THE UNIVERSITY OF TEXAS AT AUSTIN + COCKRELL SCHOOL OF ENGINEERING
TEXAS PAVEMENT PRESERVATION CENTER
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TPPC Board of Directors

Our Mission

The mission of the TPPC, in joint collaboration with the Center for Transportation Research (CTR) of the University of Texas at Austin and the Texas Transportation Institute (TTI) of Texas A&M University, is to promote the use of pavement preservation strategies to provide the highest level of service to the traveling public at the lowest cost. The executive sponsor for the TPPC is the Texas Department of Transportation (TxDOT).

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Past and Upcoming Events

Regional TVAR Workshop

The TxDOT Regional Workshop on Transversely Varying Asphalt Rates (TVAR) was held in Austin on April 30. When applying seal coats, the asphalt rate can be varied across the width of the roadway in order to better address the needs of the existing pavement surface. The practice of TVAR can improve the performance of seal coats on pavements with flushed surfaces by adjusting the asphalt application rates to account for the difference between the wheel paths and the rest of the pavement. This workshop provided participants with detailed information regarding the use of TVAR, and concluded with a demonstration of the sand patch test – a valuable tool for the determination of proper asphalt rates. Videos of this workshop and additional instructional materials regarding TVAR will be available for use online at: http://www.utexas.edu/research/tppc/index.html.

TPPC Seal Coat Training Courses

Seal Coat training courses will continue to be offered by the TPPC. The course designed for inspectors, entitled "Seal Coat Inspection and Applications," focused on proper inspection methods and the equipment used during chip seal construction. The other, "Seal Coat Planning and Design," instructed engineers on planning, designing, and constructing chip seals.

TxDOT Regional TVAR Workshop

Figure 1. Sand Patch Test Demonstration

Defining TVAR

Transverse Variance of Asphalt Rates (TVAR) is the seal coat practice of varying the amount of seal coat asphalt across the width of the roadway in order to better address the needs of the existing pavement surface. TVAR can improve the performance of seal coats on pavements with flushed surfaces by adjusting the asphalt application rates to account for the difference between the wheel paths and the rest of the pavement. TVAR allows more asphalt to be put on the road without causing flushing in the wheel paths, resulting in a better seal overall. This practice can be used to improve the skid properties of the roadway by reducing wheel path flushing, while at the same time providing adequate asphalt coverage outside of the wheel paths to securely hold aggregate.

Optimal roadway performance requires that the wheel path need for asphalt rates be the engineer's primary concern. But it is a common misconception that TVAR, in order to eliminate the potential of seal coat flushing, reduces the amount of asphalt placed on a roadway. In fact, TVAR increases the total amount of asphalt placed on the road. After designing an asphalt rate based on the needs of the wheel path, this rate is increased for the areas outside of the wheel path. So if previous practice has been to design an application rate for the whole roadway based only on the needs of the wheel paths, then TVAR will allow for more asphalt on the roadway than would have been possible with a single-rate application.

Where to use TVAR

Asphalt rates should be transversely varied wherever asphalt demand varies across the width of the road. Compared to the current seal coat practice of averaging asphalt needs across the roadway, TVAR will reduce the reoccurrence of wheel path flushing, as well as improve aggregate retention outside of the wheel paths. By meeting the specific needs of different regions of the existing pavement surface, TVAR has the potential to increase the longevity of seal coat treatments.

TVAR may be placed on any pavement surface, but is most effective when severe flushing causes a large degree of texture difference between the wheel path and the rest of the pavement. Usually, these texture differences occur on roads with prior seal coats.
TVAR can be used with both hot asphalt cements and emulsions, and has demonstrated limited success with rubber asphalt. Additionally, aggregate type is not a factor, though many experienced practitioners of TVAR warn against using it with Grade 5 aggregate.

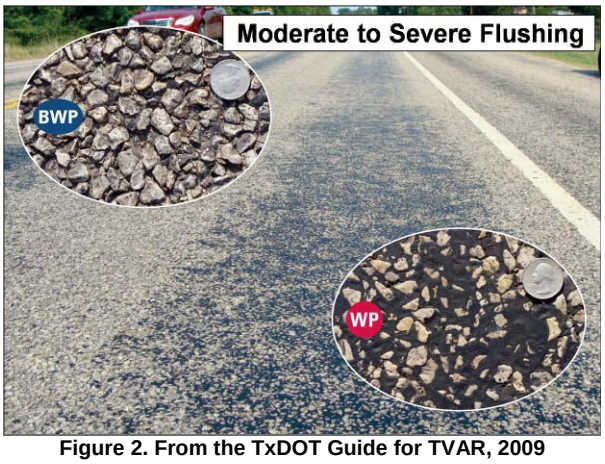

Figure 2. From the TxDOT Guide for TVAR, 2009

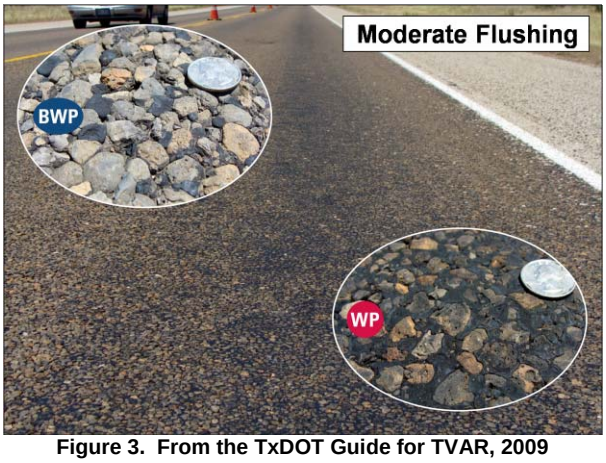

Figure 3. From the TxDOT Guide for TVAR, 2009

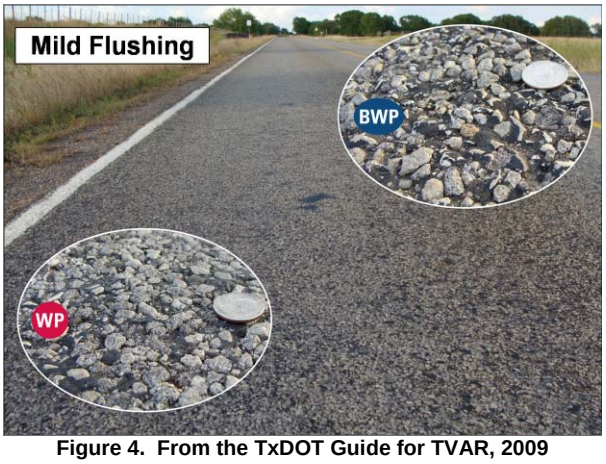

Figure 4. From the TxDOT Guide for TVAR, 2009

TVAR should not be used on new construction, but only with seal coat applications. Also, asphalt rates should

not be varied on road surfaces that do not exhibit consistent traffic patterns, such as shoulders, parking lots, or continuous left-hand turn lanes. Finally, emulsions on rutted or super-elevated pavements should not be considered for TVAR since the uneven road surface might allow for the emulsion to flow back into the wheel paths, disrupting the designed rate and cancelling the potential benefit of TVAR.

Selecting Shot Rates

The asphalt application rate must be designed to meet the needs of the wheel path first. TxDOT's *Seal Coat Surface and Treatment Manual* describes a method for selecting a rate which will adequately hold the aggregate without later allowing asphalt to flush to the surface. Once this wheel path rate has been chosen, the engineer should decide if the pavement in question is a good candidate for TVAR. The next decision is whether or not the asphalt rate outside of the wheel paths should be increased, and if so, how much variance there should be.

Figure 5. Dual Spray Bar Distributor

The amount of variation will often depend upon the type of distributor that is available for the seal coat project. When the contractor is using a single spray bar distributor, transverse variance can only be obtained through the use of different nozzle sizes across a single spray bar. This limits the potential range of rate variations, which in turn will affect the determination of shot rates. But by using a combination of standard nozzles sizes, contractors with a single spray bar can usually provide an asphalt rate increase outside of the wheel path in the range of 22-33%. So when using a single spray-bar distributor, the engineer must typically decide between this rate increase in the range of 22 to 33% or no rate increase at all.

On the other hand, distributors with dual spray bars can allow for more subtle rate variations. In this case, a broader and more optimal use of TVAR is possible. An asphalt rate increase of 10 to 15% outside of the wheel paths can address pavements with mild wheel path texture differences, and experienced inspectors can dial up specific percentage variations for different sections of the same roadway. However, if neither the inspector nor the contractor has much experience with TVAR, it is recommended that the possible variations be simplified to three choices: no increase, 10-15% increase outside of the wheel paths, and 22-33% increase outside of the wheel paths.

Sand Patch Test

If visual determination is inconclusive, a simple pavement surface test can be performed in order to quantify pavement condition and assist in the TVAR decision. The sand patch test, described in Tex-436-A, should be used if there is any uncertainty regarding the appropriate TVAR difference.

Figure 6. The Sand Patch Test

In this test, a fixed amount of sand is poured into a conical pile on the surface of the roadway in the wheel path area. Then, with light, circular motions, the pile is spread into a circle until the sand is at the same level as the highest aggregates, as shown in Figure 7.

Figure 7. A Sample Sand Patch Diameter

The diameter of the resulting circle should be measured four times, and the average of these measurements will provide an indication of the surface texture. Next, the test should be performed with the same volume of sand on the pavement surface outside of the wheel path.

The difference in the resulting sand patch diameters will correspond to the difference in pavement textures, since a fixed amount of sand is used in each case. The more open the surface texture is, the smaller the sand patch diameter will be. On the other hand, heavily flushed pavements will yield a sand patch with a very large diameter, since there are fewer voids in the pavement texture.

Figure 8. Measuring the Diameter of the Sand Patch

The degree of difference between the sand patch in the wheel path and the sand patch outside of the wheel path should provide a helpful indication of the appropriate asphalt rate variation.

Figure 9. High Pavement Texture Difference

As a general guideline, if the difference in sand patch average diameters is less than 20 mm, the asphalt rate should not be increased outside of the wheel paths. If the difference is between 21 and 50 mm, the asphalt rate should be increased by 15% outside of the wheel paths (This 15% rate assumes that the contractor is using a dual spray bar distributor). Finally, if the difference in sand patch diameters between the wheel path and the rest of the pavement is greater than 50 mm, a 30% asphalt rate increase outside of the wheel path is appropriate.

Distributor Inspection

The contractor is required to provide the selection of nozzles that will provide the designed asphalt rate variation, but the inspector must define the desired wheel path locations, effectively letting the contractor know where to place the various nozzles. Usually, nine nozzles on the spray bar will cover a 3-foot wheel path, but the exact nozzle configuration is the decision of the inspector, and must match the wheel path widths and locations of the actual roadway.

The following chart provides an example of different nozzle configurations based on recommendations by the Brownwood and Bryan districts.

Lane Width, Feet	Number of Center Line to Wheel Path Nozzles	Number of Inside Wheel Path Nozzles	Number of Between Wheel Path Nozzles	Number of Outside Wheel Path Nozzles	Number of Wheel Path to Pavement Edge Nozzles
9	1	9	6	9	2
10	2	9	6	9	4
11	4	9	7	9	4
12	5	9	8	9	5
12 (with edge line)	6	9	8	9	4
13	7	9	8	9	6

Figure 6. Suggested Nozzle Configurations

To ensure the proper application of transversely varied asphalt rates, the contractor and the inspector must both understand how to communicate the desired rate variation to the distributor's computerized controls. If the contractor is using a distributor with dual spray bars, each controlled by separate computers, then the asphalt rate to be entered into each computer is the rate that is expected from that spray bar. One spray bar will apply the asphalt rate determined for the wheel paths, and the other will apply the rate determined for outside of the wheel paths.

But if the contractor is using a distributor with a single spray bar, the asphalt rate entered into the computer should be a weighted average of the two transversely varied rates. The correct entry of this information is critical for the success of any TVAR application. The average asphalt application rate in gal/sy (gallons per square yard) to be set on the distributors computer, when varying nozzle sizes are used on a single spray bar, can be determined with the following formula:

[(L/100) x (V/100) x R] + R = Average Rate

Where: L = % of larger nozzles = (number of larger nozzles/total number of nozzles) x 100; V = % increase in asphalt rate selected for outside of the wheel paths; and R = design rate of asphalt application for the wheel paths in gal/sy.

Calibration

When preparing to use TVAR, first the contractor must perform his usual calibrations. These calibrations ensure that the distributor is able to apply asphalt at a

near uniform rate. Then, the contractor must additionally demonstrate that the distributor is capable of providing transversely varied asphalt rates at the designed percentages. A single bar distributor must be able to provide a TVAR increase within the range of 22 to 33 percent. If the contractor is using a dual bar distributor, the inspector should request a demonstration of the distributor's ability to provide at least two variation rates, preferably 15% and at 30%. If the distributor is able to adequately meet these standards, then it should be able to provide any variation rate within the calibrated range.

Adjusting Shot Rates

The condition of the resulting seal coat should be the basis for making adjustments to the TVAR percentage. Inspection of embedment depth both inside and outside of the wheel paths should be performed immediately after rolling, then again after the pavement has been subject to one or two days of traffic. 30% embedment is judged satisfactory immediately after rolling; ideally the aggregate embedment will increase to about 40% after several days of traffic.

Specifications for TVAR

Standard Specification Item 316 already allows for transverse variation in asphalt rate, so no special provision is needed. It is only necessary to include a plan note further define the use of TVAR in the project, and to clarify the necessary additional distributor calibration procedures. A recommended plan note is included in the TxDOT *Guide for Transversely Varying Asphalt Rates*. The plan note makes it clear that the engineer, not the contractor, will be responsible for determining when to transversely vary asphalt rates. Also, it is suggested that the plan note require distributors to be able to provide at least one transversely varied asphalt rate in the range of 22 to 33%. This requirement allows contractors with both single spray bars and dual spray bars to bid on the seal coat project.

Figure 7. Austin TVAR Workshop, Randy King, Yetkin Yildirim, Paul Krugler, Darlene Goehl

TxDOT Legacy Knowledge Documents Regarding TVAR

Joe Higgins works in the Abilene district, and has been familiar with TVAR practices for almost fifteen years. In the early days, he says he used variable nozzles on all roads in the district, shooting a wide range of variation: 20-40%. In his selection process, Higgins typically begins with a guess, basing the amount of variation on experience rather than calculation. "And then when I go back in twelve months and see that it is working fine, then maybe that was a good rate variation." Recently he has been requiring a variation in the range of 20-30%.

The need for TVAR is apparent, Higgins notices, on the roads that have been sealed two or three times over the years. When a road is either flushed in the wheel paths or has lost some rock between the wheel paths and outside the wheel paths, "To me, that is the biggest indication that something needs to be done differently," he says. The asphalt rate should be designed for the wheel path, and then an increased rate should be applied outside of the wheel path. "I tell my inspectors not to change their rock rate, but to hold it constant and alter the asphalt rate," Higgins explains, adding that asphalt rate should be adjusted based on traffic and pavement conditions only. According to Higgins, increasing the asphalt rate outside of the wheel path will help hold the rock and do a better job of sealing the pavement.

Higgins also stresses the importance of considering the time of application when evaluating asphalt rates. He recommends waiting 12 months to check a seal coat, then depending on how it looks, adjusting the rates to make recommendation for other roads in the district. But he cautions, "You can't totally judge the seal coat on whether or not you lose rock or get some flushing. The time of year that you shoot is critical." Higgins explains that if you shoot too late in the season, the pavement may not get hot enough for the rock to seat properly. In this case, the pavement may lose rock not because the asphalt rate was wrong, but because the seal coat was applied at the wrong time of year.

Higgins has never thought that embedment was an accurate measure of shot rates, and advises instead giving the pavement time to settle. "You have to wait and go through a winter and a summer to see if it's going to bleed or lose rocks," he says. "I trust what I have learned from experience about adjusting rates for traffic and road conditions instead of spending a lot of time looking at embedment."

Darlene Goehl has been transversely varying asphalt rates in the Bryan district for around ten years. She claims to use TVAR on about 50% of the seal coat locations in the district. "The director of construction and I ride all the roads in the district seal project a couple of weeks before the project starts," she says. At this time, Goehl sets up the asphalt rate table, and decides whether or not to use TVAR.

This is usually a visual determination, she explains. "We look to see if the wheel paths are visible. We also

look to see if there is raveling outside of the wheel paths." In addition to this visual inspection, Goehl also considers traffic volume and road width when making her decision. At 1000 Annual Daily Traffic (ADT) or above, she usually opts for the variable rates. This ADT specification is a number that Goehl has come up with based on her experience observing the district roads. "I've noticed that somewhere around 1000 ADT we start noticing the wheel paths," she says.

Figure 8. Embedment Slightly Higher than Desired

The asphalt rate should be designed according to the wheel path. "It is all about embedment and embedment depth," she says. "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." But the low rate required by the wheel path may not provide enough asphalt to hold the aggregate outside of the wheel path. This is the main reason, according to Goehl, that variable rates should be used: to hold the aggregate outside the wheel path.

Goehl also advises that if TVAR is being applied with a single spray bar, the average shot rate is the rate that must be entered into the distributor's computer. "If you want 0.35 gal/sy asphalt outside the wheel paths and you are varying rates by 20%," she says, "Then you will have to set the computer at something like 0.39 gal/sy. This setting will give you about 0.42 gal/sy asphalt outside the wheel paths." It is important that the number entered into the computer is this average and not either of the two asphalt rates.

John Baker has been working with the Atlanta district's seal coat program since 1989. Initially, determining how and when to transversely vary the asphalt rate was hardly more than a guess, but Baker was determined to find a method that would help to quantify the decision. One thing he tried was the old sand patch test. "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."

Figure 9. Performing the Sand Patch Test

The sand patch test allowed Baker to attach numbers to his observations of roadway conditions, and assists him in determining asphalt rates. The test doesn't need to be run on every pavement, he explains, only where there is uncertainty regarding the amount of variation to ask for.

The first thing that Baker looks at when determining whether or not to use TVAR is the condition of the wheel path. Most of the roads he observes have some degree of flushing or bleeding. First, he explains that the asphalt rate appropriate to the condition of the wheel path must be chosen, and then the rate can be increased for outside of the wheel path.

This rate selection, according to Baker, usually occurs about a week to ten days before the contractor begins work. "It's probably better to go out in the afternoon than first thing in the morning," he suggests. Once the sun as had a chance to heat up the pavement, Walker explains that "You get a better idea of how alive the asphalt gets in the wheel paths." This will help make a more accurate selection of the appropriate asphalt rate.

Richard Walker has been transversely varying asphalt rates for almost 40 years, and working in the Brownwood district for 28 of those years. He describes how the district used to make its own custom nozzles. "It was a tedious process involving a lot of trial and error," he says, because the variance of the nozzles changes depending on the viscosity of the asphalt and the pressure being used.

This is one of the reasons that Walker advises giving contractors a 10% variance range. "The reality is that the nozzles of just one size, when you buy them, can vary as much as 10%." Walker concludes from this margin that it will take at least a 20% asphalt rate variation to make a noticeable difference outside the wheel path, and recommends a 30% variation for most roads. Contractors with double spray bar distributors can be more precise, but Walker advises that "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."

Walker recalls that at times, when using emulsion, he increased the asphalt rate too much outside of the wheel paths. He warns that "If you go very far over 30%, the asphalt viscosity of emulsion allows some flow back." In this case, we were getting more asphalt in the wheel paths than we designed because the emulsion was flowing toward the wheel paths from the outside. Walker cautions that it is difficult to use TVAR methods with low viscosity emulsions.

He also warns that it is easy for the inspector to make mistakes regarding the placement of the various nozzles. "It's always good practice to check them at least every morning or when you move," he explains. "Sometimes at night, the operator might decide to clear out his nozzles and throw them all in a bucket. You never know what happens when you aren't there." Walker stresses the importance of verifying at every opportunity that the nozzles have been returned to their right places. Even during application, if one of the nozzles gets stopped up, the operator may remove it and accidently replace it with the wrong kind. "You always have to pay attention," he says.

In Walker's experience, varied asphalt rates should never be used to put less asphalt in the wheel paths. "Put exactly what the wheel paths require, then put more outside to hold the rock," he says. "You aren't shooting less to prevent flushing." Walker also reminds TVAR practitioners that it can take a year before you can tell if the rate you chose was right. The road has to go through a winter and a summer before the success of the TVAR seal coat can be determined.

Randy King works in the Brownwood district, which varies the asphalt rate on about 60-70% of their seal coats. King describes making asphalt rate decisions by driving the roads in the seal coat program one month before application, and observing the specific conditions. "Sometimes a road looks like a road we shot last year," he says, "And I'll go back and find the rate that I shot last year." His experience with TVAR has greatly facilitated the district's initial rate determination process.

King emphasizes the importance of experience in providing consistently positive results. "One thing that really helps to get good seals is to have the same guys out on the seal coat project year after year," he says. The experience gained through practice with TVAR allows for quick rate adjustments, and the ability to respond to the needs of the pavement surface. In his experience, the ability to make adjustments during application has been an essential component of Brownwood's TVAR success.

One important factor to consider when using emulsion, according to King, is the viscosity level. "If the wheel paths are depressed, emulsion will run down into them, giving you more asphalt than you designed for," he points out. For this reason, Brownwood added a viscosity check to their asphalt specification in order to ensure that TVAR could be used effectively with emulsions as well.

TVAR requires some extra calibration, as well. First, King explains, the contractor will do a calibration using the same sized nozzles on a straight bar to show that each nozzle is within 10% of the specified rate. Then, the contractor must put in the variable nozzles and perform a calibration to show that they will achieve the variation required by the plan note. King says that for this second calibration, they typically use the bucket test.

King encourages other districts that variable nozzles definitely work. "Look at your roadways, and use the variable nozzles on the roadways that really need them," he says. However, there are certain scenarios in which TVAR is not recommended. King cautions not to use TVAR if the district shoots grade 5 aggregate, if the existing seal is a microsurfacing treatment or a hot mix project, or if wheel paths are not visible due to irregular traffic patterns (left turn only lanes, in-town roadways, or parking lots).

Paul Montgomery works with TVAR in the Lufkin district. In his experience, transversely varying asphalt rates should result in more oil on the road, and a better seal overall. He also mentions the value of applying more asphalt to the shoulders of the roadway. "If you are just shooting the shoulders," Montgomery says, "You can aim for about 50% embedment, because you don't have to worry about tracking."

Jimmy Parham has been transversely varying asphalt rates for about eight to ten years in the Lufkin district. He diagnoses that 40 to 50% of the roads in the Lufkin district need TVAR, and the district's use of a contractor with a dual spray bar distributor allows Parham maximum flexibility when it comes to determining asphalt rates.

"I usually ride the roads beforehand, but the final decision is made the day we shoot the roads," Parham says. He sets the asphalt rates according to the visual appearance of the wheel paths, but also utilizes a small temperature gauge to check the roadway temperature and a small rock to check the potential embedment. "I'm trying to determine how much asphalt we already have out there," he explains. "The contactor will shoot oil that is 330˚ or 340˚ F, and that will liven up any asphalt that is already on the road." If too much asphalt is applied, considering what is already at the surface, the seal coat rock will be too deeply embedded once traffic gets on the road.

There are many other factors that influence Parham's rate adjustments. Hot oil will liven up the asphalt on the existing roadway more than emulsion, so asphalt type becomes an important factor in determining the appropriate asphalt application rates. Other factors to consider, Parham recommends, are the pavement type and the ADT numbers. "If you have a lot of heavy loads coming through," Parham suggests, "You want to try to shoot your wheel paths even lighter. Climbing lanes would be another example of a place to lower the shot rate a little more."

Parham checks his shot rates by looking at the embedment of the rock. After the rollers have gone

through, 35% of the rock should be embedded. This number allows Parham to account for the future effects of weather and traffic. As an experienced practitioner of TVAR, Parham recommends that other districts who notice a lot of flushing give it a try. "You aren't going to get every wheel path perfect," he says, "But it will help you with the embedment of your rock."

Albert Quintanilla works in the Laredo district, which has been using transversely variable asphalt rates off and on for the last ten years. Over the years, Quintanilla says that Laredo has probably varied asphalt rates at about 10% of its seal coat locations.

In this district, the asphalt rate is determined by consensus between the inspector and the contractor before the beginning of the seal coat project. Quintanilla aims for a variation that puts about 15% more asphalt outside of the wheel paths. "We allow the inspector to make limited adjustments to preset shot rates," he adds. "I typically tell the inspector that 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." But the final decision is up to the engineer, and according to Quintanilla, the inspector is not allowed to increase the total asphalt rate by more than 0.06 gal/sy with the approval of the area engineer.

Quintanilla also emphasizes the importance of having good communication with the seal coat contractor. As long as they have enough lead time to change the nozzles without stopping the operation, Quintanilla notices that contractors typically don't complain about TVAR. "If you let them know when the distributor gets to the location," he suggests, the contractors "can change nozzles while they wait for the sweepers and rollers to show up."

Ernest Teague works in the Paris district, and just started using transversely variable rates last year. When he first heard of the Brownwood district asking for 30% variation, he thought it was too much. He understands how it might be appropriate for very flushed wheel paths, but Teague wanted to use TVAR on all of his seal coats, which caused him to look for a way to get a smaller variation while still using a single spray bar.

He describes a unique method used in the Paris district to achieve a 10-15% rate variation with a single spray bar. Number 5 and Number 4 nozzles are alternated in the wheel path, allowing the fan spray patterns from the nozzles to overlap one another and give an average rate. "To get a uniform average," Teague explains, "you need to set the spray bar height to get double overlap instead of triple." The variation between this Number 4/Number 5 alternation and straight Number 5 nozzles is about 15%.