The Role of an Asphalt Rejuvenator in Pavement Preservation
Use and Need for Asphalt Rejuvenation

Jim Brownridge – Marketing Manager
Tricor Refining, LLC
Bakersfield, California 93312

Charles Grady- Director International Group
Crafco, Inc.
Chandler, Arizona 85226
charley.grady@crafco.com

ABSTRACT

An asphalt rejuvenator was introduced in 1960 by the Golden Bear Oil Company. That product was Reclamite® It has a history of use spanning 50 years. In an era of moderately low price asphalt products, the rejuvenator was ahead of its time. Thousands of laboratory tests and field trials have been performed to determine the best possible formula and procedures for applying an asphalt rejuvenator.

There are many methods of surface treatments entailing use of asphalted emulsions with the predominant focus on gluing and binding the aggregate. Rejuvenators are derived from very specific crude stocks and are not as generic in their manufacture, thus on a national level, product availability as well as manufacturer/refiner marketing has impacted limited expansion and use of the products. But…asphalt rejuvenators have been one of the most field tested applications there are. This paper presents the technical components of an asphalt rejuvenator and how they differentiate from generic asphalt emulsions. Discussion is focused on fog seal use of rejuvenators. Long term test results are presented as well as a visual perspective showing the appearance of before and after treatments.

Conclusive history shows that a properly formulated asphalt rejuvenator meets stipulated requirements and is a proven method to extend pavement life at a low cost.

Keywords: Golden Bear Oil, maltenes, pavement preservation, RAP, rejuvenator, RAP, Reclamite®, Tricor, Witco.

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Table: 4@250 words per table=1000
Photographs: 7@250 words per photograph=1750
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1.0 INTRODUCTION

Pavement Preservation is now on the mind of every agency charged with maintaining their inventory of asphalt pavements. The current volatilities in crude have seen asphalt pricing skyrocket, then plunge. This rollercoaster has created a difficult task for agencies budgeting and controlling their maintenance dollars. Many county and state agencies over the years have evolved operations to perform their own in house chipseal or slurry applications. This method had become more of a nationwide industry standard to maintain asphalt pavements at a relatively low cost. Under present economic conditions gone are the days of agencies doing the large 35 to 50 mile wear course seal projects. Because of the structure of these in house agency programs, much of this work has and had been done on newer asphalt pavements incorporating roads into these programs that may not have required a wear course and were sealed because of that program in place, use of the in house equipment and use of in house manpower. It was simple and dollar funding, aggregate sources and low priced emulsion was available.

In our current economic times there has not been a more opportune time for agencies to consider rejuvenator use. Price has never been the objection in the use of a rejuvenator. Rejuvenators have a very long history of use – 50 years to be exact and have been studied extensively from the Corps of Army Engineers, US Department of the Navy[3], Independent States and the National Center for Pavement Preservation most recently in the National Sealer Binder Study and the California Pavement Preservation Center Fog Seal and Rejuvenator Study.

Yet…Very Few Have a Good Grasp on Product Use and What a rejuvenator is.

The intended use of an asphalt rejuvenator is to keep good roads in good condition. When evaluating pavement preservation treatments it is appropriate to think in terms of extended life rather than design life. **"Pavement Preservation is to take a newly constructed pavement and extend its service life affording the agency significant real cost benefit savings."** Now we hear from the FHWA Expert Task Group Saying:

An effective pavement preservation program
will address pavements while they are
still in good condition before the onset of
serious damage.

AASHTO Highway Subcommittee on Maintenance Says:
Preventative maintenance is typically applied to pavement
in good condition having significant remaining
service life. As a major component of pavement
preservation, preventative maintenance is a strategy of
extending the service life by applying cost-effective
treatments to the surface of structurally sound pavements.

Industry is also hearing much from the green movement; "rejuvenator use will reduce aggregate resource depletion, and dramatically reduce carbon emissions, for the least possible cost!" Reducing the carbon footprint is the widely used phrase.

As stated in the NCCP booklet titled [1]"A Quick Check of your Highway Department Health" Assume every lane mile of road in the network was rated by the number of service years remaining until the end of it's life (terminal condition) If no improvements are made in 1 year then it's remaining service life will decrease by 1 year except for those stacked at zero. The zero stack will increase significantly until the agency has the majority of road inventory in the zero stack and obviously no funding to change this. Assigning priorities to fixing worst first or reconstruction is a proven death spiral for agencies. This "zero stack" is the situation the majority of our regional cities and towns are in.

So why is it that asphalt rejuvenators, a product studied more than many other types of treatments, yet so unknown by many in academia and those charged with maintaining our nation's pavements having a good grasp of a rejuvenators use – both as a surface treatment tool and for RAP rejuvenation?
It is the writer's opinion that to many, belief that the fluxing, solvency, co-mingling phenomenon that occurs is too good to be true. Of course in the product application there is a little pain for much gain. That pain is in terms of some product tracking because of a little longer cure time and the sanding that is required as a blotter. In our rejuvenator studies different surfactant technology has been tested and asphalt modification but the fact remains that in order for a rejuvenator to penetrate it cannot be retarded by blending in an asphalted emulsion or formulated into a quick dry emulsion. Once you stop the absorption then you lose the rejuvenation effectiveness. There are many asphalt emulsions being marketed that claim their rejuvenation capability. The fact remains if the emulsion breaks or cures on the pavement surface then it is sealing, not rejuvenating.

Commenting on conventional methods of gluing and binding, use of wear course seals. These methods are not filling the void – use of the too good to be true rejuvenator is now front and center.

Rejuvenators are derived from very specific crude stocks and are not as generic in their manufacture, thus on a national level, product availability as well as manufacturer/refiner marketing has impacted limited expansion and use of the products. But…asphalt rejuvenators have been one of the most field tested applications there are.

Concept of Pavement Preservation with Rejuvenators:

- Maximizing performance of assets while minimizing the cost of ownership of those assets.
- Establishing a minimum PCI for your inventory and working to increase that PCI
- Extending the RSL (remaining service life) of a pavement

- "Rejuvenation is the Right Way"

2.0 SCOPE

Beginning in the mid 1950's. the rejuvenator Reclamite® was developed out of the work done by [2]Dr. Fritz Rostler and Richard White. " It is generally recognized that failures of asphalt pavements caused by embrittlement and other changes in physical properties during the aging process are due to chemical reactions of all or some of the asphalt components".

The approach of wear course seals – slurry and chipseal as with other asphalted emulsions is to bind and glue versus reconstituting the existing binder and improving it. They both have specific uses and it is the presenter's opinion that many pavements receive a wear course seal that are perfect candidates for rejuvenation for several reasons;

1. Because of lack of knowledge by the agency,
2. Promotion by the contractor,
3. The belief that a wear course will yield a longer service life.
4. Cosmetic Attributes

Many studies on both the cause and effect of asphalt aging have been reported. The interpretations of causes of aging range from; the assumption that asphalt hardening and embrittlement is purely a phenomenon of evaporation of the light fractions; to more thorough explanations predicated on the correlation of chemical composition of asphalt to long-term performance on the road. That is the relationship of the chemical fractions that make up asphalt.

What are the main functions of an asphalt rejuvenating agent?

- They are engineered cationic emulsions containing maltenes, saturates (light fractions)
- Their primary purpose is to soften the stiffness of the oxidized AC pavement surface and flux with the asphalt binder to extend the life of the pavement surface by adjusting properties of the AC mixture. Maximum absorbance of the rejuvenator is expected.
- To extend the life expectancy or service life of the restored pavement.

To fulfill the above functions, there are keys to a properly formulated rejuvenator:

- Proper base is essential. A naphthenic or wax free base is ideal – the molecular make up offers more solvency or absorption and fluxing ability with the binder.

- Rejuvenators are manufactured as emulsions – typically 60-65% residual. They have the ability to "wet" the asphalt binder that is present.

Rostler developed what we refer to as the "Rostler Analysis". This is ASTM Test D-2006-70 which determines the relationship of the light fractions maltenes/acidiffins/saturates. It sets the stage for a properly formulated rejuvenator.

			Min	Max
[3]Maltene Distribution Ratio $\frac{PC + A_1}{S + A_2}$	D-2006-70	---	0.3	0.6

Chemical composition by ASTM Method D-2006-70:

PC = Polar Compounds, A_1 = First Acidiffins.

A_2 = Second Acidiffins, S = Saturated Hydrocarbons.

Note: ASTM D-2006-70 (last updated in 1970) is also referred to as the Rostler Analysis because of the development by Fritz Rostler. The test was predominately used in the rubber extender industry and adopted for use by all suppliers including Tricor. This test has since been replaced but functions very well and produces very valid test results for our rejuvenator oils and emulsions.

3.0 TECHNICAL

WHAT IS AN ASPHALT REJUVENATOR?

Asphalt consists of two main fractions:
"asphaltenes" which are
the hard brittle component, insoluble and not affected by oxidation and the highly reactive sub-fractions:
"maltenes" These maltenes are oily and resinous in appearance

Table 1

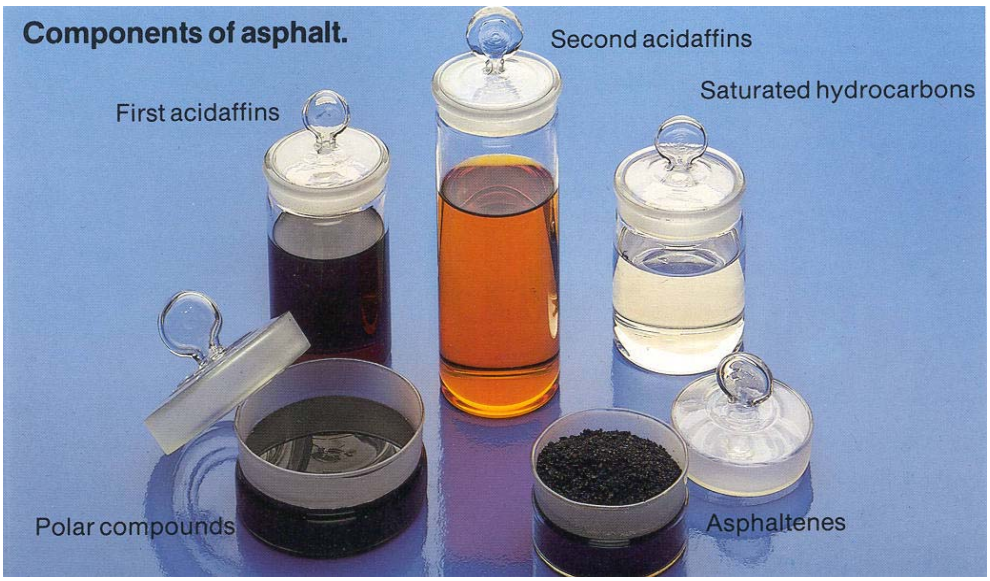
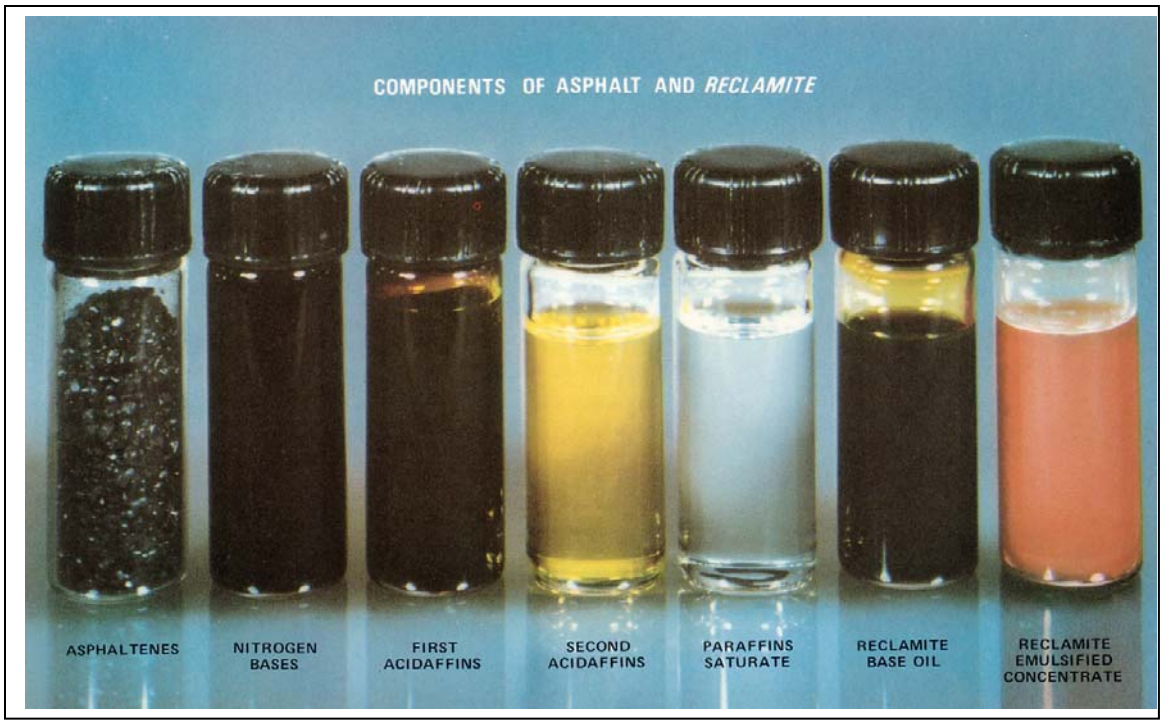


Table 2



Rejuvenators need to be a fine-particle size cationic, oil in water emulsion of a selected blend of maltene components tailored to facilitate and assure the desired mode of incorporation of the added maltene fractions, into an asphalt pavement. Specific properties are summarized in Table 3.

Many features are considered and built into the rejuvenator formulation, keeping in mind that after penetration of the emulsion into the asphalt pavement the essential function is to deposit the blend of maltene fractions on the films of aged asphalt without disturbing the existing structure of the asphalt-aggregate mix with respect to adhesion, cohesion and stability. Of importance is that the deposited maltene fractions must then flux with the aged asphalt in place. Stability of the emulsion, ease of handling and simplicity of application are other significant objectives. A cationic emulsification system is needed which will penetrate rapidly into the pores of the asphalt pavement, without displacing the asphalt films from the aggregate or destroying the existing structure of the asphalt-aggregate mix. Table 4 shows how the composition of asphalt changes

Table 3

Asphalt Rejuvenating Emulsions Specifications

Specifications:

Tests	Requirements	Test Method ASTM	AASHTO	Min. Max.
Tests on Emulsion:				
Viscosity @ 25°C, SFS	40	D-244	T-59	15
Residue, % w[1]	65	D-244 (mod)	T-59 (mod)	60
Miscibility Test[2] Coagulation		D-244 (mod)	T-59 (mod)	No
Sieve Test, % w[3]	0.1	D-244 (Mod)	T-59 (mod)	---
Particle Charge Test	Positive	D-244	T-59	
Percent Light Transmittance[4]	30	GB	GB	---
Cement Mixing	2.0	D-244		
Tests on Residue from Distillation				
Flash Point, COC, °C	---	D-92	T-48	196
Viscosity @ 60°C, cSt	200	D-445	---	100
Asphaltenes, %w	0.75	D-2006-70	---	0.4
Maltene Distribution Ratio	0.6	D-2006-70	---	0.3
$\frac{PC + A_1}{S + A_2}$[5]				
PC/S Ratio[5]	---	D-2006-70	---	0.5
Saturate hydrocarbons, S[5]	28	D-2006-70	---	21

[1]ASTM D-244 Evaporation Test for percent of residue is made by heating 50 gram sample to 149°C (300°F) until foaming ceases, then cool immediately and calculate results.

[2]Test procedure identical with ASTM D-244 60 except that .02 Normal Calcium Chloride solution shall be used in place of distilled water..

[3]Test procedure identical with ASTM D-244 60 except that distilled water shall be used in place of two percent sodium oleate solution.

[4]Test procedure is attached.

[5]Chemical composition by ASTM Method D-2006-70:

PC = Polar Compounds, A_1 = First Acidaffins.

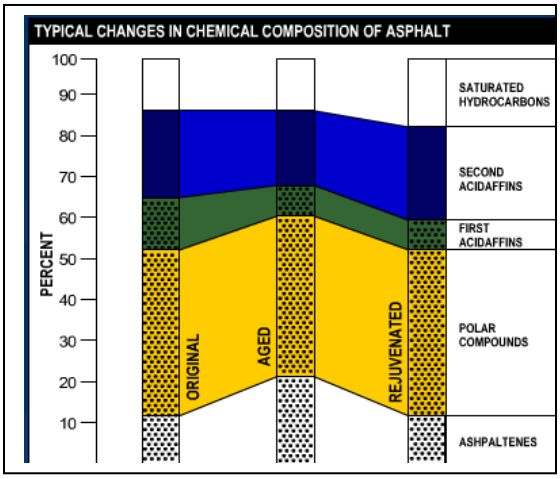
A_2 = Second Acidaffins, S = Saturated Hydrocarbons.

The principal obstacle to understanding the chemistry of asphalt aging was the lack of a reliable method of subdividing and defining the resinous and oily fractions of the maltenes. The Rostler analysis provides such subdivision by determining four principal fractions of maltenes:

Polar Compounds	PC
First acidaffins	A^1
Second acidaffins	A_2
Saturates	S

The influence of maltenes on the durability of asphalts as cementing agents has been show to depend on the ration of these four fractions. The parameter: $\frac{PC + A_1}{S + A_2}$

The ratio of the more reactive to the less reactive fractions has proved a useful guide. Table 4 shows the typical changes in chemical composition with aging of a typical asphalt pavement.



4.0 MEASURING THE EFFECTIVENESS OF AN ASPHALT REJUVENATOR

We know the benefits of an asphalt rejuvenator are:

1. Increasing penetration value of the asphalt cement in the top portion of the pavement which extends the pavement's lifecycle.
2. Sealing pavement against intrusion of air and water, thereby slowing oxidation, preventing stripping and raveling and protects the pavement in-depth.
3. Increasing the durability of the asphalt in the top portion of the pavement by improving the chemical composition of the asphalt cement.

How to Measure the Effectiveness

- Measure the reduction in viscosity of the aged asphalt binder to determine the rejuvenators effectiveness. (See Table 5)
- The viscosity of the recovered binder before and after treatment is determined.
- The test methods for the extraction and recovery of the asphalt binder and viscosity measurement need small quantities of mix.
- 4 inch or 6 inch pavement cores are taken and the viscosity of the recovered binder is measured
- Normally the top ½ inch layer of the core is removed for this determination.

California DOT (Caltrans)[4] test methods are used:

- California Test Method CT 348 – "Method of Test for Determining the Viscosity of Bituminous Materials by Means of the Sliding Plate Micro viscometer"

- California Test Method CT 365 – "Method of Test for the Micro-Recovery of Asphalt from Bituminous Core Slices". (Penetration)

Table 5

Core Location	**Micro viscosity, 25ºC, MP**		**Equivalent**
	0.05 Sec-1	**0.001 Sec-1**	**Penetration**
R1 (Untreated)	**53.0**	**750**	**14**
R1 (Treated)	**15.5**	**42.2**	**25**
R2 (Untreated)	**50.0**	**655**	**14**
R2 (Treated)	**7.6**	**20.8**	**41**

It is well documented and shown by the figures in tables 5 and 6 below how a rejuvenator adjusts viscosity:

- Restores proper balance among the five asphalt components.

- Restores flexibility and ductility to the top portion of the old, brittle pavement.

- Stops raveling and stripping of the aggregate.

- Road markings and striping will remain visible.
- Seals surface against intrusion of air and water.

Testing:

The top 3/8-inch of each core was removed for testing. The asphalt was extracted and recovered as prescribed by California Test Method 365 (CTM 365). Viscosities were determined on the recovered asphalt binder using a sliding plate micro viscometer (CTM 348). Penetrations were calculated from a nomograph. Test results are as follows:

Table 6[5]

Core #	Core Identification Travis County, Texas	Micro viscosity, 25°C, MP		Equivalent Penetration
		0.05 sec^{-1}	0.001 sec^{-1}	
1 B	"Before" Letti Lane	90.0	128.0	11
1 A	"After" Letti Lane	22.6	44.5	21
2 B	"Before" Cranston Drive	104.0	112.0	10
2 A	"After" Cranston Drive	30.0	75.0	18
3 B	"Before" Blackthorn Drive	39.1	255.0	16
3 A	"After" Blackthorn Drive	3.50	7.45	49
4 B	"Before" Shiner Street	40.6	120.0	16
4 A	"After" Shiner Street	3.75	9.50	48
5 B	"Before" Stormy Ridge Road	160.0	174.0	8
5 A	"After" Stormy Ridge Road	14.0	42.4	26
6 B	"Before" Briner Pass	78.5	148.0	10
6 A	"After" Briner Pass	2.52	5.20	57
7 B	"Before" Denim Trail	162.0	259.0	8
7 A	"After" Denim Trail	0.5	2.8	110

As shown in Table 6, viscosity is reduced and corresponding penetration values increased appreciably.

5.0 WHERE TO USE AN ASPHALT REJUVENATOR

A well planned program of preventative maintenance is one which takes into consideration the characteristic behavior of asphalt. The aging process is caused by chemical changes in the asphalt. The original concept for the asphalt rejuvenator Reclamite® that came on the market in 1960 was a product that would reconstitute the asphalt. To keep "good" roads in "good" condition. The functional use was to revitalize aged asphalt in place, stop and reverse the shrinkage process which results in hairline cracking, to inhibit pitting and raveling, to reduce air and water permeability. This concept is unchanged today.

Asphalt Pavement Surface Treatments – the typical candidate is a asphalt pavement in the 3-7 year age range. But this is only a benchmark as rejuvenators are used as a construction seal to new asphalt to decrease permeability. They are used on segregated pavements, pitted and raveled pavements. The ideal candidate is a pavement with no base failure, good profile but showing the early signs of distress as stated above.

Photograph 1

Photograph 1 shows the tightening and densifying effect of a rejuvenator treated pavement. (State of Idaho)

Photograph 2

Photograph 2 shows the appearance of a treated road in the County of Merced, California in good profile.

Photograph 3

Photograph 3
This photo shows the results of a 10 year study between 1977 and 1987 – City of Cleveland, Ohio – rejuvenator application is to the left. Photo depicts the noticeable tightness and densifying of the binder.

Photograph 4

Photo Taken: October 19, 2006 , Reclamite® rejuvenator emulsion placed September 2001
Sealed for 5 Years

Reclamite® Engineered Emulsion Hwy 95
40 miles north of US Interstate 40 , Winslow, Arizona. FP2 Sealer Binder Study

Note the fluxing, densifying of the binder in the Left lane which was sealed. The right lane was Unsealed.

Photograph 5

Typical appearance of a Rejuvenator fog seal application.

City of Lemoore, California (Central Valley of California)

6.0 CONCLUSION AND COMMENTS

1. A properly formulated non asphalt base rejuvenator manufactured as an emulsion conclusively has shown its ability in 1000's of core tests to extend pavement life by restoring the light fractions (maltenes) to the oxidized and dry binder in the top ¼ - 3/8 inch of asphalt surface when used as a fog seal application.
2. It is in this top portion of asphalt that surface distress makes its way to decay and erode the underlying asphalt. The maltene fractions "wet" the existing asphalt, fluxing with, densifying through their solvency effect with the binder. The molecular make of the naphthenic base oil used in the formulating provides this solvency all without the use of distillate or solvents as we know them.
3. The wetting densifying function reverses the drying effect caused by air, moisture, time to reverse the aging effects.
4. The rejuvenator seals the pavement against intrusion of air and water, thereby slowing oxidation, preventing stripping and raveling and protects the pavement in-depth.
5. The rejuvenator increases the durability of the asphalt in the top portion of the pavement by improving its chemical composition.
6. In current global economic times – rejuvenators are the new green emulsion – no cutbacks or solvents, less use of haul trucks, less use of aggregate.
7. "With the right care, the miles don't show" - Engineered Asphalt Rejuvenator emulsions can be a maintenance department's lowest cost surface treatment alternative to extend pavement life

Non asphalted rejuvenators both as emulsions and base oils find use in both cold recycling and hot recycling. The end result is much the same as the fog seal rejuvenator use – restoration of the maltenes and restoring them in select chemical balance.

ACKNOWLEGEMENTS

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