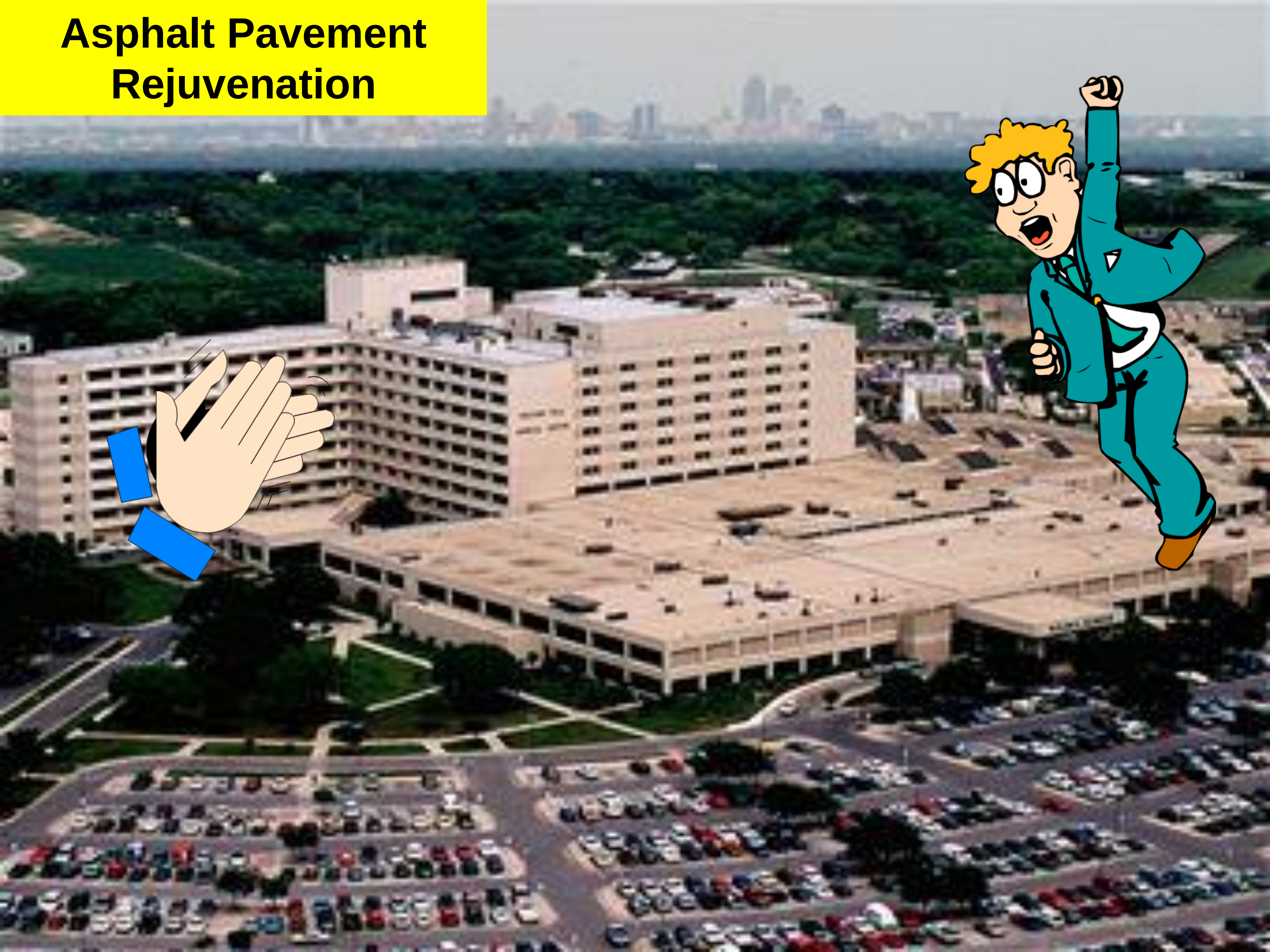
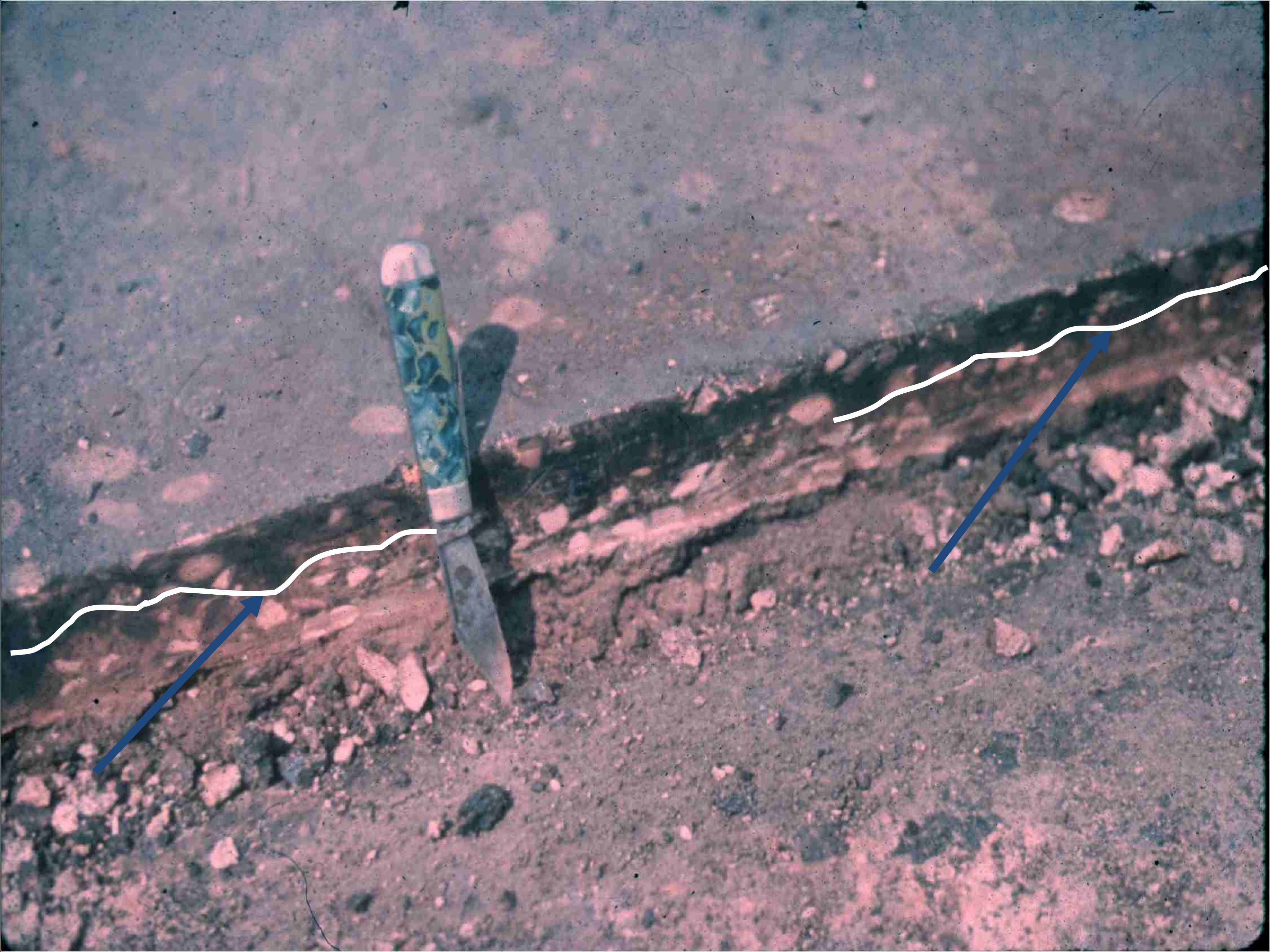
ASPHALT PAVEMENT REJUVENATION

Robert E. Boyer, PhD, PE
Consultant – Asphalt Pavements

ncpp
National Center for Pavement Preservation

Asphalt Pavement Rejuvenation





“Asphalt Pavement Rejuvenators”

- Importance of Rejuvenators
- Understanding Rejuvenators
- Using Rejuvenators

“Asphalt Pavement Rejuvenators” OVERVIEW - 1

- **Importance of Rejuvenators**
  - **Pavement Preservation**
  - **Economic Benefit**

Pavement Preservation Techniques

Crack Seal

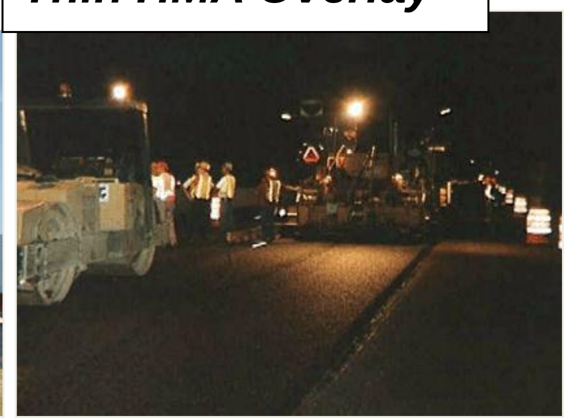
Rejuvenator

Slurry Seal

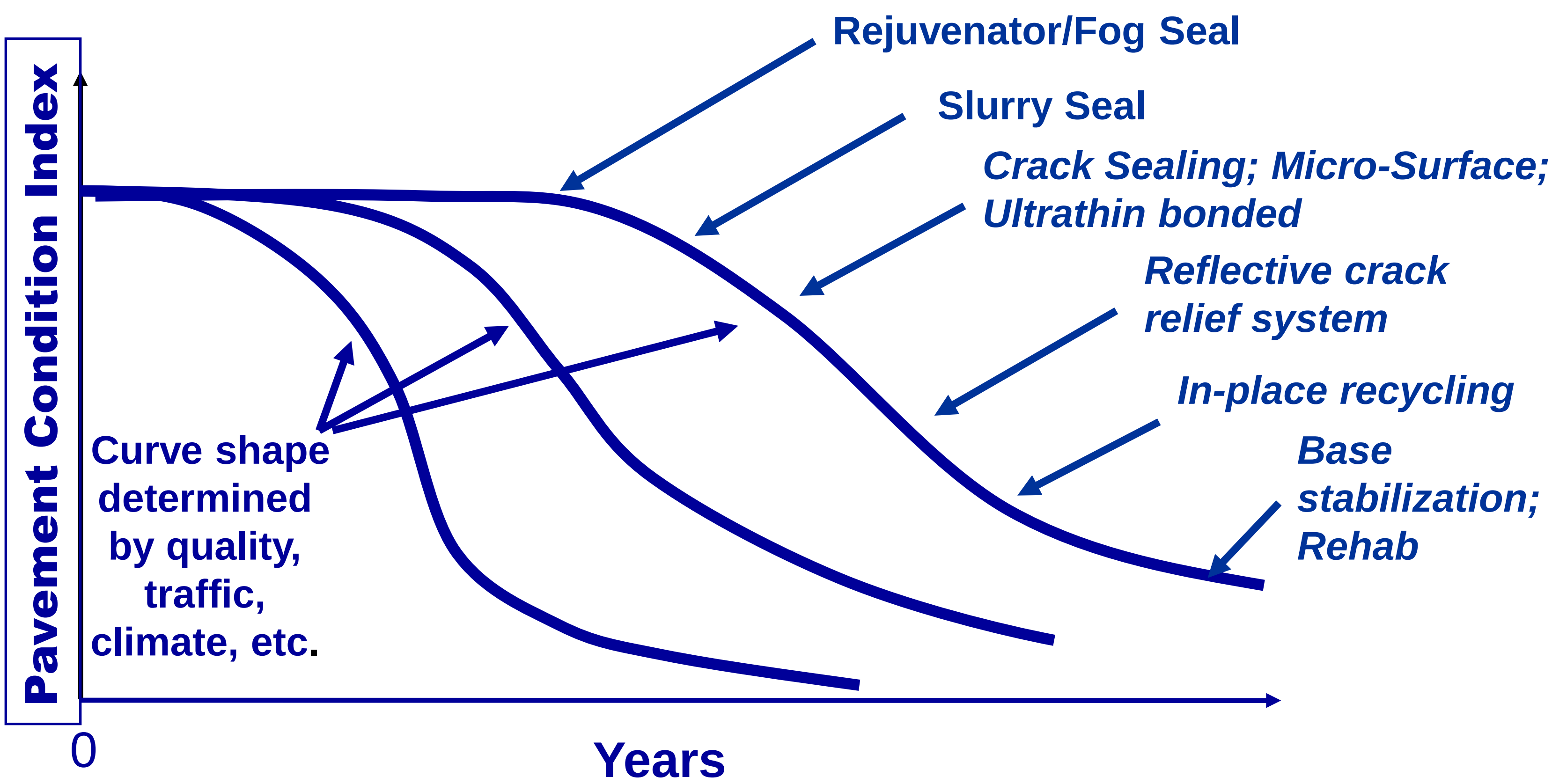
Micro-Surfacing

Ultrathin Bonded Wearing Course

Thin HMA Overlay



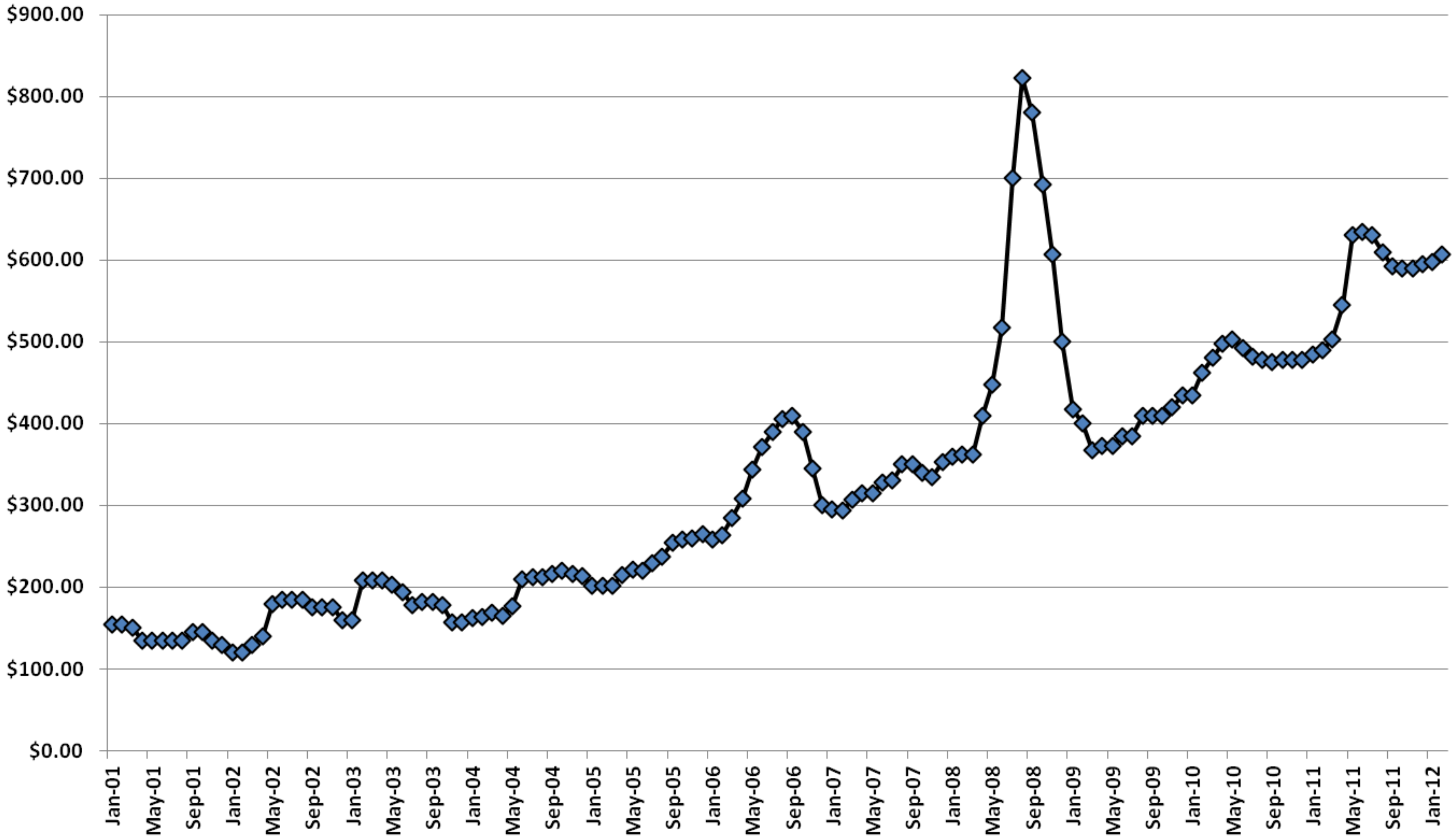
Pavement Preservation Timing



Timing --- PCI = 70

Asphalt Binder Prices

Cost History: January 2001 thru January 2012



<$150/Ton: 2002 **>$800/Ton: 2008** **?$700/Ton: 2012**

Average Cost: HMA In-Place $21/ton to $97 ton past 9 years.

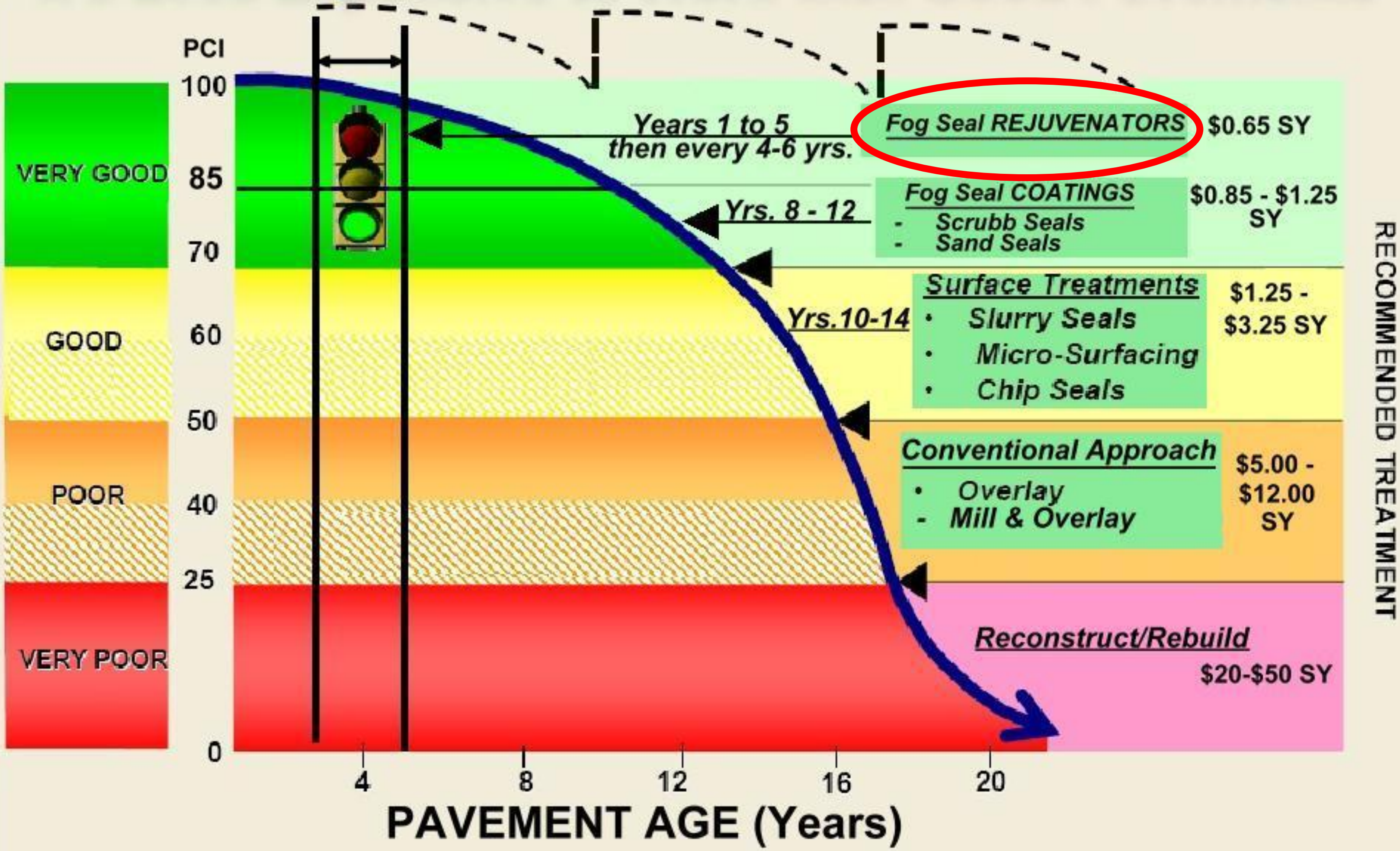
AC Cost Impact on HMA & Paving

Liq. AC COST ton	AC COST lb.	Lbs. AC in 1 Ton HMA @ 6%	AC Cost in 1 Ton HMA	AC Cost SY 1.5" OL	AC Cost Per Lane Mile (11'w)	HMA COST PER TON IN-PLACE	OL Cost for One Lane Mi.
$150	$0.08	120	$9.00	$0.75	$4,840	$21	$11,012
$200	$0.10	120	$12.00	$1.00	$6,453	$28	$14,683
$250	$0.13	120	$15.00	$1.25	$8,066	$35	$18,354
$300	$0.15	120	$18.00	$1.50	$9,680	$41	$22,025
$350	$0.18	120	$21.00	$1.75	$11,293	$48	$25,696
$400	$0.20	120	$24.00	$2.00	$12,906	$55	$29,366
$450	$0.23	120	$27.00	$2.25	$14,519	$62	$33,037
$500	$0.25	120	$30.00	$2.50	$16,133	$69	$36,708
$550	$0.28	120	$33.00	$2.75	$17,746	$76	$40,379
$600	$0.30	120	$36.00	$3.00	$19,359	$83	$44,050
$650	$0.33	120	$39.00	$3.25	$20,972	$90	$47,720
$700	$0.35	120	$42.00	$3.50	$22,586	$97	$51,391

Cost for 1 lane mile - $11K to $51K.

PAVEMENT PRESERVATION

It's Less Expensive to Work with Good Pavements



Importance of Rejuvenators

Economic Benefit

10 Miles of Rejuvenator

FOR

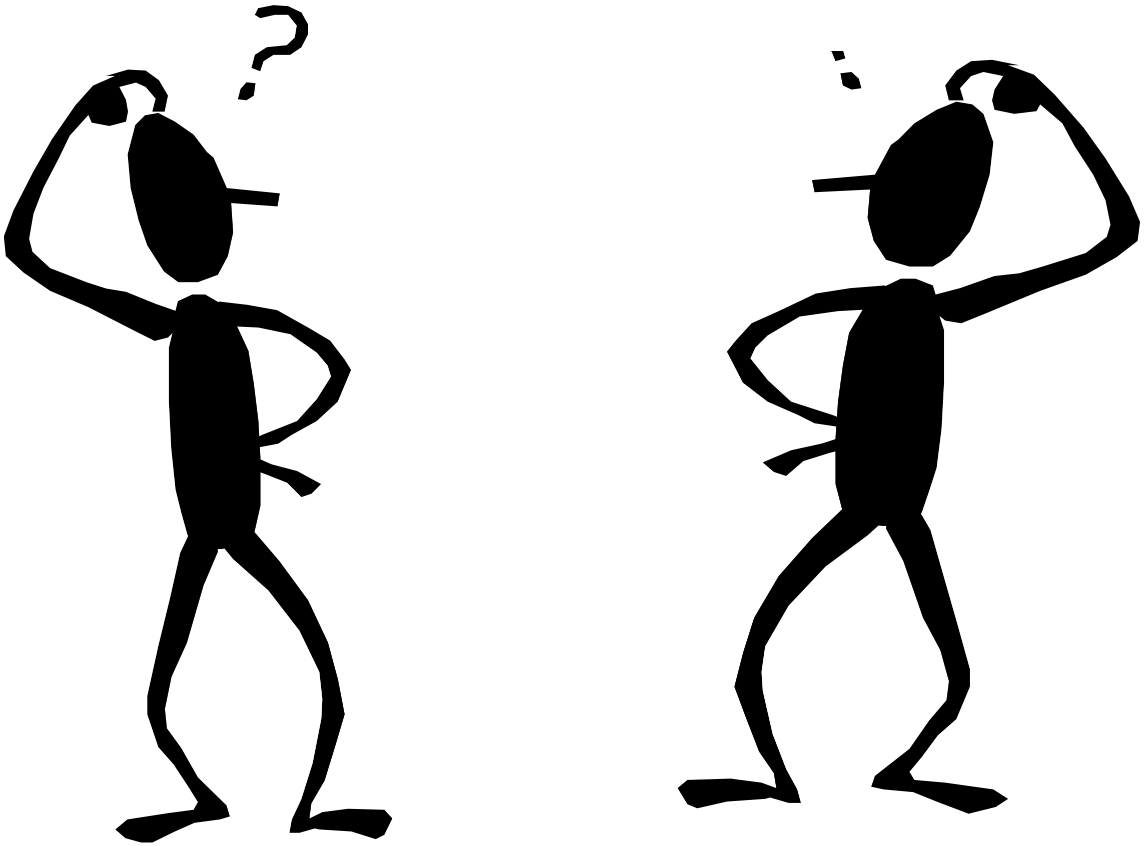
1 Mile of HMA Overlay

Importance of Rejuvenators

Economic Benefit

Miles of HMA Overlay	FOR	Miles of Rejuvenator
5 Miles	→	50 Miles
2 Miles	→	20 Miles
1 Miles	→	10 Miles
1/2 Mile	→	5 Miles

What is a REJUVENATOR?



"Asphalt Pavement Rejuvenators" OVERVIEW - 2

- Importance of Rejuvenators
- Understanding Rejuvenators
- Using Rejuvenators

"Asphalt Pavement Rejuvenators" OVERVIEW - 2

- Understanding Rejuvenators
  - Chemical Composition of Asphalt
  - Asphalt Components/Fractions
  - Asphaltenes & Maltenes Fractions
  - Maltenes Classes
  - Relationship: Asphaltenes & Maltenes

CHEMICAL COMPOSITION OF ASPHALT

- From Organic Matter
- 90-95% C & H - "Hydrocarbon"
- Heteroatoms [N, O, S]
- Trace Metals [Va, Ni, Fe]

- Molecular Structure - Extremely Complex
- State of the Practice – Separate Components by Solubility

Table 1.1 Elemental Analysis of Four Asphalt Cements

Asphalt Cement	A	B	C	D
Carbon, percent	83.77	85.78	82.90	86.77
Hydrogen, percent	9.91	10.19	10.45	10.93
Nitrogen, percent	0.28	0.26	0.78	1.10
Sulfur, percent	5.25	3.41	5.43	0.99
Oxygen, percent	0.77	0.36	0.29	0.20
Vanadium, ppm	180.	7.	1380.	4.
Nickel, ppm	22.	0.4	109.	6.

INFLUENCE OF CHEMICAL COMPOSITION OF ASPHALTS ON PERFORMANCE, PARTICULARLY DURABILITY

By

FRITZ S. ROSTLER
Director of Research

and

RICHARD M. WHITE
Research Chemist

Golden Bear Oil Co.
Bakersfield, Calif.

Reprinted from AMERICAN SOCIETY FOR TESTING MATERIALS
Special Technical Publication No. 277, pp 64-88
1959

Asphalt Binder Fractions

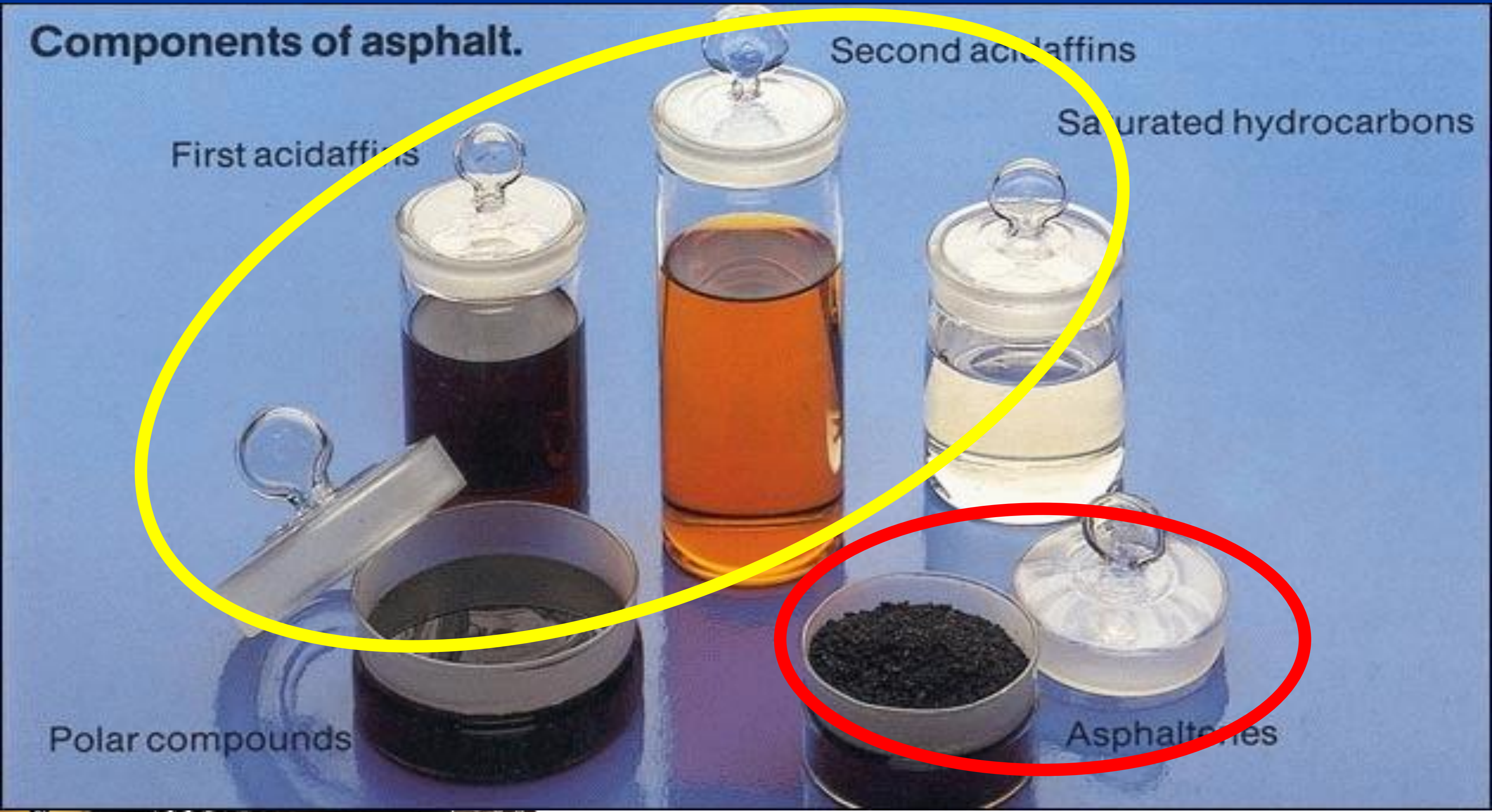
- **<u>Asphaltenes (A)</u> - fraction of asphalt insoluble in n-pentane.**
  - **Bodying agent**
- **<u>Maltenes</u> – fraction of asphalt material after precipitation of asphaltenes.**
  - **Four functional classes of Maltenes**

Asphaltenes Fraction/ Maltenes Functional Classes

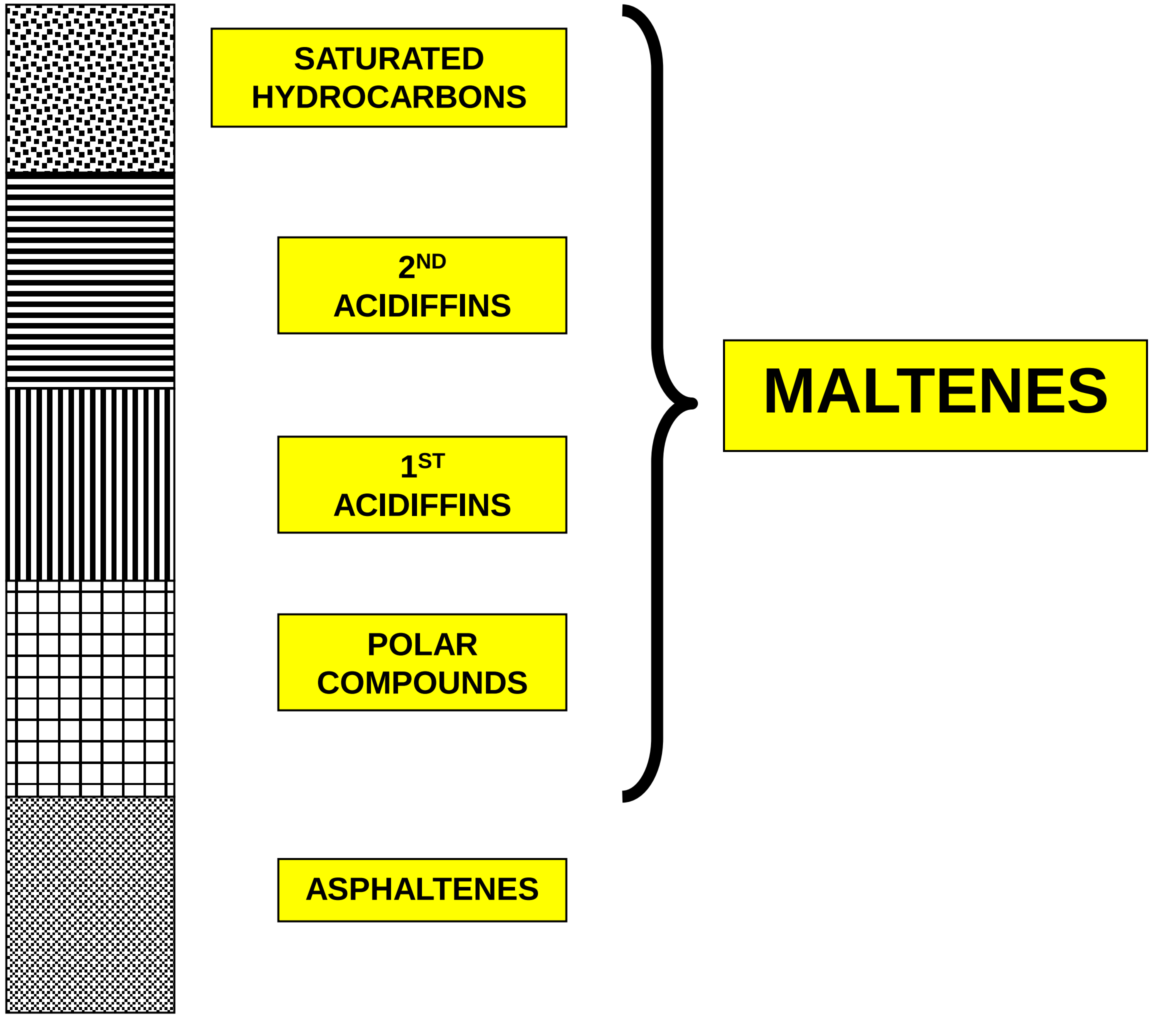
Fractional Component	General Description	Definition ASTM D2006	Chemical Reactivity	Significant Function
A Asphaltenes	High Molecular Wt. Product	Insoluble in n-pentane	Very Low	Bodying Agent
PC Polar Compounds	Polar Compounds	Precipitates with 85% H_2SO_4	High	Peptizer for Asphaltenes
A_1 1st Acidiffins	Unsat. Resinous Hydrocarbons	Precipitates with Concentrated H_2SO_4	High	Solvent for Peptized A
A_2 2nd Acidiffins	Slightly Unsat. Hydrocarbons	Precipitates with Fuming H_2SO_4	Low	Solvent for Peptized A
S Sat. Hydrocarbons	Wax - Saturated Hydrocarbons	Nonreactive with Fuming H_2SO_4	Low	Gelling Agent

Petroleum Asphalt is comprised of two fractional components:

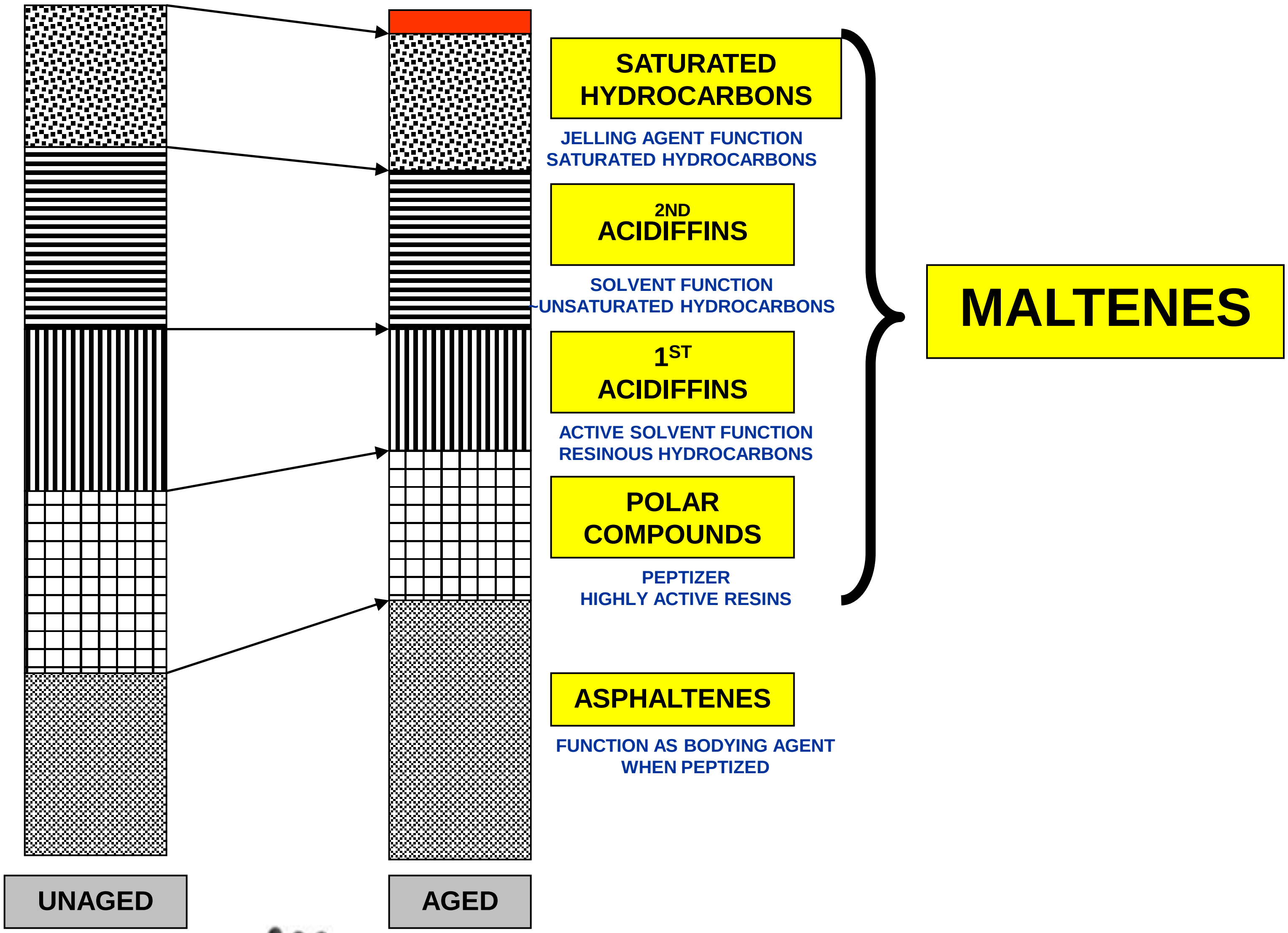
ASPHALTENES and MALTENES.



ASPHALT FRACTIONAL COMPONENTS
TYPICAL ASPHALT BINDER



ASPHALT FRACTIONAL COMPONENTS
TYPICAL ASPHALT BINDER



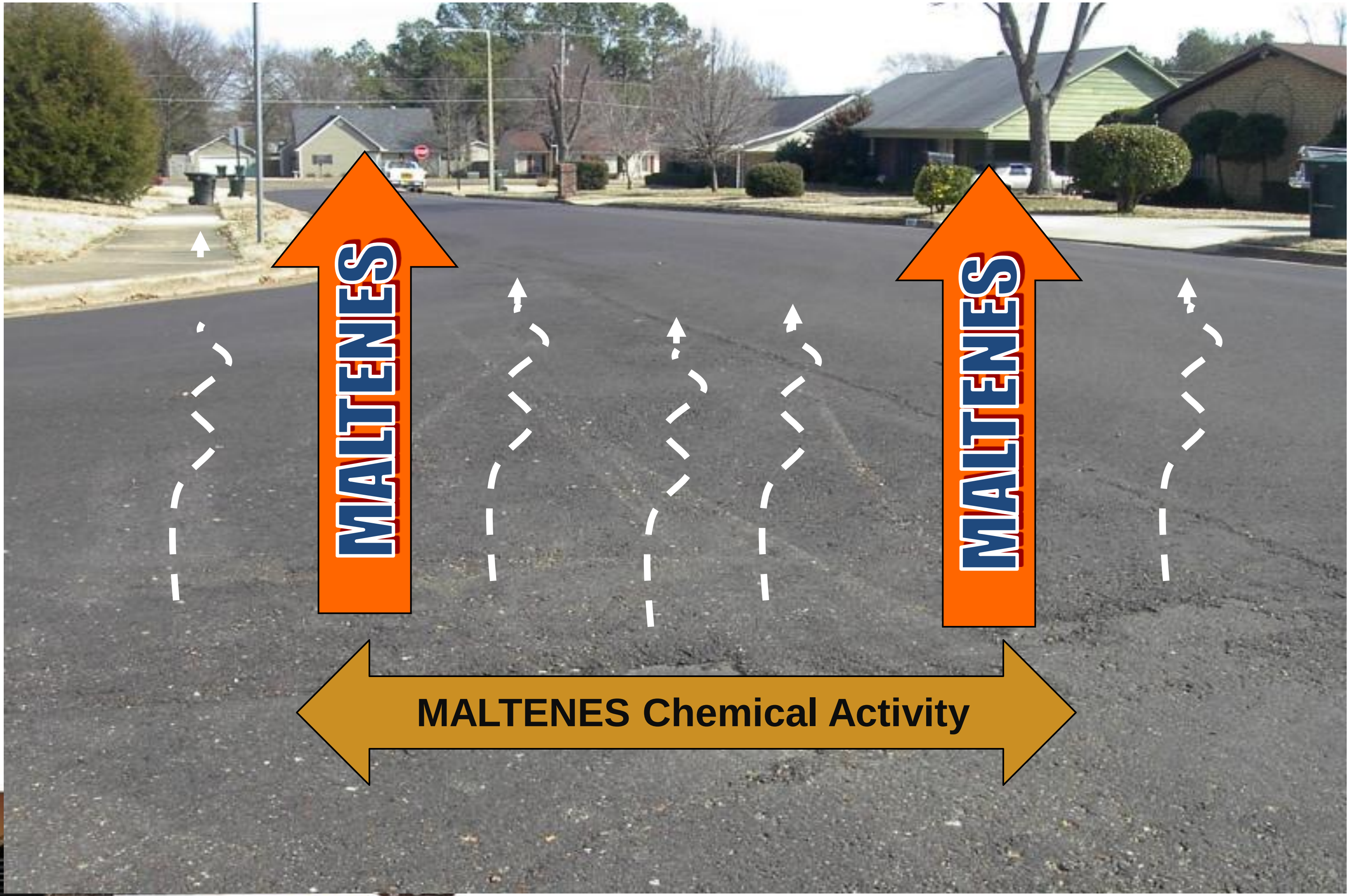
Aging - Reduction of maltenes begins at the HMA plant due to the extreme heating

- Increase in chemical activity

Aging continues over pavement life by:

- Exposure to the UV rays
- Environment
- Oxidation Process
- Stripping Action of Water
- Traffic Wear

AGING OVER PAVEMENT LIFE



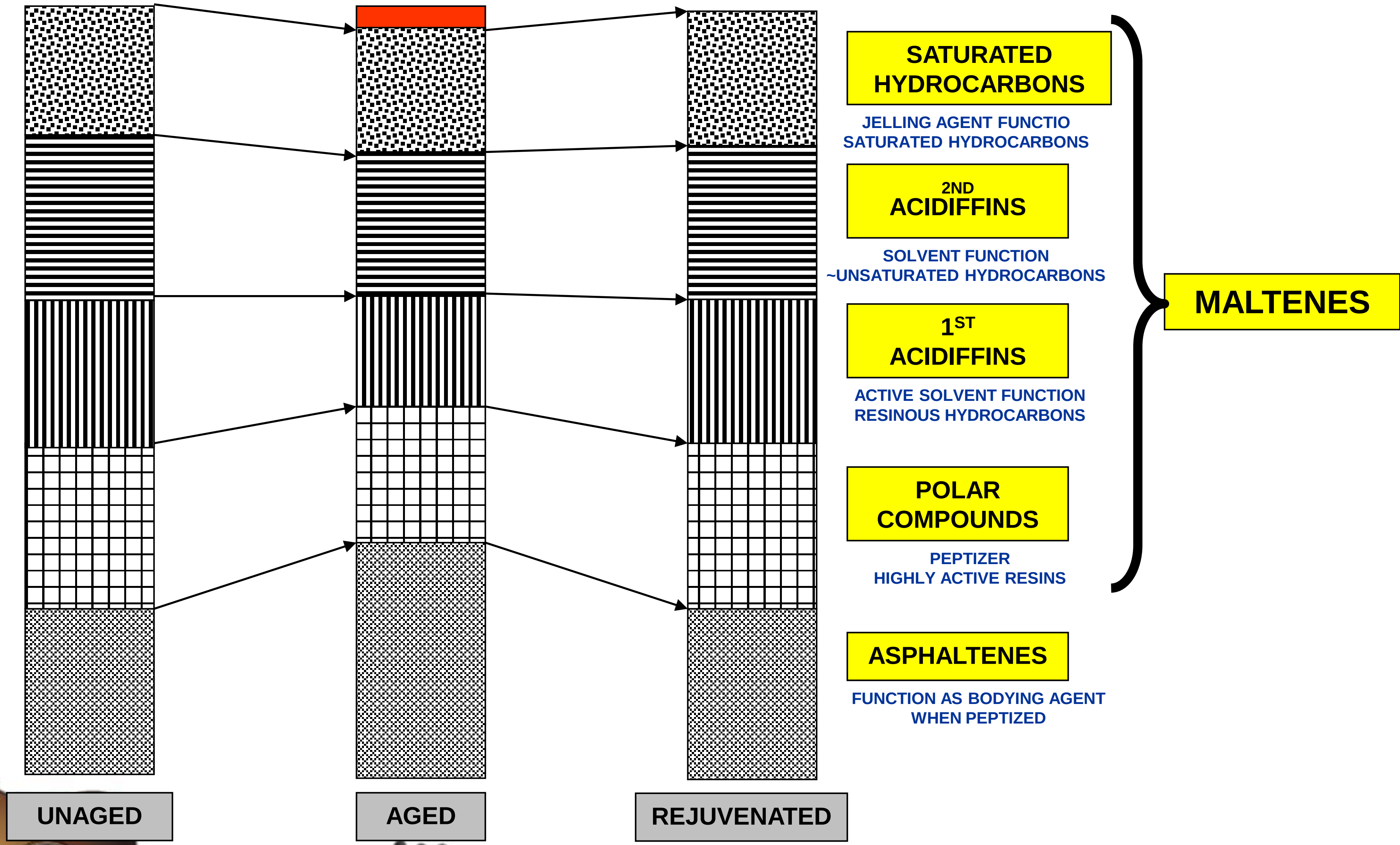
Understanding Rejuvenators

- **CRITERIA FOR A REJUVENATOR**

  must involve two important phenomena:

  - **Must contain Maltenes Fraction, to balance Maltenes to Asphaltenes ratio**
  - **Must penetrate binder to facilitate for chemical activity [fluxing/absorption]**

ASPHALT FRACTIONAL COMPONENTS TYPICAL ASPHALT BINDER



Rejuvenator Test Sections

"Asphalt Pavement Rejuvenators"

- Importance of Rejuvenators
- Understanding Rejuvenators
- Using Rejuvenators

"Asphalt Pavement Rejuvenators" OVERVIEW - 3

Using Rejuvenators

- Pavement Project Candidates
- Specifications [Material/Performance]
- Performance versus Skid Resistance
- Other Requirements [Equipment/ Experience/ Environmental Conditions]
- Application Rate

– Relationshi

Using Rejuvenators – [Excellent Candidates]

Using Rejuvenators – [Unsuitable Candidates]

- **High speed Roads & Expressways**
- **Runways & High Speed Taxi Exits**
- **Pavement w/Excessive Distress**
  - **Base and/or Subgrade Failure**
  - **Structural Distress without Repair: e.g., Alligator Cracking; Shoving**

Using Rejuvenators –
[Material Specifications, If Desired]

Tests	SPECIFICATIONS TEST METHOD ASTM	AASHTO	Requirements MIN.	MAX.
Tests on Emulsion:				
Viscosity @ 25°C, SFS	D-244	T-59	15	40
Residue, % W[1]	D-244(mod.)	T-59(mod.)	60	65
Miscibility Test[2]	D-244(mod.)	T-59(mod.)	No Coagulation	
Sieve Test, %W[3]	D-244(mod.)	T-59(mod.)	-	0.1
Particle Charge Test	D-244	T-59	Positive	
Percent Light Transmittance[4]	GB	GB	-	30
Tests on Residue from Distillation:				
Flash Point, COC, °C	D-92	T-48	196	-
Viscosity @ 60°C, cst	D-445	-	100	200
Asphaltenes, %w	D-2006-70	-	-	1.00
Maltene Dist. Ratio	D-2006-70	-	0.3	0.6

$$\frac{PC + A_1}{S + A_2}$$ [5]

PC/S Ratio[5]	D-2006-70	-	0.5	- Saturated
Hydrocarbons, S[5]	D-2006-70	-	21	28

Product Purchase Description

Using Rejuvenators – [Material Performance, Desired]

Table 1. Pavement Three (3) Years or Less in Age			
Item	**Property of Recovered Binder**[2]	**Requirement**	**Test Method**
1	Absolute Viscosity $_{60\,°C}$, P	≥ 25% Decrease[2]	ASTM D 2171
2a	Complex Modulus $_{60\,°C}$, G^*		AASHTO T 315
2b	Viscosity $_{60\,°C}$, $\eta = G^* / \acute{\omega}$ Pa•s		
2c	Phase Angle $_{60\,°C}$, δ, °	Report	

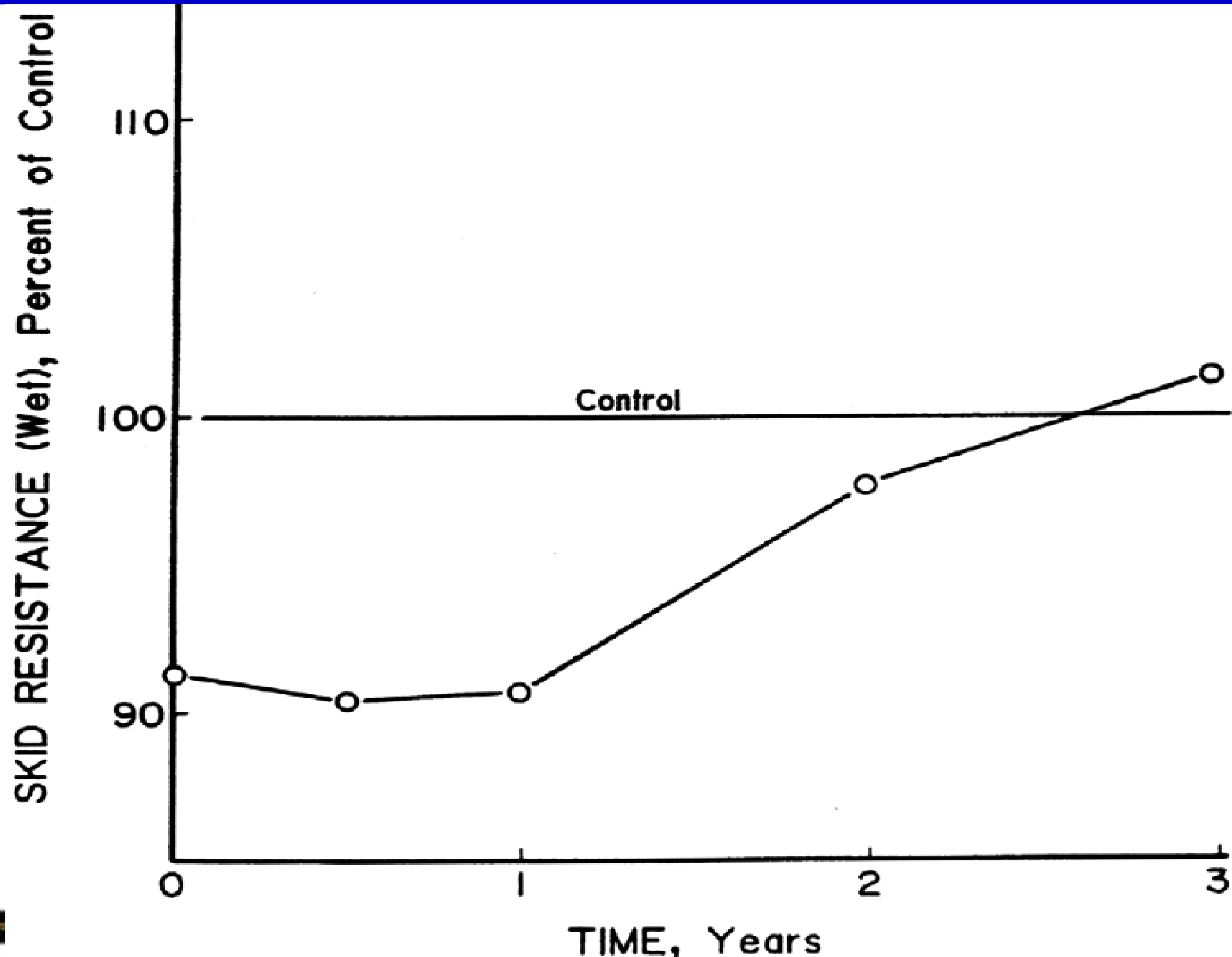
Table 2. Pavement More than Three (3) Years in Age			
Item	**Property of Recovered Binder** [2]	**Requirement**	**Test Method**
1	Absolute Viscosity $_{60\,°C}$, P	≥ 40% Decrease [2]	ASTM D 2171
2a	Complex Modulus $_{60\,°C}$, G^*, kPa		AASHTO T 315
2b	Viscosity $_{60\,°C}$, $\eta^* = G^* / \acute{\omega}$ Pa•s		
2c	Phase Angle $_{60\,°C}$, δ, °	Report	

Using Rejuvenators – [Material Performance, CONCERN]

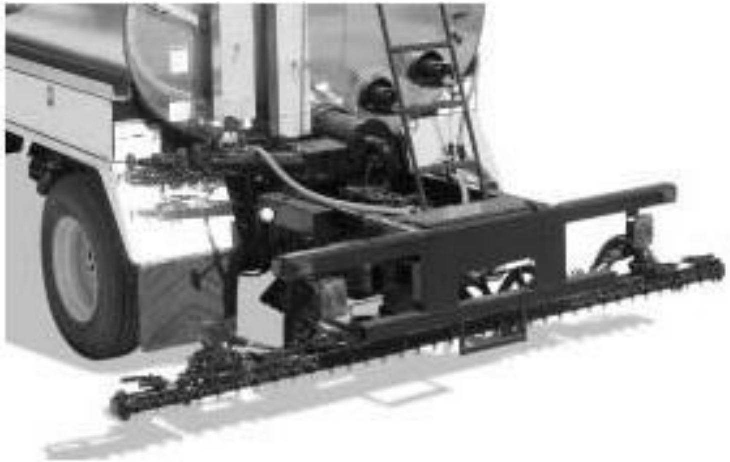
- Trade-Off between ---
  - Performance
    - AND
  - Friction Resistance

- ***MOST IMPORTANT PRINCIPAL*** **for --**
  - Using Rejuvenators!!!!!

Using Rejuvenators –
[Material Performance, CONCERN]



Using Rejuvenators – [Equipment]



Using Rejuvenators – [Construction]

Experience/Certification:

- **# Years/# Projects Successfully Complete**

Environmental Conditions:

- **Dry Surface**
- **Precipitation Forecast: Prohibit, when >0.1-in < 4 hrs.**
- **Ambient Temperature: > 40 degrees F**

Spray Application Rates
Rejuvenators

- -0.03 – 0.08 gal/sy
- -”Ring Test”
- -Test Patches
- -Test Strips
- -DO NOT OVER APPLY

“Asphalt Pavement Rejuvenators” [SUMMARY]

- Importance of Rejuvenators
- Understanding Rejuvenators
- Using Rejuvenators

Project Documentation

Evaluation of Seal Coat Runway 16–34 Lajes Field, Azores

Rejuvenator

by
J. E. Pickett

Geotechnical Laboratory
U.S. Army Engineer Waterways Experiment Station
P.O. Box 631
Vicksburg, Mississipi

March 1983

Lajes Field, Azores

Pickett – Lajes Field, Azores [1983]

	Application Rate
Phase I	
Center 100–ft–wide area	0.053 gal/sq yd
All other areas	0.061 gal/sq yd
Phase II	
From center line runway out 50 ft	0.055 gal/sq yd
All other areas	0.066 gal/sq yd
Phase III	
From center line runway out 50 ft	0.058 gal/sq yd
All other areas	0.074 gal/sq yd

Pickett – Lajes Field, Azores [1983]

Lajes Rejuvenator, 1983

Sample Number	Station From South End R/W & C	Penetration 77°F (25°C) 100 g, 5 sec 0.1 mm		Absolute Viscosity 140°F (60°C) 300.0 mm Hq Vacuum, Poises	
		Untreated	Treated	Untreated	Treated
1	2 + 43, 83.7 ft W	11.00	20.00	401, 351	65, 420
2	23 + 55, 134.9 ft W	11.00	23.00	449, 520	62, 011
3	34 + 34, 5.1 ft E	13.00	31.00	242, 293	32, 860
4	52 + 07, 51.3 ft W	9.00	27.00	1, 852, 362	43, 497
5	64 + 36, 32.4 ft E	4.00	17.00	2, 774, 367	177, 941
6	80 + 67, 14.6 ft W	9.00	22.00	863, 971	62, 736
7	86 + 86, 121.4 ft E	6.00	34.00	1, 263, 880	23, 444
8	99 + 17, 17 ft E	6.00	29.00	1, 318, 687	41, 392
Average		8.63	25.38	1, 145, 804	63, 663
Change (%)		Penetration	194.00	Viscosity	94.40
			Increase		Decrease

Thank You…

Questions ?

ncpp

National Center for Pavement Preservation