John Baker's Thoughts on ….

TVAR Seal Coat Use
TVAR Distributor Inspection
Sand Patch Testing for TVAR Design

I've been working with the Atlanta District's seal coat program since 1989. We have supervised all of the district's seal coat construction planning and record keeping since some time in the early 1990's. We get recommendations from maintenance supervisors on which roads to seal, and then we go over the pavement scores and look at skid numbers on the different roads to see if we have serious problems somewhere. Then we develop the seal coat plans and go on and build it the next summer. We generally set the seal coat rates and hope the contractors can hit them.

At first, determining when and how to transversely vary asphalt rates was kind of subjective. It was just "I think we need this much asphalt." It's a guess at how many hundredths of a gallon per square yard it will take to fill the voids in the existing pavement. I set out to come up with some way to get a definite number attached to that decision. One thing I tried was something like the old sand patch test we used to measure tine depths on bridge decks. I poured either 100 ML or 200 ML of sand on the pavement between the wheel paths, spread it out down to the top of the rocks, and measured the diameter of the circle. The diameter is an indication of how much asphalt I'll need to fill up the voids between the rocks. After awhile I developed a table showing circle diameters and shot rate adjustments I thought were about right. For instance, if I spread out 100 ML and the diameter is between 15 ½ and 19 ¾ inches, I would increase the asphalt rate 0.02 gal/sy to fill up those voids. Toward the other end of the range, if the diameter was between 7 ½ and 8 inches, I would increase the rate 0.10 gal/sy. These rate adjustments versus diameters were developed for Grade 4 hard rock and lightweight precoat aggregate. I don't need to use the test on every pavement we are going to shoot. I just run it where I'm uncertain on the amount of variation I should ask for.

When we go out to set asphalt rates, generally the first thing we look at is the wheel path. Most of the roads we see will have some degree of flushing or bleeding. Or at least the asphalt has come to the top of the existing surface. Then we set an asphalt rate needed for the wheel paths. After that we select an asphalt rate for outside the wheel paths. If a road is in fairly good shape, and we usually see this on low traffic roads, we haven't varied the rate at all if there's still a good texture across the surface. But probably the majority of roads need the asphalt variation.

Selecting the asphalt rates is usually done about a week to ten days before the contractor gets started. Sometimes it is even as close as three to four days before. Also, it's probably better to go out in the afternoon than first thing in the morning. It's hot and the sun has been out for awhile, so in the afternoon you get a better look at how alive the asphalt gets in the wheel paths.

I would mention a couple of thing to districts that haven't been transversely varying shot rates. Make sure you get the right rate into the right distributor computer if the distributor has two spray bars. Getting that wrong makes a mess in a hurry. If the distributor has only one bar, you've got to watch to be sure they get the different nozzle sizes where they are supposed to be. I would also suggest that they add the variation incrementally until they are comfortable with it, a smaller variation at first and then work up from there.

Key Words, by Category:

Geographic Area - Atlanta district, northeast Texas

Information Type - Legacy knowledge

Legacy Knowledge Source – John Baker, June 2008 interview

Analyses Involved – Tex-436-A, Sand Patch Test

Flexible Pavement Distresses Involved – Flushing, bleeding

Other Descriptors – Transversely varied asphalt rate, TVAR, seal coat, texture

Search Acronyms: Legacy Knowledge – Flexible Pavement – Maintenance, lkfpm, Legacy Knowledge – Flexible Pavement – Inspection, lkfpi, Legacy Knowledge – Flexible Pavement – Construction, lkfpc, Legacy Knowledge – Flexible Pavement – Specifications, lkfps, Legacy Knowledge – Flexible Pavement – Unique Application & Innovation, lkfpu

Darlene Goehl's Thoughts on ….

TVAR Location Selection
TVAR Seal Coat Inspection

We have been transversely varying asphalt rates for around eight, maybe ten years in Bryan. So we have been doing it for quite awhile now. I would guess that we average using it on about 50% of our district seal locations.

The director of construction and I ride all the roads in the district seal project a couple of weeks before the project starts. We set up the asphalt rate table to be used, and that is also when we decide where we are going to use transverse variable shot rates.

Deciding on when to use variable rates is a visual determination, but we also consider the traffic and road width. Usually around 1000 ADT and above we are going to go with variable rates. On the other hand, if the road is really narrow, 20 to 22 feet, we may go with a straight bar because the wheel paths are in odd locations. This is typically how we decide. We look and see if the wheel paths are visible. Are they worn down? Is the aggregate worn down or is the asphalt flushed up? If we can see the wheel paths, then we will usually shoot variable asphalt rate because something different is going on in the wheel paths. We also look and see if we have any raveling outside the wheel paths. If there is raveling, it may be an indication that we need more asphalt outside the wheel paths. So that may be another reason to use variable asphalt rates.

The 1000 ADT break point I mentioned is a rule of thumb we came up with. I have the ADT numbers with me when we drive the roads, and I've noticed that somewhere around 1000 ADT we start seeing the wheel paths.

We always design the asphalt rate for the wheel path condition. Then we have to decide if we need more asphalt than that for outside the wheel paths. If we have a low volume road and we are going to shoot asphalt on the higher end of the normal range, we may go with a straight bar because we will have enough asphalt for outside the wheel paths. It is all about embedment and embedment depth. So the lower the ADT, the less embedment benefit you get from traffic and the higher your asphalt rate needs to be in the wheel paths. On the other hand, if we are shooting a low rate in the wheel paths, we will have to have more asphalt outside the wheel paths to hold the aggregate. That is typically the main reason we shoot variable rates, to hold aggregate outside the wheel paths. In our district, we are not lowering the asphalt rate in the wheel path. We are increasing the asphalt rate outside the wheel paths to prevent raveling.

We have transversely varied asphalt using both emulsions and asphalt cements. The type of asphalt doesn't matter. As for the aggregate, we'll do it with grade 3 and grade 4, but usually not with grade 5. We use grade 5 on rehabs, and they are usually being put on top of the base. Grade 5 is also small to begin with, so varying asphalt rate would be more difficult.

Our approach in the specifications has been to have a general note that says we want a minimum of 20% variation possible. However, the flexibility that we can get on a given project is going to fall back to the equipment that the contractor has out there. Some distributors have two spray bars, and you can vary the rate over a wide range. When the equipment has a single spray bar, the contractor has to go to the next size of spray nozzle. This usually gives about a 20% difference in rate.

When you vary the nozzle sizes on a single spray bar you need to be sure that the average shot rate is what is entered into the distributor's computer. If you want 0.35 gal/sy in the wheel paths and you are varying rates by 20%, then you will have to set the computer at something like 0.39 gal/sy. This setting will then give you about 0.42 gal/sy asphalt outside the wheel paths. We've developed a set of tables to help figure out average asphalt rates for each lane width (Example in Figure 1 for 12-foot lanes).

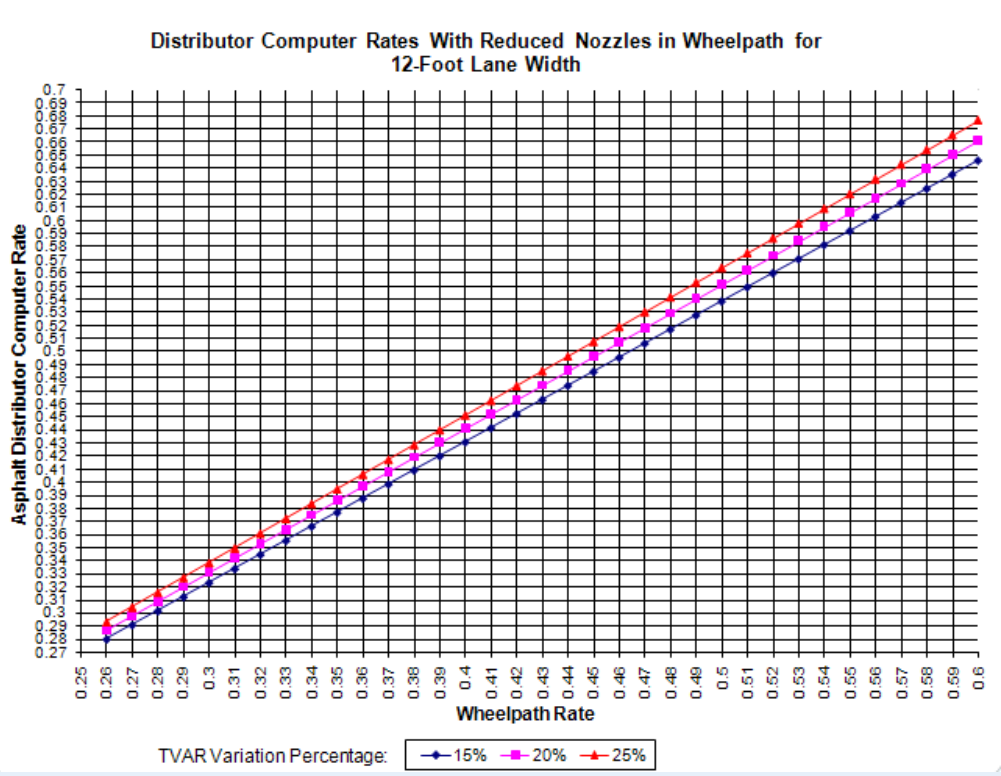

Figure 1

When we vary the asphalt rate, we usually assume the wheel path is 3 feet wide no matter how wide the lane is. But the locations of the wheel paths change with different lane widths. We developed a table to help us place the different sized nozzles correctly on pavements with different lane widths (Figure 2).

Lane Width, ft.							
	Center Line	ft.	Wheel Path Width, ft.	ft.	Wheel Path Width, ft.	ft.	Edge Line
9		0	3	2	3	1	
10		1	3	2	3	1	
11		1.33	3	2	3	1.66	
12		1.66	3	2.7	3	1.7	
13		2.3	3	2.7	3	2	

Figure 2

On the inspection end of things, we need to make sure the right nozzles are in the right places when the contractors change the nozzles out. That is the main thing for the inspector to check. Before you start, the contractor should have a calibration record for those nozzles. That's also important.

Key Words, by Category:

Geographic Area – Bryan district

Information Type – Legacy knowledge

Legacy Knowledge Source – Darlene Goehl, May 2008 interview

Flexible Pavement Distresses Involved – Flushing, raveling

Other Descriptors – Transversely varied asphalt rate, TVAR, seal coat, grade 3, grade 4, grade 5, nozzle sizes, nozzle configuration, traffic, average asphalt rates, distributor calibration

Search Acronyms: Legacy Knowledge – Flexible Pavement – Maintenance, lkfpm, Legacy Knowledge – Flexible Pavement – Inspection, lkfpi, Legacy Knowledge – Flexible Pavement – Construction, lkfpc, Legacy Knowledge – Flexible Pavement – Specifications, lkfps, Legacy Knowledge – Flexible Pavement – Unique Application & Innovation, lkfpu

Joe Higgins' Thoughts on ….

TVAR Seal Coat Design
TVAR Seal Coat Inspection

I've been involved with transversely varying asphalt shots as far back as fifteen years ago. I don't know for sure which year Thomas Bohuslav came to the Abilene District from Brownwood, but I remember we talked about asphalt rates and variable nozzles at that time, and we were already using some transverse rates in those years. I had done district seal projects for years, but then I got away from them for awhile. When I started doing the seal coats in my area three or four years ago, we went back to using variable nozzles.

In the early days I would use variable asphalt rates on all the roads in the district seal coat program, whether or not they showed any flushing in the wheel paths. Even on fairly decent looking pavements; I didn't think it was right to wait until you had flushed up asphalt in the wheel paths to start using variable nozzles. I still think that's the way to go because if you use straight nozzles where there's traffic, eventually, those wheel paths are going to show up. It will either be flushing in the wheel paths or you will be losing rock outside the wheel paths. While I would use variable rates on all of the main lanes, we would use straight nozzles on the shoulders.

When Thomas Bohuslav came, he brought a lot of good ideas from the Brownwood District. One thing Brownwood did was they made their own nozzles. We had two or three sets of nozzles made up and we would require the contractors to use them. However, there were some problems with that. We would have to use adapters to make them fit different contractor's spray bars. I really didn't like that, but that's what we did. I think those nozzles were made to give a variation of about 25%.

About two years ago I wanted to go with standard manufacture's nozzles. I picked two nozzles, trying to get as close as possible to 25% variation. Those two nozzles gave about 42% variation when we did the bucket test. Or maybe the 42% was based on the manufacture's literature. We went with them and it seemed to work pretty well. I imagine if we were to vary that much two or three times in a row we might start seeing something. I would say that as far as the amount of variation to use, there is a wide range there. I don't know if anybody really has a good handle on exactly how much variation you should use.

It's my understanding that at least one distributor manufacturer can now make nozzle sets to give the percent variation you want. That's good. Before, I let the

contractor get by with something outside of the range I was looking for in order to use standard nozzles. Now, I would be a little bit more demanding that we get the variation requested because I know they can get those nozzles.

Recently we have been requiring a variation in the range of 20% to 30%. We need to give the contractor a range because even with good nozzle manufacturing equipment, it's hard to hit a specific rate very closely. I would say 25% plus or minus 5% is about right.

Dealing with traffic and pavement condition adjustment factors, I have a sheet for the inspector that provides the recommended variations (Figure 1). I have another sheet to document the locations where you plan to change the average asphalt rate or the percent variation (Figure 2). That sheet also shows the numbers involved. The average asphalt rate depends on the lane width, because the width determines how many large nozzles you will have to have. So the worksheet guides the inspector through to come up with the average rate being obtained from the nozzles.

Nozzle Configuration

road width	nozzle configuration left to right (L-large, sm-small)	# small nozzles	# large nozzles	total # nozzles	25% variance av. rate* multiplier	30% variance av. rate* multiplier
9	1L 9sm 6L 9sm 3L	18	10	28	1.089	1.107
10	3L 9sm 6L 9sm 4L	18	13	31	1.105	1.126
11	5L 9sm 6L 9sm 5L	18	16	34	1.118	1.141
12	6L 9sm 8L 9sm 5L	18	19	37	1.128	1.154
13	7L 9sm 8L 9sm 7L	18	22	40	1.138	1.165
14	7L 9sm 8L 9sm 10L	18	25	43	1.145	1.174
15	7L 9sm 8L 9sm 13L	18	25	43	1.145	1.174
16	7L 9sm 8L 9sm 16L	18	28	46	1.152	1.183

* wheel path rate = base rate + traffic adj. + truck adj. + surface adj.

outside wheel path rate = wheel path rate X (1+%variance). Example: for variance of 25% then (1+%variance) = 1.25

average rate = wheel path rate X variance multiplier above. Example: for 12' width & 25% variance, multiplier=1.128

above factor = (#small + #largeX(1+variance))/total # of nozzles

Surface Condition Adjustment

surface	description	gr3	gr4	gr5
Seal	very dry seal with many cracks	0.06	0.06	0.04
	dry seal with few cracks	0.03	0.03	0.02
	good seal with no cracking	0.00	0.00	0.00
	flushed seal	-0.02	-0.02	-0.01
	bleeding seal	-0.04	-0.04	-0.02
ACP	ACP	0.12	0.10	0.05
Cold Mix	dry, well aged	0.12	0.10	0.04
Patch	fresh (less than 3 months)*	0.00	0.00	0.00
Prime	prime - dry surface, light rate	0.05	0.04	0.02
	prime - average codition	0.02	0.02	0.01
	prime - free asphalt on surface	0.00	0.00	0.00

*recommend cold mix patches have adequate cure time (plus 6 months minimum)

NOTE: Surface & traffic adjustment factors are subject to change based on experience.
If you experience problems using these rates, please contact Joe Higgins, Hamlin TxDOT.

Base Rate

Aggr. Grade	Asph base rate gal/sy	Aggr. rate cy/sy
3	0.40	105
4	0.34	115
5	0.25	130

Table base rates are not to be used for emulsions.

Truck Adjustment

% trucks	aggr grade 3	aggr grade 4	aggr grade 5
average	0	0	0
heavy	-0.03	-0.02	-0.01

Traffic Adjustment

vol/lane	gr 3	gr 4	gr 5
0	0.07	0.05	0.04
50	0.06	0.04	0.02
100	0.04	0.03	0
300	0.01	0.02	NA
500	0	0	NA
700	-0.01	-0.01	NA
1000	-0.02	-0.02	NA
1500	-0.03	-0.03	NA
2000	-0.04	-0.04	NA

2 lane = ADT/2
4 lane urban = ADT/4
4 lane rural = ADT *.35 outside lanes
4 lane rural = ADT *.15 inside lanes
Shoulder ADT = zero

Figure 1

Asphalt Design Rate Worksheet

Highway _____ County _____
Asphalt type _____ CSJ _____
Nozzle var. (20% or 30%)===> _____ aggregate rate (cy/sy)==> _____
Aggregate Size (3 or 4 or 5===> _____ asphalt base rate (gal/sy)==> _____

width feet	ADT veh/day	Veh per Lane	truck %	Location (normally Texas ref. mark (or station) and direction)	traffic adjust gal/sy	truck adjust gal/sy	surface adjust gal/sy	wheel path rate* gal/sy	outside wheel path rate** gal/sy	average rate*** gal/sy

Comments:

Vehicles per lane
2 lane = ADT/2
4 lane urban = ADT/4
4 lane rural = ADT *.35 outside lanes
4 lane rural = ADT *.15 inside lanes

*wheel path rate = base rate + traffic adj. + truck adj. + surface adj.
**outside wheel path rate = wheel path rate X 1.25 (for 25% variance)
***average rate = wheel path rate X variance multiplier from nozzle conf. table

Figure 2

Now, with seal coats, my experience is everybody is an expert. You can have a summer hand who has been out there two weeks and knows exactly what to do, what kind of rates to use, and everything else. Regardless of how much or little experience, people think they have it figured out. The recommended rates and adjustments in the worksheet are based on what has worked in the past. I continue to adjust them. There's a note at the bottom of the worksheet that says, "If you use these rates and they don't work for you, let me know and we can adjust them." In fact, I have recently made some adjustments based on the last couple of years of experience. One thing that often throws people off is shooting on top of hot mix. It seems people never add enough asphalt to the base rate when shooting on hot mix. That's a number I have increased in my recommendations. The recommendations are a continuing process, tweaking them as we go.

The biggest thing for the inspector to monitor is that the right nozzles are in the right places. That can be hard once you get the nozzles and spray bar covered with asphalt. An inspector has to be able to look at the spray bar and tell if the nozzles are oversized or too small. Contractors can get a little lazy and put standard nozzles on and not change them when they go back to the main lanes, or vice versa. What we did last year was have the contractor put washers on the bigger or smaller nozzles. We could then check them without getting some diesel and a rag and trying to see the numbers on the nozzles.

A method some people use to check if the varied asphalt shot rate is proper is to look at the rock embedment behind the rollers. I have never thought that was a good method because there is no way you can really tell when varying shot rates. You have to wait and go through a winter and summer to see if it's going to bleed or lose rocks. So I trust what I have learned from experience about adjusting rates for traffic and road conditions instead of spending a lot of time on my knees looking at embedment. We wait twelve months before checking to see if we had a successful seal coat. When we check it we see if it lost rock, if it bled, we look at when we shot it, and what the rates were that we used. Our district is doing much better with keeping up with the rate we placed and evaluating the condition of the road afterwards. Those evaluations can lead to tweaking the adjustment factors.

When it comes to the process of varying asphalt rates, we have always designed the asphalt rate for the wheel paths first because the wheel paths tell you more. We pick a rate for the wheel paths, and then we increase asphalt outside the wheel paths. If you use variable nozzles, you put down more asphalt than you would otherwise, and you get a better finished product.

The additional asphalt outside the wheel paths helps you hold the rock better and you get a better job of sealing the pavement. It's the same on the shoulders. My instruction to the inspectors on shooting shoulders is to shoot as much asphalt as your construction equipment can get through. If the seal starts picking up on construction equipment, you've shot too much and back off. We always put down a lot of asphalt on the shoulders since they don't carry traffic. I have developed a theory on that. If you want to save money, shoot the shoulder only every other cycle. The cycle that you do shoot it, put down such a heavy rate that that the seal should hold better through the cycle when it's not shot.

The seal contractors that have worked in my district are pretty neutral on transversely varying asphalt rates. Now I do suspect the hands that have to change those nozzles out probably have an opinion on it. But the contractor, the owner of the company, they just go with it. I don't know if they add anything to the bid price or not, but I suspect they get their money back without an increase because they will be putting down a little more asphalt for the same amount of work.

One thing I would tell districts that haven't tried transversely varying asphalt rates is to just look at your roads. On the roads that have been sealed two or three times over the years, you can see it's either flushed in the wheel paths, or you've probably lost some rock between the wheel paths and outside the wheel paths. To me, that is the biggest thing I see that should convince everybody we need to be doing something a little different. I think varying nozzle sizes makes obvious

sense. The more traffic you have, the more that traffic is going to beat the rock down into the asphalt, and the traffic runs in the wheel paths.

For me, the biggest unanswered question would be how much variation you need. How much variation is enough and not too much? If I can vary from 20% to 40%, that's a wide range. What I have liked to do in the past is base the amount of variation on experience. And then when I go back in twelve months and see that it is working fine, then maybe that was a good rate variation. But the number I pick for a percent variation is just a guess. I don't use a calculation or anything for the amount of variation.

While I haven't tried it, I think using the sand patch test is a very good concept. But I can tell you where it's not going to work if you are testing only the wheel paths. It won't work on hot mix and hot mix-cold laid pavement surfaces. If you do the sand patch test in the wheel path it's going to indicate that you need to back off on the asphalt because the hot mix surface is closed up, similar to a partially flushed seal coat. But you really need to go the other way. My discovery on hot mix is that I have had to bump up the asphalt rate one-tenth above base rate. I increase asphalt at one-tenth for a grade 4 now and twelve-hundredths for a grade 3 aggregate. I have never seen hot mix to bleed up after someone sealed on top of it. I do see a lot of rock loss though. So I keep bumping the rate up for hot mix surfaces. I have a theory on hot mix. Hot mix is just a flush surface and the seal coat rock can't nestle down into it, it just sits on top.

I have one more thing that hasn't been mentioned, and that is you can't totally judge the seal coat based on whether you lose rock or get some flushing. The time of year you shoot is so critical. If you shoot a seal coat in the spring, you have the summer ahead of you before the winter, and you can be good. If you shoot it late, sometimes the pavement doesn't get hot enough for the rock to properly seat. That's when you can lose rock. But in that case it wasn't because the asphalt rate was wrong. It was because of the time of year that you shot it.

One thing I tell my inspector is, "Don't change your rock rate. Keep your rock rate the same." We have so many contractors and inspectors to start increasing rock rather than holding it the same and decreasing the asphalt if they start seeing a little picking up on the dump truck or chip spreader. I try not to vary my asphalt rate based on the time of season, but if we are doing a rehab job and we want to finish it, I might shoot a little more asphalt. But I try to hold my asphalt rate based on the traffic and the pavement conditions, those two factors only. If it's too late in the season, we probably just shouldn't be shooting.

Key Words, by Category:

Geographic Area - Abilene district, west Texas

Information Type - Legacy knowledge

Legacy Knowledge Source – Joe Higgins, September 2008 interview

Analyses Involved – Test Method Tex-436-A, Sand Patch Test

Flexible Pavement Distresses Involved – Flushing, shelling

Other Descriptors – Transversely varied asphalt rate, TVAR, seal coat, texture, grade 3, grade 4, grade 5, work sheet, asphalt adjustment factors, nozzle size identification, shoulders, rock rate, picking up, hot mix, hot mix cold laid, traffic, embedment, Thomas Bohuslav

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Randy King's Thoughts on ….

Seal Coat Asphalt Rate Selection
TVAR Asphalt Distributor Calibration
TVAR Seal Coat Inspection

I would say that the Brownwood District transversely varies asphalt on about 60% to 70% of our seal coats. I make the asphalt rate determinations on each road in our district, including if we will vary rates or not.

We have a seal coat design report program in our laptop. I'll go out on the roadway within a month before our seal coat program starts and drive each of the roads that we have set up. I usually make the asphalt rate decisions based on what I see and using the design method. But sometimes a road looks like a road we shot last year, and I'll go back and find the rate I shot last year. How the road from last year looks helps me set the rate for this year's road.

There are some times I wouldn't recommend transversely varying the asphalt rate. If a district shoots a grade 5 rock, which our district doesn't shoot, I would probably not recommend varying the asphalt rate on it. Also, you really want to look at the roadway to see what type of roadway it is, what seal is there, or if it's a hot mix or a microsurface. You definitely don't want to use variable nozzles on a microsurface or a hot mix project because the roadway is consistent all the way across. You also don't want to do it if you don't see a set traffic pattern and wheel paths. In-town sections are higher volume and the traffic tends to use the whole roadway. So you want to be careful on the hot mix and microsurface projects and places where there's no set traffic pattern.

One thing that really helps to get good seals is to have the same guys out on the seal coat project year after year. They get experience with those variable nozzles and with making rate adjustments. Making rate adjustments out on the roadway is part of using variable nozzles. That's the reason I have one guy that's been with me for 10 to 12 years, and he and I get together make those rate adjustments. When you do decide to lower the rate a little bit where wheel paths are flushed, you have more leeway because of the 22 to 32% higher rate going outside the wheel paths.

There's a requirement in the spec book that the distributor has to be calibrated. The contractor does it now. He has to perform it each year, or whenever the district wants him to do it. There's more to it when you are going to use variable nozzles. He will do a calibration using the same sized nozzles all the way across because there is a spec that says each nozzle has to be within 10%. After that

he’s got to put in the variable nozzles and do a calibration to show that they will give the 22 to 32% variance that’s required in the plan note. We do the bucket test for calibration, usually for a standard 12-foot width set up on the spray bar.

As far as distributor inspection, I just make sure that once we decide on the rates we’re going to shoot that we give the contractor all those different rates. Since there are four or five dials on the computer in the distributor cab, he can go ahead and put those rates into his computer. That way, when he sees we want a different rate by what we wrote on the roadway, he’s ready to make those adjustments. But as far as an inspection procedure, I just make sure I have a couple of inspectors that know these variable nozzles well enough. When the contractors change nozzles out, we need somebody there watching to see that they get them changed correctly for the type of roadway and the locations of the wheel paths. You can sure mess up a road if they put the nozzles in there wrong.

The location of the wheel paths varies on different roads, but we pretty well always use a three-foot wheel path width when we vary the asphalt rate. For example, if it’s an FM road with maybe 9 or10 foot travel lanes, the traffic will normally run to the middle of the center line. So you have to make spray bar adjustments for wheel path locations on those type roadways. But when you get on a US or a state highway with a shoulder and an edge line on the travel lane, the traffic tends to move over towards your shoulder to follow that stripe. But three foot is pretty well the width of your wheel path in all cases.

Something to keep an eye on if you’re using emulsion is the viscosity of the emulsion. If your wheel paths are depressed a half inch or so lower than outside the wheel paths, the emulsion will tend to run down into your wheel paths and give you more asphalt there than you want. So you really have to watch the viscosity on emulsions. That’s the reason we put a viscosity check in our spec a few years ago, in early 2000. If we saw something changing or something different with the emulsion viscosity out on the roadway, that we could stop, halt the project, and bring a test sample in and check it. Hot oil doesn’t have this problem because it cools so quickly and the viscosity is higher.

The complaint that I hear from contractors about transversely varying the asphalt rate is they don’t like changing the nozzles, stopping and having to change nozzles. They say it holds them up. There are some that it doesn’t bother a bit. But the biggest complaint I have heard is from their guys that run the distributors. They just don’t like getting back there and changing them. That’s probably the biggest complaint. I would say if you’ve got a good distributor guy, and he doesn’t have a problem changing them, he can have them changed out in 15 to 20 minutes pretty easily. Your inspector should be there with him, helping him by showing him where the smaller nozzles should go. Yeah, I would say on average that you're changed and ready to go in 15 minutes. Normally we try to get the

contractor to change them as soon as the distributor gets to that roadway, because they're waiting for the rest of the equipment to get there anyway. So what I do is send my inspector up there to get with the distributor operator right away. There's not really any down time for the contractor if you do it that way.

Last year I tried to use a lower asphalt rate in only one wheel path. We had one wheel path that was slick and the other one that wasn't slick. So I wanted to try using the smaller nozzles in only one wheel path. But we didn't go very far because I could tell right away that something didn't look right. For some reason the distributor pushed too much oil into the other wheel path, so I had to stop and readjust.

Something I would tell districts that don't use variable nozzles is that they work. They definitely work. But I'd also tell them to be sure to look at your roadways and use the variable nozzles on the roadways that really need them. They will save some slick wheel paths, just make sure to use them in the right places.

Key Words, by Category:

Geographic Area – Brownwood district

Information Type – Legacy knowledge

Legacy Knowledge Source – Randy King, June 2008 interview

Analyses Involved – Test Method Tex-922-K

Flexible Pavement Distresses Involved – Flushing

Other Descriptors – Transversely varied asphalt rate, TVAR, seal coat, emulsion viscosity, field sampling, contractor communications, grade 5, changing nozzles, nozzle sizes, nozzle arrangement, traffic, distributor calibration

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Paul Montgomery's Thoughts on ….

TVAR Seal Coat Objectives
TVAR Seal Coat Specification Approaches

The whole concept behind transverse variable shot rates is to give us the ability to put more oil on the road. We want more oil on the road, but we don't want traffic to track it. Using variable rates let us lessen it up in the wheel paths to prevent the tracking and then to put more oil in the areas where the traffic isn't predominately running. The net result is more oil on the road and a better seal.

Another thing that's desirable is putting a little more asphalt on the shoulders. If you're just shooting the shoulders you can aim for about 50% embedment. You don't have to worry about asphalt tracking as much.

Our plan note about transverse variable shot rates generally says, "Do what Jimmy says to do." Jimmy has come out of the maintenance side in the district and he's gone through his career doing seal coats, actually riding the distributors. We have enough confidence in him to set an approximate rate on the plans for every road and then let Jimmy figure it out from there. You'll find that Brownwood does it differently. I know Randy King goes out and does some calculations on each road to get the shot rates. Randy comes from the design end and has a good method. It all depends on your personnel. Our approach works out well for us and Brownwood has a really strong seal coat program and their approach works out well for them.

Key Words, by Category:

Geographic Area - Lufkin district, east Texas

Information Type - Legacy knowledge

Legacy Knowledge Source – Paul Montgomery, April 2008 interview

Other Descriptors – Transversely varied asphalt rate, TVAR, seal coat, shoulders, aggregate embedment, Randy King, Jimmy Parham

Search Acronyms: Legacy Knowledge – Flexible Pavement – Maintenance, lkfpm, Legacy Knowledge – Flexible Pavement – Inspection, lkfpi, Legacy Knowledge – Flexible Pavement – Specifications, lkfps, Legacy Knowledge – Flexible Pavement – Unique Application & Innovation, lkfpu

Jimmy Parham's Thoughts on ….

TVAR Seal Coat Inspection
Communicating Asphalt Rate Changes
Sealing over Fresh Hot Mix Patches

We have been transversely varying asphalt rates for about eight to ten years in Lufkin. There have been some years we might not have a road where we use it. In other years, we might have several roads where we use it. It fluctuates every year. I imagine it averages close to 40 to 50% of our roads need it.

I usually ride the roads before we shoot them, look at them, and make some notes about asphalt rates and other things. But the final decision on asphalt rate is made the day we shoot that road. I'll go ahead of the distributor after the shots are marked and communicate back to the distributor operator by CB. I have a CB in my truck and the distributor operators have them in their trucks. When we're going to make a decision on a shot mark, I'll tell them a rate for the wheel paths and then a higher rate for outside the wheel paths. If we want the variable rate just part way through a shot, I'll make a little mark on the road to let him know where he should begin shooting the asphalt rate full width. We can be this flexible because our contractor usually has two spray bars on his distributor. So he doesn't have to change nozzles to go back to shooting straight bar.

The asphalt rates for the wheel paths are set pretty much by their visual appearance. But I do have a little temperature gage to check the roadway temperature. And a lot of times I'll take a rock and push it down into the oil to see how much free asphalt we actually have in the wheel path. Then I'll make my adjustments. I might make a short test shot to see what it does, what kind of embedment we get with the amount of oil that is already on the roadway.

Another factor to consider is what type of oil we are using. If we are shooting hot oil, it's going to liven up the oil on the roadway more than if we are shooting an emulsion. So that's a factor as well. What I'm doing is trying to determine how much asphalt I already have out there by how far I can push that rock in. Then I can cut my asphalt rate back because the contractor is going to shoot oil that's 330 or 340° F, and it's going to liven up that asphalt we already have on the road.

If you shoot too much asphalt considering how much oil is already at the surface, the seal coat rock is going to be pushed down and embedded too deep after traffic gets on it. Before you know it, the rock is gone and your oil is on top again. So I use that rock test to kind of check the depth of the asphalt that I already

have out there. Then I can cut my rate down. I might cut it down as low as 0.22 gal/sy in some cases.

Another factor is the type of pavement you are sealing. I had a road that had a lot of fresh milled inlay patches on it. I had to change my rates based on that. I cut my rates down when shooting on fresh hot mix. When I get back on just old seal coat that has been there five or six years, I'm increasing the rate back up.

Your ADT, your traffic count, is another factor. If you have a lot of heavy loads coming through there, you want to try to shoot your wheel paths even a little lighter. Climbing lanes would be another example of a place where you may want to lower the shot rate a little more.

There's nothing too different for an inspector to look at when shooting variable rates. They just need to check to see if the different sizes of nozzles are in the right places and have their angles right. Also, any time you shoot, you have to check the speed of the distributor. Some of them get in a hurry and want to get the tank emptied out, particularly when they're running behind. I always like my distributors to shoot about 350 feet a minute. The height of the bar is another thing to always check.

The way I tell if my variable shot rates are correct is to look at the embedment of my rock. I go back and check it out after my rollers have rolled it and gotten through. I'll get out, walk, look and check the embedment of my rock. When I shoot, I like to try to get about 35% of my rock embedded. When it heats up during the summer and traffic runs on it, the rock is going to push down some more. So you have to allow some room for that.

If the contractor's distributor requires that he change the nozzle sizes every time the rates are varied transversely, you aren't going to have a lot of options on variable rates. If he has number four nozzles across the spray bar, you have him change to number three nozzles in the wheel paths.

I would recommend to anyone that has a lot of flushing in the wheel paths to give a shot to transversely varying the asphalt rate. Over the years I've been doing this I've learned that you aren't going to get every wheel path perfect by varying the asphalt rates, but it will help you on the embedment of your rock. Where you're seeing a little flushing, you can keep it from flushing again. I would recommend everybody to give it a try, at least.

Key Words, by Category:

Geographic Area – Lufkin district, east Texas

Information Type – Legacy knowledge

Legacy Knowledge Source – Jimmy Parham, April 2008 interview

Analyses Involved – Pavement temperature, depth of surface asphalt

Flexible Pavement Distresses Involved – Flushing

Other Descriptors – Transversely varied asphalt rate, TVAR, seal coat, embedment depth, temperature, distributor speed, hot mix patches, traffic, climbing lanes, asphalt adjustment, nozzle sizes, CB, contractor communications

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Albert Quintanilla's Thoughts on ….

TVAR Seal Coat Use
TVAR Seal Coat Inspection
Field Adjustments to Asphalt Shot Rates

The Laredo District has used transversely variable asphalt rates off and on for about the last ten years. This past year we didn't use any though. If I had to guess, over the years we have used it on about 10% of the locations in our annual seal coat programs. The determination of the seal coat asphalt rate is made in the field by consensus between the inspector and contractor prior to beginning seal coating on that particular location.

When we decide to transversely vary the asphalt rate, our experience has been to change out distributor nozzles so the areas outside the wheel paths receive about 15% more asphalt than the wheel paths. We change the nozzles on the distributor spray bar which generally follow the wheel paths. This is standard regardless of the aggregate being used.

Concerning construction inspection and decisions made on the roadside, the most important decision is determining if the pavement condition prior to the seal coat warrants having the contractor changing nozzles on his distributor. On projects where this is done, we inspect the nozzles before the contractor installs them to insure they'll give the proper varied rate. The biggest error that can be made would be not changing the nozzles in the wheel paths when it's needed. If they aren't changed, tracking or bleeding issues occur.

We allow the inspector to make limited adjustments to preset shot rates. As far as increasing the shot rates, typically I tell the inspector he can increase the asphalt rate up to 0.05 gal/sy based on the existing pavement conditions and up to 0.05 gal/sy based on traffic. However, he or she isn't allowed to increase the total asphalt rate by more than 0.06 gal/sy without prior approval from the area engineer.

Also, it's important to have good communication with the seal coat contractor. They usually don't complain about changing the nozzles as long as they have enough lead time so they can do it without stopping the seal coat operations. In other words, if you let them know when the distributor first gets to the location, they can change the nozzles while they wait for the sweepers and rollers to show up and for the temporary tabs to be installed.

Transversely varied asphalt shot rates are just another tool that can be used on seal coats. What matters most is having the knowledge to use the right tool for the right job.

Key Words, by Category:

Geographic Area – Laredo district, south Texas

Information Type – Legacy knowledge

Legacy Knowledge Source – Albert Quintanilla, June 2008 interview

Analyses Involved – None

Flexible Pavement Distresses Involved – Flushing

Other Descriptors – Transversely varied asphalt rate, TVAR, seal coat, field asphalt shot rate adjustments, contractor communications

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Ernest Teague's Thoughts on ….

TVAR Seal Coat Use
TVAR with Asphalt Rubber

We started doing transverse variable rates last year. Our experience so far has been with a contractor having a standard, single-spray-bar distributor. What we did for a typical 12-foot lane was consider the outside 2 feet on each side to be outside the wheel path and that there would be 2 feet between the wheel paths. This gives us two 3-foot wheel paths. Typically, if they're putting down a straight shot, they will use all number 5 nozzles when they are shooting AC-20-5TR or AC-20XP. They like to use the bigger nozzles for those asphalts. When we ask for a variation in shot rate, which for us means 10 to15% less in the wheel paths, they alternate the nozzles between number 5's and number 4's in the wheel paths. This works well because the fan spray patterns from the nozzles overlap one another and gives you an average. To get a uniform average, you need to set the spray bar height to get double overlap instead of triple.

I checked with the Brownwood District when we started looking into this. They are probably TxDOT's champions in varying asphalt shot rates. They go from a number 5 nozzle outside the wheel paths to a number 4 nozzle inside the wheel paths. This results in about a 30% difference in asphalt rate. When I first heard about that, I thought 30% was too much of a difference for us to start out with even though they obviously like it. They've been getting good results with that for years. Now I could see where 30% might work, in particular where you have wheel paths that are flushed. But I wanted to use this on all of my seals and wasn't willing to go that far. So we looked for a way to get 10 to15% variation, and alternating nozzle sizes in the wheel paths was the method we came up with.

As we evolve in our thinking and get more experience, I can see a situation where I might have a road that is flushed badly in the wheel paths. I might be inclined to go with a 30% variation there. We would want to shoot a lot less in the wheel path and still try to keep enough oil up between the wheel paths and outside the wheel paths to hold the rock. At the same time we would want to try to keep from re-creating the flushing problem in the wheel paths. I could see asking a contractor to vary 30% if we had that type of situation.

Last year we shot hot asphalt rubber on IH-30 in Hunt, Hopkins and Franklin counties. We were having trouble with some old dry asphalt, and it was starting to shell out on us. We needed to capture that right quick. We opted for the hot rubber product because we felt that we needed something with a lot of elasticity.

We didn't want to use grade 3 rock because of broken windshields, especially with the high speed traffic on the interstate. Also, we knew that grade 4 rock is harder to get the asphalt just right to keep from losing rock and keep it from bleeding. That was when we decided to use variable asphalt rates, which was the first time I tried it. I had pretty good luck with it. There's a stretch in another county done by the same contractor where the asphalt rubber rate wasn't varied. Right now you can drive through there and see that there isn't a whole lot of difference in the wheel path, but you can see a little difference in rock loss outside the wheel path where the rate wasn't varied. It was the same contractor and the same product. That's just an example of the advantages we can gain by transversely varying asphalt. That little difference can sometimes show up in a big way, and that sold me.

Key Words, by Category:

Geographic Area - Paris district, northeast Texas

Information Type - Legacy knowledge

Legacy Knowledge Source – Ernest Teague, June 2008 interview

Flexible Pavement Distresses Involved – Flushing, shelling

Other Descriptors – Transversely varied asphalt rate, TVAR, seal coat, grade 3, grade 4, alternating nozzle sizes, nozzle arrangement, hot asphalt rubber, broken windshields, double overlap, AC-20-5TR, AC-20XP

Search Acronyms: Legacy Knowledge – Flexible Pavement – Maintenance, lkfpm, Legacy Knowledge – Flexible Pavement – Inspection, lkfpi, Legacy Knowledge – Flexible Pavement – Construction, lkfpc, Legacy Knowledge – Flexible Pavement – Specifications, lkfps, Legacy Knowledge – Flexible Pavement – Unique Application & Innovation, lkfpu

Richard Walker's Thoughts on ….

History of TVAR Use in Brownwood
Nozzle Manufacture and Precision
Basis for TVAR Specification Range
Double Surface Treatments
Asphalt Distributor Calibration

I've been working in the Brownwood District for 28 years, and they had been transversely varying asphalt about 10 years before that. So the district has been transversely varying asphalt for around 38 to 40 years.

Whenever I am asked to talk about transverse nozzles, I always preach on one thing. You never put less asphalt in the wheel path. Instead, you put exactly what the wheel paths require, and then put more asphalt outside the wheel paths to help hold the rock and keep it from shelling. You will invariably here people say, "We put less asphalt in the wheel paths with variable nozzles." You didn't. You put exactly what the wheel path required. When I tried to explain it to the contractors, some of them thought they were getting cheated. They thought they were shooting less asphalt now. But they're shooting more. In an ideal world if everybody was designing for the wheel paths, the variable nozzles would be letting you hold rock outside of the wheel paths. You aren't shooting less to prevent flushing.

We use a lot of emulsions in our district. Sometimes the asphalt rate was increased too much outside of the wheel paths. What was actually happening was the emulsion was flowing toward the wheel paths and we were getting more asphalt in the wheel paths than we designed. You want to make sure that the viscosity is good whatever asphalt you are using. It will flow if it's too thin. I really like emulsions, but low viscosity can cause more problems than anything else with them.

If you have a standard asphalt distributor, one with a single spray bar, the only way to vary asphalt rates is to use a special set of nozzles. Making the nozzle sets is a tedious process that takes a lot of trial and error. We used to make them in our district shops. It's not something everybody can do, and even when you make a nozzle set, its variance will change depending on the viscosity of the asphalt and the pressure being used. So you can't tell the contractor that "I want a 25.6% variance," because he can't ever obtain something that precise. What we do is give them a 10% variance range that they have to hit, between 22% and 32%. I went up to 32% because, at the time, there were some nozzles you could

buy where two different sizes would give you a 32% variation. We were really looking for a 30% variance on most of our seal coat roads, but because that one combination made a 32%, we didn't want to cut them out. If you are going to fine tune and vary less than that, you have to give them a pretty good range for that too. For example, if you want to lower the rate to about half that much, you would need to give them a range something like 12 to 20%. The reality is that the nozzles of just one size, when you buy them, can vary as much as 10%. So, if you are not varying rates by more than 10%, you may not be accomplishing that much. That's why I think you need at least 20% variation to be sure you're accomplishing something. On most roads, a 30% variation works pretty well. If you go very far over 30%, the asphalt viscosity of emulsion allows some flow back. The distributor may be shooting it right, but it doesn't end up right on the highway. Over the years and by trial and error the first people using it in Brownwood determined the maximum amount they could put out there successfully was around 30%.

Now, contractors with distributors with double spray bars can do more adjusting of the rates. Double bar distributors can fine tune the amount of asphalt being put down through each bar and separately control the asphalt rates outside and inside the wheel paths. I haven't seen the double bar asphalt distributor here in our district. If you set up your specs for just the double bar distributor, you eliminate a lot of contractors and cause the cost to go up quite a bit because there aren't many contractors who have them.

One thing that would be easy for the contractor or the inspector to miss when using variable nozzle sizes is making sure the right nozzles are in the right places on the spray bar. It's always good practice to check them at least every morning or when you move. Sometimes at night the operator might decide to clear out his nozzles and throw them all in a bucket. You can never know what happens when you aren't there. I've even seen them put in there backwards. If you put the big nozzles in the middle of the wheel paths you make a terrible mess. That's the worst possible error that can occur. So it's good to verify that you've got the right nozzles in there when you start in the morning.

We had a few area engineers a long time ago who liked to put down a small variance in asphalt rates on new construction. They might want a 12% variation or something like that. We custom made all our nozzles back then, and we tested all our nozzles, so we could really fine tune the nozzle sets contractors used. Things have changed, and we aren't able to do that anymore. Making nozzles is a very time consuming and labor intensive process, and then you needed to keep them in good shape. What would happen was the nozzles would get lost during seal coat jobs. We got to the point where we couldn't keep supplying the nozzles with our limited forces. So that's when we turned it over to requiring the contractors to furnish nozzles. Very few contractors have the expertise or the

time and knowledge to make nozzles. That's why we went to the 22 to 32% range, so they could use combinations of purchased nozzles.

The nozzle set I really liked had obviously different nozzle sizes. You could easily see whether the right nozzles were in place or not by looking at the back of the bar (Figure 1).

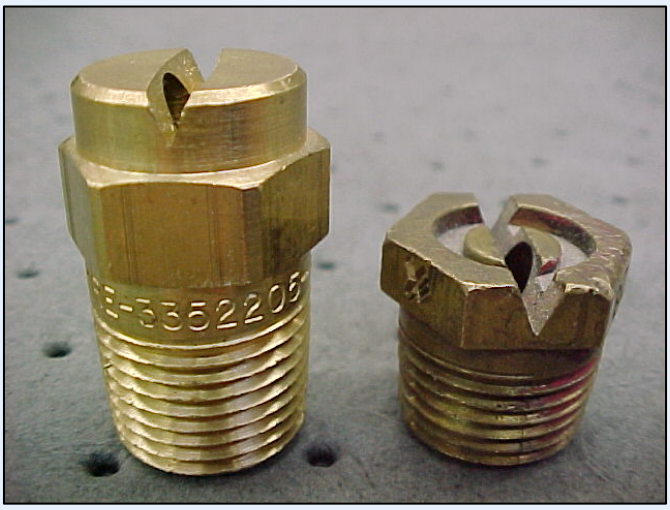

Figure 1 – Taller Nozzle for Outside Wheel Paths, Shorter Nozzle for Wheel Paths

When you make a nozzle set yourself in the machine shop, sometimes the only way you could tell the difference in sizes was to mark the nozzles. We used to put an "X" on the larger nozzles. But when you got asphalt on them, it was still tough to tell whether the right ones were in the right places. You always have to pay attention because you never know when one of the nozzles will get stopped up. If you're not there, the operator may just take it out and stick another one in without insuring it's the right size.

When we decided to require the contractor to furnish the bucket test, we wanted to ease into it. It's a test that wasn't commonly run in the industry. It doesn't require a special person or a lot of equipment. You just have to have a calibrated set of scales to run the test. I have a series of photos I can send you showing the calibration process (Figures 2 – 6). Now, more and more contractors are getting calibrations run at commercial labs. But there's nothing prohibiting a contractor from doing his own testing right now. We have the option, if we are out there and something doesn't look right, to stop him and call in our own forces or require him to furnish a new calibration.

Figure 2 – Building Calibration Test Pad

Figure 3 – Blowing Out Spray Bar

Figure 4 – Cylinders Placed Under the Nozzles

Figure 5 – Cylinders ¾ Filled with Asphalt

Figure 6 – Weighing Cylinders to Nearest Gram

We use double surface treatments primarily on new construction. We really don't have the need to use variable nozzles much on new construction. What I do suggest, if they're going to shoot the first course then right away back up and shoot the second course, is that they take the design asphalt rate for the bottom course and cut it down some and add that amount to the top course asphalt rate. That lets more asphalt fill in the voids from the top instead of from the bottom. We've done that in the past pretty successfully. Doubles are really tough to design, and it all depends on how the top rock fits into the bottom rock, how it geometrically fits in there. I really like them to shoot one course one year and come back a year later to shoot the second course. You can see how you did on the first course and fix any problems with the second course. We do double seal coats a lot in new construction, but it's not the easiest thing to do.

As I said, we use a lot of emulsions in our district. In dealing with emulsions, the textbook says that your spreader box should follow right behind the distributor. You should just push one of them with the other one. Sometimes in construction that just doesn't work real well. It's an ideal thing to shoot for, but I would say that 95% of the emulsions that are shot are shot after a short wait time so the rock sticks to the asphalt before the spreader box gets on it. You put the rock on as quickly as possible, and it's left up to the inspector to determine how quick and possible that is. Any type of literature you read on this will tell you that with emulsions you put the rock on right behind the distributor. And if you can do that, it is the best way. But in construction if the rock rolls too much or gets asphalt on top of it, the rock starts sticking to your roller tires. This causes a lot of other

problems. So it's just not always possible to put the rock on right behind the distributor, but the intent is to get the rock on the asphalt as quickly as you can.

When deciding if the asphalt rate you chose was right, sometimes it takes a year before you can tell. The road has to have gone through a winter and summer before you can tell if it is doing what you wanted it to do or not. You can kind of tell out there after construction. But with most seal coats, it's hard to tell until they've gone for a year.

What we really need for transversely varying seal coat is to have an accurate way to measure the rock embedment. Right now we know how much embedment we think we want, but we don't always know if we're getting that embedment or even if that is the correct embedment. We're going off some theories. The design procedure we've used is based on the embedment and has a long track history of being successful, but we don't know if the embedment is actually 35% or 30%. We calculated it to be 35%, but we aren't positive on how that embedment changes over time. After time the embedment increases, your rock wears down, and you push it down further into the asphalt. If you had an accurate way to actually measure the embedment, you could measure the performance of that road by how its embedment was changed.

Key Words, by Category:

Geographic Area – Brownwood district

Information Type – Legacy knowledge

Legacy Knowledge Source – Richard Walker, June 2008 interview

Analyses Involved – Test Method Tex-922-K, AASHTO T 72

Flexible Pavement Distresses Involved – Flushing

Other Descriptors – Transversely varied asphalt rate, TVAR, seal coat, emulsion viscosity testing, field sampling, contractor communications, nozzle sizes, nozzle manufacture, double surface treatment, distributor calibration, photos, bucket test, aggregate embedment

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