HISTORY OF ASPHALT GRADING SYSTEMS

Grading By Chewing

- Chewing - first mode of testing to determine asphalt hardness
- Initially used for natural asphalts such as Trinidad Lake asphalt
- Trinidad asphalt contains colloidal clay of volcanic origin
- Solubility in carbon disulfide used to determine the purity
- First sheet asphalt pavement using Trinidad asphalt - Pennsylvania Avenue, Washington, DC (1876)

Penetration Grading

- Bowen of Barber Asphalt Co. invented penetration test in 1888
- Many modifications of No. 2 sewing needle (tip truncated)
- Specified load, time, and temperature
- ASTM Committee D-4 adopted penetration test (1903)
- Non-uniformity in application of penetration values by states

Penetration Grading (cont.)

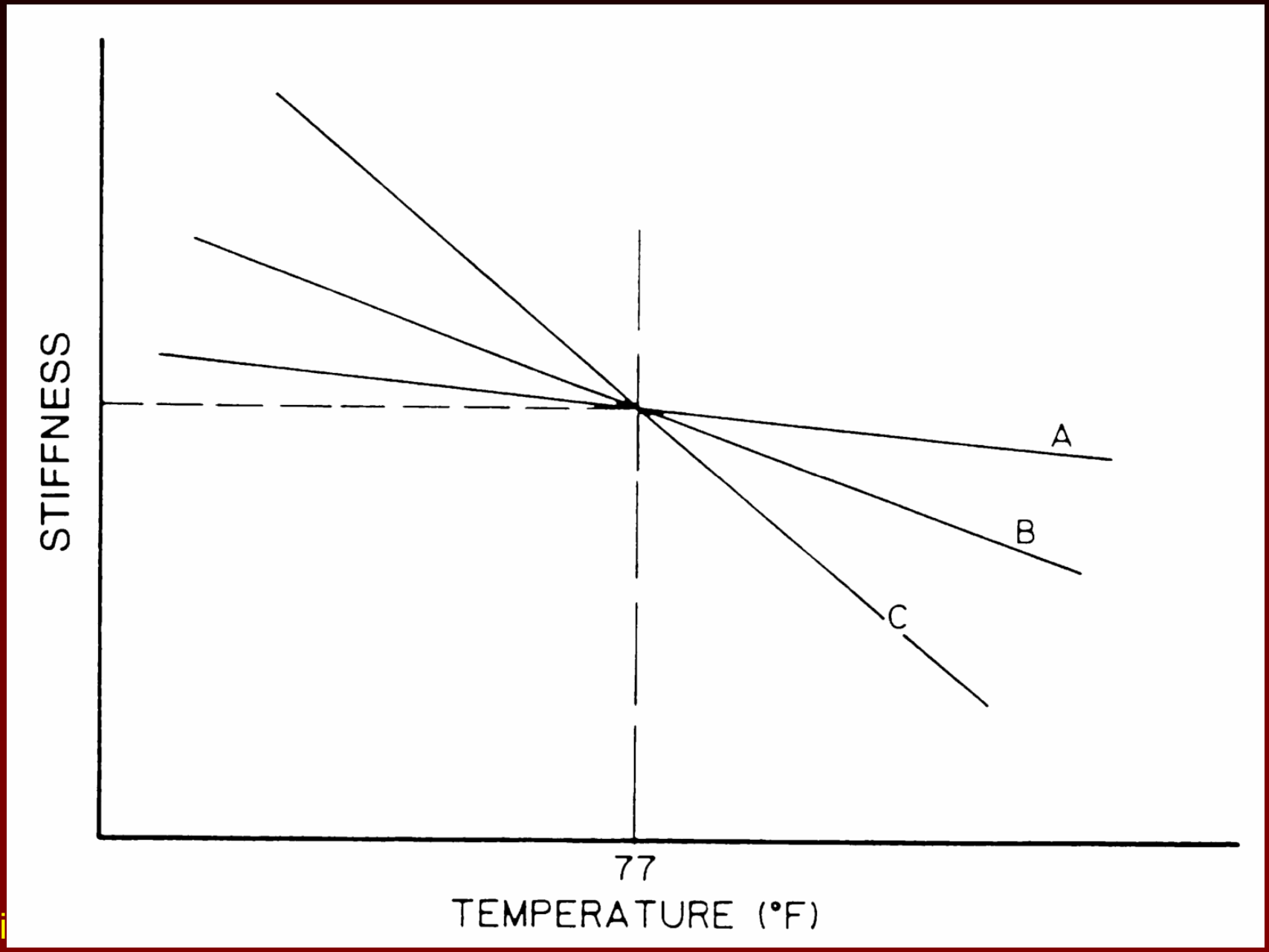
- 1918 Bureau of Public Roads (now FHWA) developed penetration grades and recommended uses for northern and southern states
- 1931 AASHTO published specifications
- 1955 Thin film oven (TFO) test added
- Current: Five penetration grades specified

40 - 50	120 - 150
60 - 70	200 - 300
85 - 100	

ASTM D 946 Penetration Graded Asphalt Cements

	Penetration Grade									
	40-50		60-70		85-100		120-150		200-300	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Penetration at 77°F (25°C) 100 g, 5 s	40	50	60	70	85	100	120	150	200	300
Flash point, °F	450	...	450	...	450	...	425	...	350	...
Solubility in trichloroethylene, %	99.0	...	99.0	...	99.0	...	99.0	...	99.0	...
Retained penetration after TFO, %	55+	...	52+	...	47+	...	42+	...	37+	...
Ductility at 77°F (25°C) cm after TFO	...	...	50	...	75	...	100	...	100	...

Temperature Susceptibility of Asphalts



Penetration Grading

- Advantages
  - Consistency at average service temperature
  - Short testing time
  - Adaptable to field applications (contamination)
  - Relatively low equipment cost

Penetration Grading (Cont.)

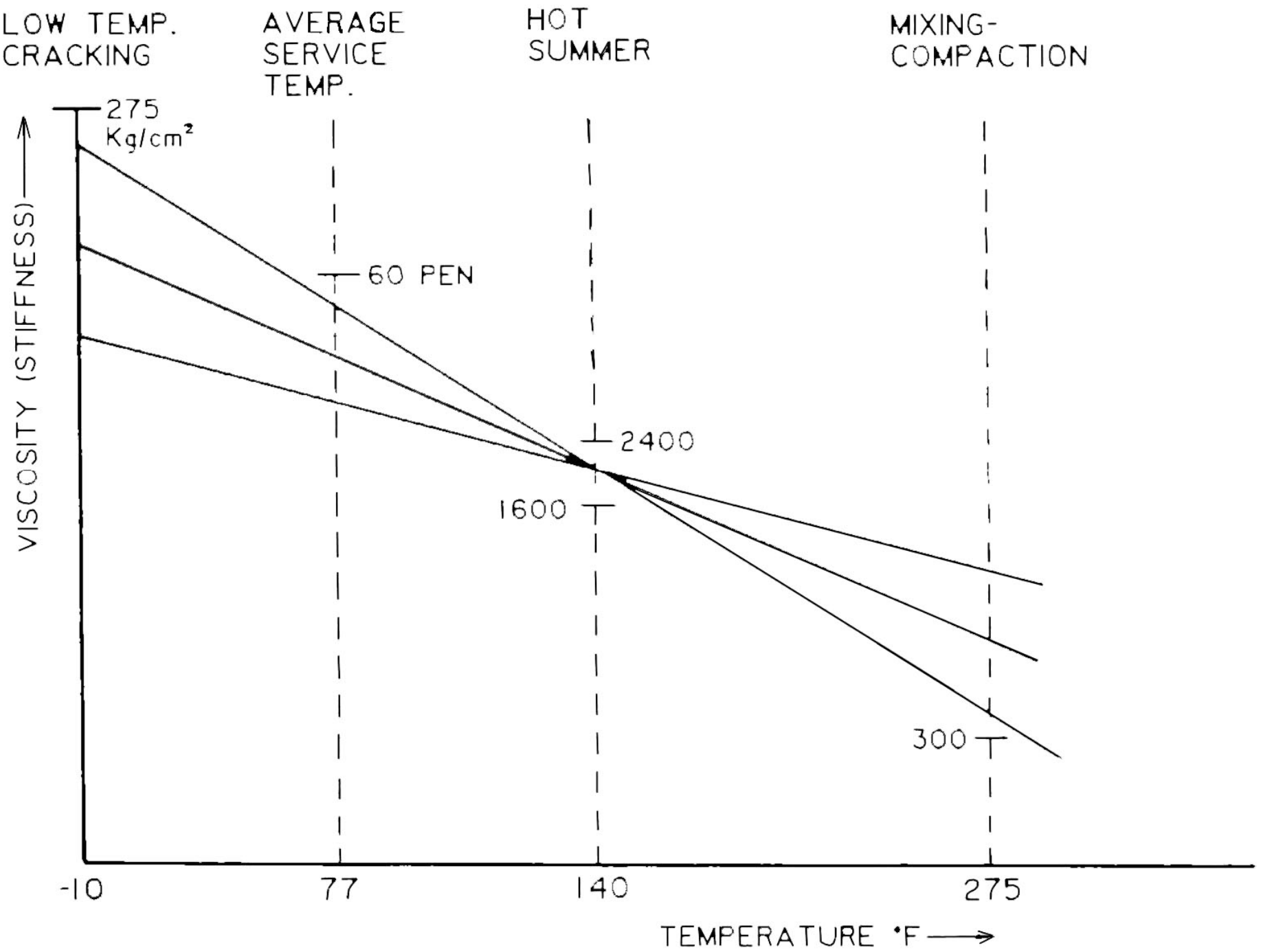
- Disadvantages
  - Grade overlap (85-100 grade = AC-5, AC-10, or AC-20)
  - Similitude at 77°F deceptive to performance at higher and lower service temperatures
  - Rates of test (shear rate) high and variable
  - No viscosity available near mixing and compaction temperatures

Viscosity Grading

- Developed due to construction and high temperature performance problems
- Fundamental rather than empirical units
- Approach similar to oils and liquid asphalts
- FHWA/Asphalt Institute (1963)
- Five grades established

AC - 2.5	AC - 20
AC - 5	AC - 40
AC - 10	

- Included viscosity at 275 F (135 C)
- Two tables specified (Tables 1 and 2 of ASTM D3381)
- AC-30 developed by southeastern states


LOW TEMP.
CRACKING
AVERAGE
SERVICE
TEMP.
HOT
SUMMER
MIXING-
COMPACTION
275
Kg/cm²
VISCOSITY (STIFFNESS)
60 PEN
2400
1600
300
-10
77
140
275
TEMPERATURE °F

ASTM D 3381 Viscosity Graded Asphalt Cements (Table 1)

Test	Viscosity Grade				
	AC-2.5	AC-5	AC-10	AC-20	AC-40
Viscosity, 140°F (60°C), P	250±50	500±100	1000±200	2000±400	4000± 800
Viscosity, 275°F (135°C), min, cSt	80	110	150	210	300
Penetration, 77°F (25°C), min	200	120	70	40	20
Tests on TFO residue:					
Viscosity, 140°F (60°C), max, P	1250	2500	5000	10,000	20,000
Ductility, 77°F (25°C), min, cm	100	100	50	20	10

ASTM D 3381 Viscosity Graded Asphalt Cements (Table 2)

Test	Viscosity Grade					
	AC-2.5	AC-5	AC-10	AC-20	AC-30	AC-40
Viscosity, 140°F (60°C), P	250±50	500±100	1000±200	2000±400	3000±600	4000±800
Viscosity, 275°F (135°C), min, cSt	125	175	250	300	350	400
Penetration, 77°F (25°C), min	220	140	80	60	50	40
Tests on TFO residue:						
Viscosity, 140°F (60°C), max, P	1250	2500	5000	10,000	15,000	20,000
Ductility, 77°F (25°C), min, cm	100	100	75	50	40	25

Viscosity Grading

- Advantages
  - Suitability to wide range of environments - Pavement temperature from 77°F (25°C) to 140°F (60°C)
  - Property fundamental - Independent of test system and sample size
  - Viscosity available near construction temperatures

Viscosity Grading (Cont.)

- Disadvantages
  - Still some grade overlap (AC-20 = 60-70 or 85-100 penetration grade)
  - Grading at 140°F (60°C) deceptive to performance at average service temperatures
  - TFOT residue viscosity can vary considerably within the same grade
  - No safeguard against low temperature cracking
  - Not suitable for modified asphalt binders

Aged Residue (AR) Grading

- Developed in 1960s following viscosity grading
- Aimed at setting problem (tender mix)
- RTFO preferred over TFO
- Lead by California Dept. Of Highways
- Five grades established (Table 3 of ASTM D3391)

AR - 1000	AR - 8000
AR - 2000	AR - 16000
AR - 4000	

- Minimum penetration at 77°F (25°C) and minimum viscosity at 275°F (135°C) for RTFO residue specified

ASTM D 3381 Viscosity Graded Asphalt Cements (Table 3 - Grading Based on RTFOT Residue)

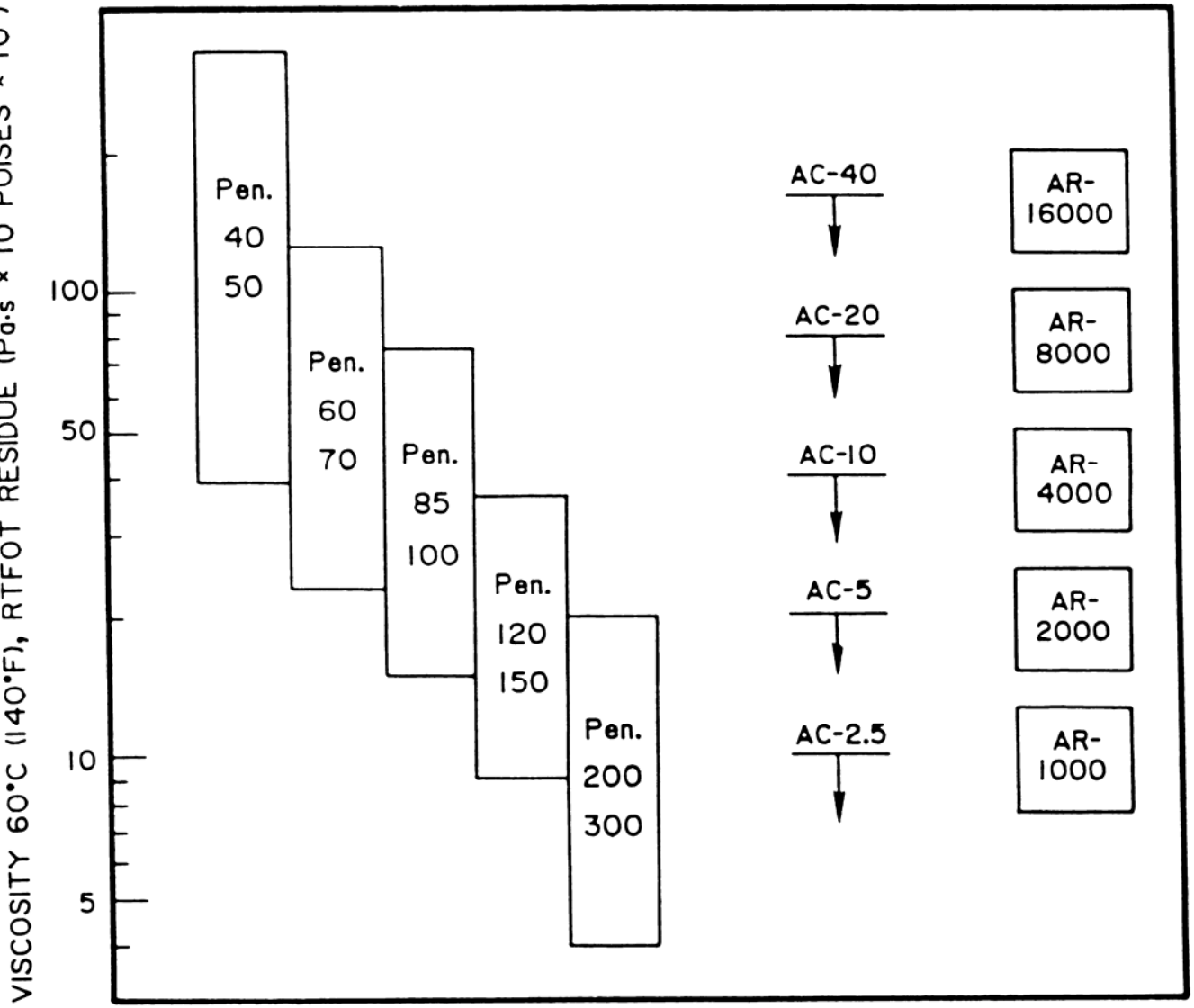
Tests on RTFOT Residue:	Viscosity Grade				
	AR-1000	AR-2000	AR-4000	AR-8000	AR-16000
Viscosity, 140°F (60°C), P	1000±250	2000±500	4000±1000	8000±2000	16000±4000
Viscosity, 275°F (135°C), min, cSt	140	200	275	400	550
Penetration, 77°F (25°C), min	65	40	25	20	20
% of original penetration, min	...	40	45	50	52

Asphalt Residue (AR) Viscosity Grading

- Advantages
  - Represents asphalt properties after mixing
  - Property fundamental - Independent of test system
  - Suitability to wide range of environments - Pavement temperature from 77°F (25°C) to 140°F (60°C)

Asphalt Residue (AR) Viscosity Grading (cont.)

- Disadvantages
  - Highly regional
  - Requires more test temperatures
  - Longer testing time (no consistency test on original asphalt)



Comparison of Penetration Grades and Viscosity Grades of Asphalt Cement (based on RTFOT Residue for AR–Grades and Penetration Grades; TFOT Residue for AC–Grades)

Superpave Performance Graded (PG) Binder System

- Developed during the SHRP Research Program, 1987-1992
- Aimed at addressing:
  - Climatic effects from complete range of pavement service temperatures
  - Construction
  - Aging during construction and in-service
  - Traffic speed
  - Traffic volume