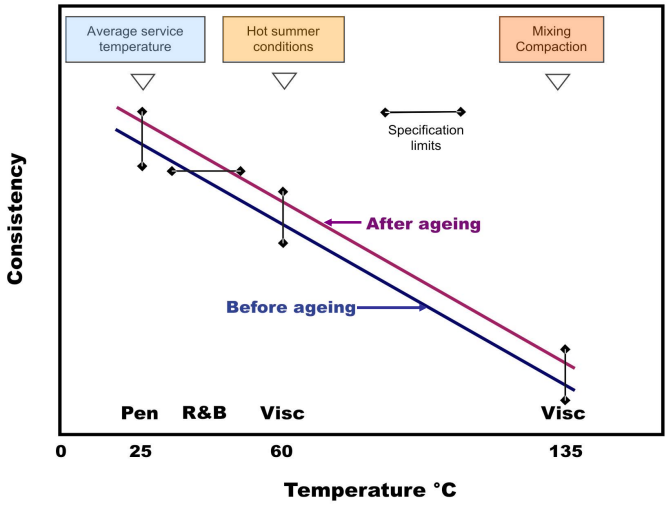
BTDC/cont…

- Provides system for common description of the following as a function of temperature:
  - Penetration value
  - Softening point
  - Viscosity at 60° C
  - Viscosity at 135° C

BTDC Heukelom



Consistency limits over temperature range



Tests on cutback bitumen

Specified in SANS 4001-BT2

Binder type	Property Tested	Test Standard
Cutback bitumen	Kinematic viscosity	ASTM D2170
	Distillation test	ASTM D402
	Penetration (on residue of distillation)	EN1426
	Flash point	ASTM D92
	Dynamic viscosity	ASTM D4402

Kinematic Viscosity test (ASTM D2170)

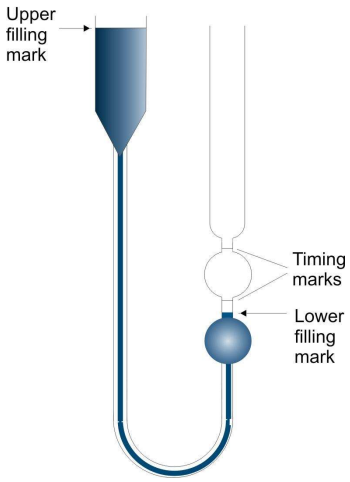
Significance and use:

- Used to classify cutback binders by their kinematic viscosity at 60°C (cSt)
- The lower limit of the viscosity range is the grade designation
- The upper limit is double this lower figure
- e.g. MC30 has a viscosity at 60°C in the range of 30 – 60 cSt
- Temperature/viscosity relationships used to determine the correct spraying, mixing and pumping temperatures

Method:

- The measurement is made by timing the flow of the binder through a glass U-tube capillary viscometer at a given temperature
- Each viscometer is calibrated and the product of efflux time and calibration factor gives the kinematic viscosity in Stokes

Kinematic viscosity test



Distillation test (ASTM D402)

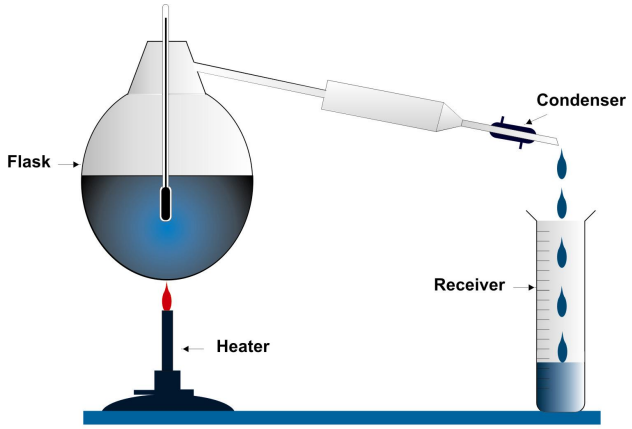
Significance and use:

- Measures the amount of the more volatile constituents in cutback bitumen
- Gives an indication of the rate of curing of the binder will through the evaporation of volatile fractions.
- Properties of the residue not necessarily characteristic of the bitumen used nor the residue left after field application

Method:

- The proportion and type of solvent present in is determined by:
  - heating the material
  - condensing the vapours and
  - noting the volume of the condensate collected at various specified temperatures up to 360°C.
- The remaining portion constitutes the binder content
- The residue of distillation is tested for penetration
- It is slightly softer than the original base bitumen (distillation process does not all the constituents of the solvent

Distillation test



Tests on bitumen emulsion

Tests specified in SANS 4001-BT3, 4 & 5

Binder type	Property tested	Test standard
Bitumen emulsions	Water content	ASTM D244
	Particle charge (anionic) (cationic)	SANS 4001-BT3 SANS 4001-BT4
	(Saybolt Furol) viscosity	ASTM D244
	Coagulation value test	SANS 4001-BT3,4
	Sieve test	SANS 4001-BT3,4
	Sedimentation test	SANS 4001-BT3,4

Water content test (ASTM D244)

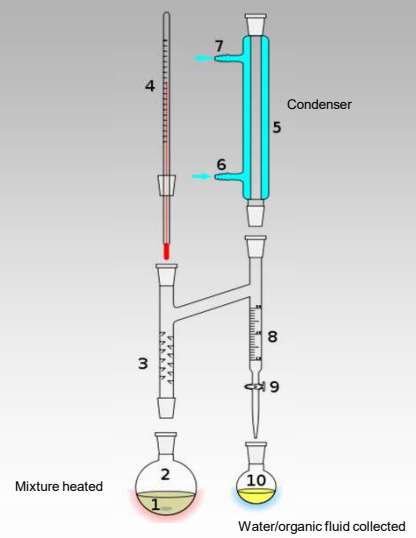
Significance and use:

- Measures the amount of water present in the emulsion, as distinct from bitumen or cutters.
- Bitumen emulsions may contain up to 40% of water v/v
- Essential that the quantity of residual bitumen (incl. cutters) applied to the road surface is accurately determined.

Method:

- Distillation using the Dean and Stark apparatus.
- An organic liquid immiscible with water (e.g. xylol) is added to the sample and the flask is heated
- The organic liquid distils into the receiving flask, carrying with it the water, which then separates into a lower layer.
- The volume of water is measured and, by difference, the residual binder content determined.

Dean and Stark apparatus



Particle charge test (SANS 4001-BT3 & BT4)

Significance and use:

This test distinguishes between cationic and anionic emulsions

Method:

- Two electrodes are immersed in a sample of emulsion and connected to a low power direct current source.
- If, at the end of the specified period, bitumen deposits are observed on the cathode (connected to the -ve pole of the current source) emulsion is cationic
- If the bitumen deposits are observed on the anode (connected to the +ve pole) the emulsion is anionic.

Viscosity test (ASTM D 244)

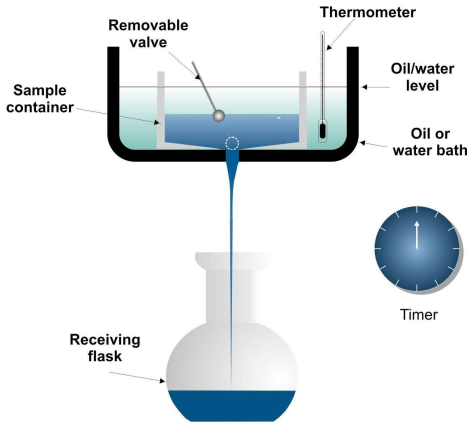
Significance and use:

- The viscosity of an emulsion is monitored to ensure that its flow properties are appropriate to the application (e.g. steep gradients and high cross fall)

Method:

- Measured by means of the Saybolt Furol Viscometer.
- Time (seconds) of efflux of a specified volume of emulsion through the standard orifice is measured at 50°C.

Saybolt Furol test



Coagulation value test (SANS 4001-BT3 & BT4)

Significance and use:

- This test determines the ability of a stable mix grade emulsion not to break prematurely in the presence of cement or lime

Method:

- Emulsion is stirred into a cement paste with further addition of water
- The materials are then washed through a 180 µm sieve
- The mass of materials retained expressed as a fraction of the binder in the emulsion sample used is the coagulation value.

Sieve test (SANS 4001-BT3 & BT4)

Significance and use:

- This test assesses the quality of an emulsion in terms of bitumen particle size.
- The bitumen particles in a good quality emulsion should be so small that virtually all pass through a very fine sieve

Method:

- A quantity of emulsion is poured through a 150µm sieve
- After rinsing, the amount of bitumen in the form of large particles, strings or lumps retained on the sieve is determined.

Sedimentation test (SANS 4001-BT3 & BT4)

Significance and use:

- This test ensures that the emulsion possesses adequate storage stability, especially when packaged in drums

Method:

- A sample of emulsion is placed in a jar, which is centrifuged for a specified time at a specified speed
- After the centrifuge stops no excessive sedimentation should occur.
- The degree of sedimentation is determined by rotating the jar end over end in a special apparatus until the sediment is re-dispersed in an added soap solution.

Tests on modified binders

Tests on modified binders are covered comprehensively in TG 1

BINDER TYPE	PROPERTY TESTED	TEST STANDARD
Modified Binders	Flash Point	ASTM D93
	Modified rolling thin film oven test	MB-3
	Elastic recovery of polymer modified binders by ductilometer	MB-4
	~~Torsional recovery of polymer modified binders~~	~~MB-5~~
	Storage stability of polymer modified binders	MB-6
	~~Modified Vialit adhesion test~~	~~MB-7~~
	Pull out test method for surfacing aggregate	MB-8
	~~Pliers test for assessment of adhesion properties~~	~~MB-9~~
	Ball penetration and resilience of bitumen-rubber blends	MB-10
	Compression recovery of bitumen-rubber binders	MB-11
	Flow test for bitumen-rubber binders	MB-12
	Dynamic viscosity of bitumen-rubber binders	MB-13
	Particle size distribution & loose fibre content of rubber crumb	MB-14
	Bulk density of rubber crumb	MB-16
	Softening point of modified binders by ring and ball method	MB-17
	Dynamic (apparent) viscosity of polymer modified binders	MB-18
	Recovery of residue of modified bitumen emulsions	MB-20
	Viscosity of modified bitumen emulsions by means of the Saybolt- Furol viscometer	MB-21
	Water content of modified bitumen emulsions	MB-22
	Residue on sieving of modified bitumen emulsions	MB-23
	Particle charge of modified bitumen emulsions	MB-24

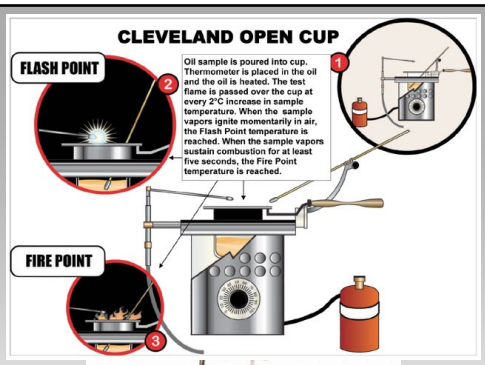
Flash Point (ASTM D93)

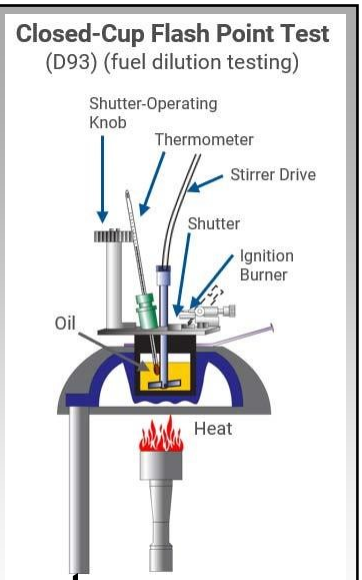
Significance and use:

- The flash point of a volatile liquid is the lowest temperature at which it can vaporise to form an ignitable mixture in air. Flash point is used in shipping and safety regulations to define flammable and combustible materials

Method:

- In the closed cup flash point test, a brass test cup is filled with a test specimen and fitted with a cover.
- The sample is heated and stirred at specified rates and an ignition source is directed into the cup at regular intervals with simultaneous interruption of stirring until a flash that spreads throughout the inside of the cup is seen.
- The corresponding temperature is its flash point





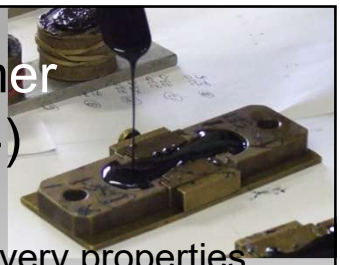
Flash point apparatus (open & closed cup)

66

Modified RTFOT (M

- Has a similar purpose and procedure to that described under the RTFOT on penetration grade bitumen
- To deal with the complex flow characteristics of modified binders a larger quantity of binder is used and metal treatment bottles with internal rollers are employed.

Elastic recovery of polymer modified binders (MB-4)

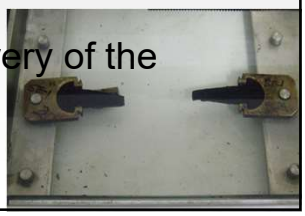


Significance and use:

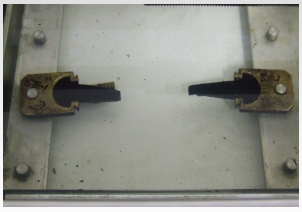
- Used to assess the elastic recovery properties of a polymer modified binder

Method:

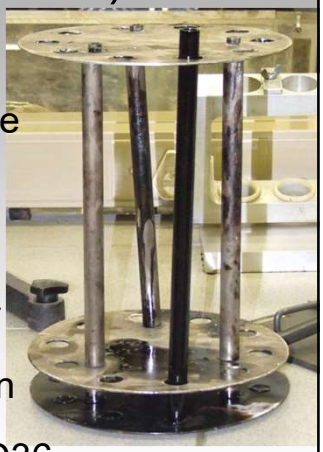
- Moulded specimens are extended for a distance of 200 mm in a ductilometer under controlled conditions.
- The elongated thread is cut
- After one hour the extent of recovery of the thread is measured.



Elastic recovery contd



Storage stability of polymer modified binders (MB-6)



Significance and use:

- The resistance of the modified binder to segregation between the modifying agent and the base bitumen during hot storage

Method:

- The softening points of the upper and lower third of a cylindrical specimen stored in a heated oven for three days are determined in accordance with method ASTM D36
- The difference in softening point is recorded in ^{o}C.

Pull out test for surfacing aggregate (MB-8)

Significance and use:

- Used to determine whether aggregates in a surfacing are sufficiently held by the binder to allow opening to traffic

Method:

- The average force required to dislodge a number of stones from the surfacing (corrected for temperature) is measured
- This force is compared to recommended minimum requirements for a set of conditions related to traffic road geometry and season.

Ball penetration and resilience of bitumen-rubber blends (MB-10)

Significance and use:

- Similar to the penetration test as it measures the relative hardness and consistency of bitumen rubber blends at 25° C.

Method:

- The penetration of a standard ball into non-aged and oven-aged binder as well as the rebound recovery is measured in this test
- A value of resilience is calculated from the results of the test.

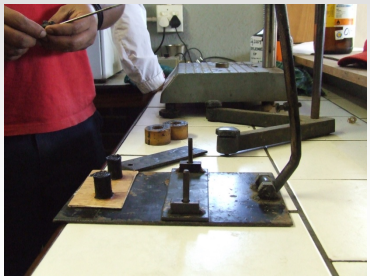
Compression recovery of bitumen-rubber binders (MB-11)

Significance and use:

- The compression recovery of bitumen-rubber is an indication of the contribution of the rubber crumbs to the elasticity of the binder

Method:

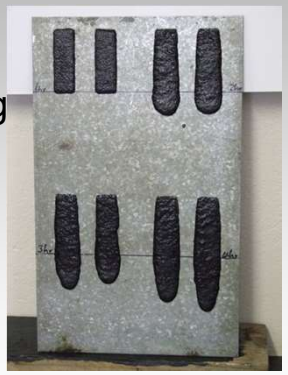
- The elastic recovery of a bitumen-rubber cylinder is measured after it has been compressed to half its original height
- The recovery is defined as the height of the recovered specimen, expressed as a percentage of the original height.



Flow test for bitumen-rubber binders (MB-12)

Significance and use:

- An indication of the flow characteristics at temperatures comparable to the upper operating temperatures in a pavement



Method:

- The flow distance of a specimen placed on a smooth metal plate inclined at an angle of 35° and subjected to a temperature of 60° C for 4 hours is reported in mm

Dynamic viscosity of bitumen-rubber binders (MB-13)

Significance and use:

- The viscosity is tested
  - in a laboratory at its recommended spray temperature
  - on site before, during and after spraying
  - to ensure that it is sprayable without congestion of the pump/spray bar system

Method:

- The test is conducted with a hand-held, battery operated rotary viscometer

Softening point of modified bitumen (MB-17)

The significance and method of this test is as described above under ASTM D36 for *penetration grade bitumen.*

Dynamic viscosity of polymer modified bitumen (MB-18)

The significance and method of this test is as described above under ASTM D4402 for *penetration grade bitumen.*

Take care at lower temperatures for very stiff modified binders

Recovery of residue of modified bitumen emulsion (MB-20)

Significance and use:

- The residue recovered in this procedure is representative of the modified binder on the road after the evaporation of fluxing oils. It is subjected to further testing

Method:

- This test is performed either with a rotary evaporator or a simple evaporation method using a Bunsen burner, during which the emulsion is heated and the residue of modified binder obtained
- The simple method is more suitable for site use.

Viscosity of modified bitumen emulsions by means of the Saybolt-Furol viscometer (MB-21)

The significance and method of this test is as described above under ASTM D244 for bitumen emulsions

Water content of modified bitumen emulsions (MB-22)

The significance and method of this test is as described above under ASTM D244 for bitumen emulsions.

Residue on sieving of modified bitumen emulsions (MB-23)

The significance and method of this test is as described above under SANS 309 and 548 for bitumen emulsions.

Particle charge of modified bitumen emulsion (MB-24)

Significance and use:

- This test distinguishes between cationic and anionic emulsions

Method:

- Method ASTM D244 is followed with the exception that thickness of the electrode is 0.71 mm

Tests on precoating fluids

Binder type	Properties Tested	Test standard
Precoating fluids	Density	
	Saybolt Furol viscosity	ASTM D244
	Distillation test	ASTM D402
	Dynamic viscosity	ASTM D4402
	Stripping test	Riedel & Weber

Viscosity test (Test method ASTM D244)

Significance and use:

- The viscosity of a precoating fluid is monitored to ensure adequate coating of surfacing aggregates that may be damp or dusty

Method:

- The viscosity is measured by means of the Saybolt Furol viscometer at 50°C.

Distillation test (ASTM D402)

Significance and use:

- A measure of the amount of the more volatile constituents
- Indication of the rate of curing through the evaporation of volatile fractions - leaving a non-tacky residual film on the surface of the aggregate

Method:

- The proportion and type of solvent present in the precoating fluid is determined by
  - heating the material
  - condensing the vapours
  - noting the volume of the condensate collected at various specified temperatures up to 360°C.
- The undistilled portion remaining constitutes the binder content of the cutback.

Stripping test (Riedel & Weber)

Significance and use:

- Assesses the effectiveness of the precoating fluid to promote adhesion of the aggregate to binder
- The results can only be regarded as indicative

Method:

- Coated aggregate is boiled successively in distilled water and in increasing concentrations of sodium carbonate (numbered 0 to 9 corresponding to 0 and 1 molar concentrations, respectively)
- The number of the concentration at which the bitumen strips to such an extent that it is no longer a film but only specks or droplets, is called the stripping value.

Tests on rubber

The following tests are carried out to assess the suitability of rubber crumbs for use in bitumen-rubber binders and are described in detail in TG1:

- Particle size distribution and loose fibre content of rubber crumbs (MB-14)
- Resilience of rubber crumbs (MB-15)
- Bulk density of rubber crumbs (MB-16)

Tests on bituminous binders

- Sampling
- Properties tested
- Standard test methods
- Performance grade tests

PG Specification framework

- Operating categories;
  - Climate
  - Traffic
- Resistance to viscous flow;
- Resistance to fatigue / durability cracking;
- Low temperature cracking;
- Mandatory reporting (interim)
- Storage stability;

Operating categories - climate

- Grading designation related to:
- Maximum temperature
  - average 7-day max pavement design temperature (20 mm below road surface)
  - 58°C, 64°C and 70°C
  - the minimum pavement design temperature.
- Minimum temperature
  - Minimum temperature at road surface

Minimum grading temperature

- Minimum ***grading temp*** aligned to US standard
- Determine temperatures at which other tests are carried out
  - intermediate temp for fatigue (durability)
  - low temperature cracking.
  - low temperatures associated with 58°C, 64°C and 70°C are -22°C, -16°C and -10°C, respectively (80°C difference in all cases)

Traffic

- Traffic classified in terms of:
  - Standard S
  - Heavy H
  - Very Heavy V
  - Extreme E
- Traffic in the design lane - 20 year period
- The classification is based on both ***volume*** and ***speed***

Categories

Design traffic (million E80)[a]	Traffic Speed (km/h)		
	< 20	20 - 80	>80
< 0.3	S	S	S
0.3 - 3	H	S	S
>3 - 10	V	H	S
>10 - 30	E	V	H
>30 - 100	E	E	V
> 100	E	E	E

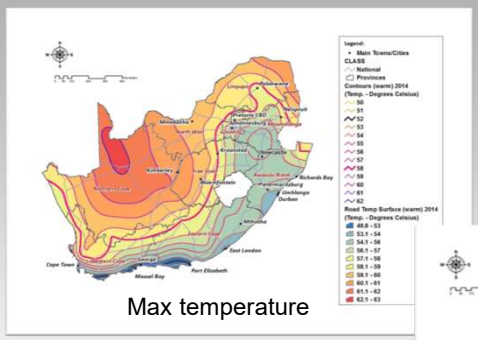
Binder classification

Classification	58S -22	58H -22	58V -22	58E -22	64S -16	64H -16	64V -16	64E -16	70S -10	70H -10	70V -10	70E -10
Maximum pavement design temperature, Tmax (˚C)	58				64				70			
Minimum grading temperature, Tmin (˚C)	-22				-16				-10			

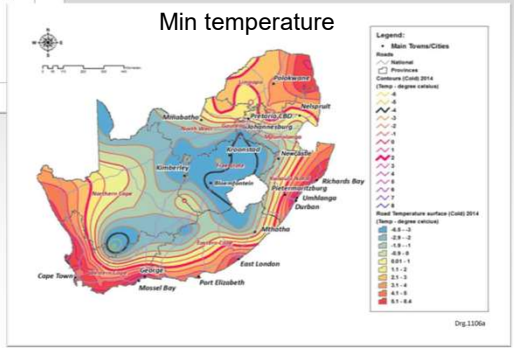
Test temperatures

- ***Maximum temperature, T_{max}***: maximum pavement design temperature,
  - e.g. 58°C, 64°C, 70°C
- ***Minimum grading temperature, T_{min}***: adopted *for grading purposes,*
  - *e.g. -22°C, -16°C & - 10°C*
- ***Intermediate temperature, T_{IT}***: $[(T_{max} + T_{min})/2 + 4]°C$
- ***Low temperature: T_{LT}***: $[T_{min}+10]°C$

SA Temperatures



Max temperature



Min temperature

Specified tests – unaged binder

- Unaged
  - G*/sinδ - at 10 rad / sec quick indication of binder stiffness for quality control
  - Viscosity at 165°C – pumpability
  - Storage stability
    - 30 cm test tube
    - 180°C for fixed period
    - DSR evaluation on top and bottom portions
    - $[G^*_{high} – G^*_{low}]$ measured at Tmax
  - Flash point

Specified tests after RTFOT

- ***Mass change***
  - As per SANS 4001-BT1
  - ≤ 1% m/m for all classes
- ***Non-recoverable compliance (J_{NR})*** *at* T_{max}
  - S-Class, $J_{NR} \leq 4.5$
  - H-Class, $J_{NR} \leq 2.0$
  - V-Class, $J_{NR} \leq 1.0$
  - E-Class, $J_{NR} \leq 0.5$

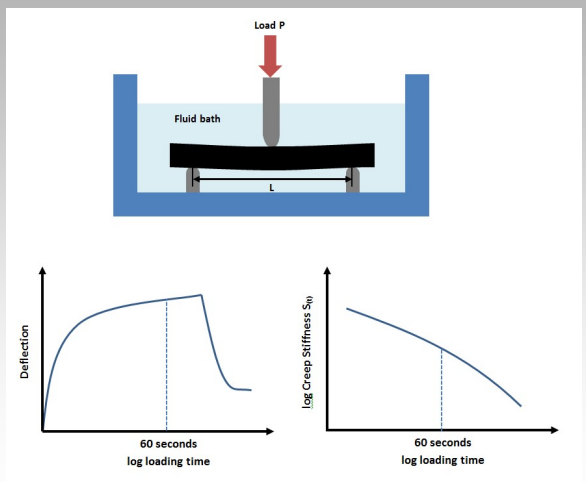
Specified tests after RTFOT

- Ageing ratio
  - G* and δ are measured at 10 rad/s at the intermediate temperature
  - Ageing ratio is calculated as the ratio between the aged bitumen and the unaged bitumen,
    - i.e. $G^*_{RTFO} / G^*_{Original}$ for the RTFO-aged bitumen.

PAV aged binder

- BBR testing
  - Max creep stiffness at 60 s, S(60)
  - Minimum m-value at 60 s, m(60)
  - ΔTc parameter > -5°C
  - at T_{min} +10°C

BBR test



Determination of ΔT_c

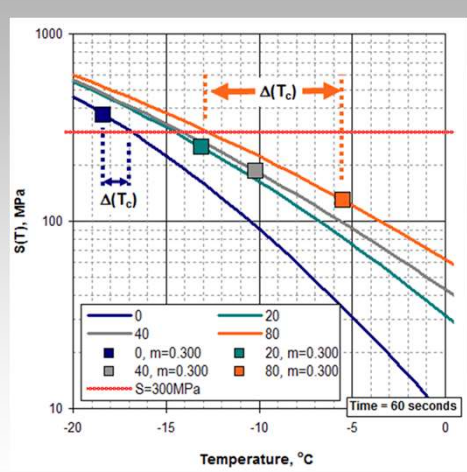
$$\Delta T_c = T_c S - T_c\, m$$

where:

$T_c S$ – *critical temperature at which* $S(60\ s)$ *is* $300\ MPa$

$T_c\, m$ – *critical temperature at which* $m(60\ s)$ *is* $0.3\ MPa/s$

Determination of ΔT_c



Test standards

Property	Equipment	Test standard	Comment
G* and δ at T_{IT}	DSR	ASTM D7175	Report only
G*/sinδ at T_{Max}	DSR	ASTM D7175	Report only
Viscosity at 165°C	Brookfield viscometer	ASTM D4402	
G^*_T, G^*_B at T_{Max}	DSR		Storage stab.
Flash point °C	Cleveland Open Cup	ASTM D92	
Short term ageing	RTFOT	ASTM D2872 / TG1 MB3	
J_{NR} at T_{Max}	DSR	ASTM D7405	
Long term ageing	PAV	ASTM D6521	
S(60), m(60), ΔT_c	BBR	ASTM D6648	

SATS 3028 Requirements

Test property	Performance grade											
	58S -22	58H -22	58V -22	58E -22	64S -16	64H -16	64V -16	64E -16	70S -10	70H -10	70V -10	70E -10
Maximum pavement design temperature, T_{max} (˚C)	58				64				70			
Minimum grading temperature, T_{min} (˚C)	-22				-16				-10			
	Original binder											
G* and δ at T_{IT}, Pa, degrees	Compulsory report only during implementation phase											
G*/sinδ, at 10 rad/sec and T_{max}, (kPa)	Compulsory report only											
Viscosity @ 165˚C, ≥30 s^{-1}, (Pa.s)	≤ 0.9											
Storage stability at 180°C (% diff, G^*_T and G^*_B) at T_{max} [1]	≤ 15											
Flash Point (˚C)	≥ 230											
	After RTFO ageing											
G* and δ at T_{IT}, Pa, degrees	Compulsory report only during implementation phase											
Mass Change (m/m), (%)	≤ 1.0											
J_{NR} @ T_{max}, (kPa^{-1})	≤ 4.5	≤ 2.0	≤ 1.0	≤ 0.5	≤ 4.5	≤ 2.0	≤ 1.0	≤ 0.5	≤ 4.5	≤ 2.0	≤ 1.0	≤ 0.5
Ageing Ratio, $G^*_{RTFOI}/G^*_{Original}$	≤ 3.0											
	After RTFO and PAV ageing											
G* and δ at T_{IT}, Pa, degrees	Compulsory report only during implementation phase											
Creep stiffness, S (60s) at T_{min} + 10ºC, MPa,	≤ 300											
m (60s) at T_{min} + 10ºC, minimum, MPa/s	≥ 0.300											
$\Delta T_c = T_c S - T_c m$, (ºC)	≥ −5											
Ageing Ratio, $G^*_{PAV}/G^*_{Original}$	≤ 6.0											

Note:

[1] While the binder is sampled at 180°C, G* is determined at T_{max}

Module 3 - Summary

- Specifications and tests are intended to ensure that binders are manufactured to accepted, uniform standards that will ensure satisfactory performance;
- A safeguard that binders are not adversely affected during correct handling
- Tests should be carried out meticulously - strictly in accordance with the test standard
  - ***Small deviations from the method***
  - ***Significant differences in results***