# A Case for Reducing and Laydown Temp

A common response to difficulties obtaining in-place density is to increase mix production temperature, because it is easier to control than other factors that may affect density. This temperature increase might be initiated by the contractor or by the agency. However, our world is changing, and there are compelling reasons to consider a temperature reduction rather than temperature increase.

It might be neighbors complaining about the "smell" of asphalt. It might be concerns about the work environment. It might be concerns about emissions, such as greenhouse gases or other combustion emissions. It might also be the desire to save fuel in an environment where prices and supplies are unstable. Consider too that in March 2005, the Environmental Protection Agency signed the Clean Air Interstate Rule. This ruling will permanently cap sulfur dioxide ($SO_2$) and nitrogen oxides ($NO_x$) in 28 eastern states and the District of Columbia with eventual 70 and 60 percent reductions, respectively, of 2003 levels.

Whatever the cause may be, there are ways to reduce production temperatures without sacrificing quality. In many cases, we can probably lower production temperatures without changing anything else, but we also want to outline some best practices that will help get things moving in the right direction – towards cooler temperatures.

Lowering mix temperatures could result in several construction and performance benefits [1]:

- Reduced aging of the asphalt binder
- Reduced fumes or odors
- Reduced tenderness of the mix during compaction
- Reduced draindown with coarse mixes

The Asphalt Pavement Environmental Council [1] developed "Best Management Practices to Minimize Emissions During HMA Construction." Available from NAPA, it outlines practices to help reduce emissions ranging from recommended production temperatures to improved burner maintenance. From experience, the asphalt suppliers developed recommended HMA plant mixing temperatures. The midpoint of these temperature ranges should be a starting point. The actual production temperature can be adjusted within that range based on a variety of factors such as ambient temperature and haul distance.

If you have tried unsuccessfully to lower production temperatures to match the recommendations shown above, there are a number of best practices which might help you achieve a 10 °F or more reduction in temperature or otherwise reduce emissions. Three of these are outlined below: keeping stockpiles dry, tarping trucks, and increasing lift thickness.

## Drier Stockpiles

Granite Construction Company won a 2004 NAPA Quality in Construction Award for Non-Typical Applications for paving under the sand stockpiles at their Tracy Aggregate Facility (Figure 1). A 75,000-square-foot area was paved with a 3 percent slope for dewatering washed sand. By loading aggregate from the high side, the moisture content of the sand was reduced from 10 to 6 percent. Jeff Otto, a project engineer for Granite, reports that Granite's Tracy Asphalt Plant has had fuel savings of 9.2 percent resulting from the drier sand which typically makes up about 35 percent of their mix.

**Table 1: Typical Asphalt Binder Production Temperatures (1)**

| Binder Grade | HMA Plant Mixing Temperature °F | |
|---|---|---|
| | Range | Midpoint |
| PG 58-28 | 260 - 310 | 285 |
| PG 64-22 or PG 64-28 | 265 - 320 | 292 |
| PG 67-22 | 275 - 325 | 300 |
| PG 70-22 | 280 - 330 | 305 |
| PG 76-22 | 285 - 335 | 310 |

# Production eratures – Today

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**Figure 1: Paved Sand Stockpile Area – Tracy Aggregate Facility**

The moisture content of a stockpile varies with elevation, with the highest moisture contents being at the lowest elevation. Water in the stockpile will drain to the lowest elevation and eventually out of the pile. The loader loads from the high side of the pile, which allows it access to drier material. Astec Industries recommends a 4-foot drop across the stockpile (3 percent grade across 133 feet) [2]. An alternative to paving under stockpiles is covered aggregate storage.

The moisture content of aggregates introduced into a drum plant affects both the production rate and the fuel consumption. Increased fuel consumption also results in increased emissions. Gencor Industries estimates that a 2 percent reduction in aggregate moisture content (from 6 to 4 percent) would result in a savings of 0.48 gallons of No.2 fuel oil per ton (a 25 percent savings) with a 310 °F discharge temperature. Reducing the discharge temperature from 310 to 285 °F would result in an additional savings of 0.12 gallons per ton (about 6 percent). Astec indicates similar fuel savings. Astec indicates that for the same 2 percent reduction in moisture content, the production rate for an 8-foot-diameter counter-flow drum would increase from 288 to 390 tons per hour [2]. Astec also suggests that paving under stockpiles will reduce plant wear and aggregate inventory loss.

Industry experience has varied. Average savings associated with paved stockpile yards have been on the order of \$0.12 to \$ 0.14 per ton. The cost for grading and paving under aggregate stockpiles will vary, but ranges of \$80,000 to \$120,000 may be expected.

### Truck Tarps

The effectiveness of truck tarps is somewhat controversial. An early NAPA publication (3) concluded that tarps were not effective for dense-graded mixes, but could be beneficial for open-graded mixes as long as the tarp tightly covers the load. Even for dense-graded mixes, the report showed an improvement in the mix temperature at the paver being an average of 6.6 °F warmer when using tarps for two of the projects and only 1.0 °F warmer for the third. Significant reductions in temperature were observed on the surface of the load between trucks with and without tarps. This cold crust is most likely not completely remixed without the use of a material transfer vehicle, resulting in isolated cold spots that can suffer from insufficient compaction.

It is generally agreed that for tarps to be effective, they must tightly cover the load and prevent air from getting under the tarp, as shown in Figure 2. It is believed that loose flapping “sand” tarps may do more harm than good. Further, all tarps are not created equal. At a minimum, an effective tarp should be waterproof. Insulated tarps may be beneficial in colder areas of the country.

**Figure 2: Properly Tarped Load with Overlap**

**Recently, a software program, Multicool 3.0 was developed by Timm et al [4]. Multicool calculates the time available for compaction for various weather conditions. Lift thickness is one of the most significant factors on time available for compaction.**

Limited data on the effectiveness of truck tarps was collected by Washington DOT and the University of Washington as part of a pavement segregation study [4]. Figure 3 shows an image from an infrared camera showing an HMA mat laid from mix hauled with and without a tight fitting tarp. The mix in the foreground was hauled in a truck without a tight fitting tarp while the mix closest to the paver came from a tightly tarped truck. In this example, the surface temperature of the mix from the truck without a tarp ranged from 194 to 239 °F, whereas the average surface temperature from the tightly tarped truck was approximately 253 °F. Temperature differentials resulting from crusting of the load were also reduced.

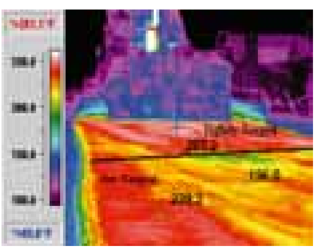

**Figure 3: Thermal image of HMA mat resulting from trucks with and without a tight tarp.** [4]

The Dean Word Company outfitted a dozen of their belly dump trailers with a 0.094 to 0.125 inch layer of sprayed-on ceramic insulation and a waterproof tarp system that completely covered the edges of the hopper and overlapped the sides. The remainder of their fleet was outfitted with pull tarps and no insulation. Dean Word summarized their experience when hauling SMA like mixes with PG 76-XX:

- For hauls distances of approximately 20 miles, there is no apparent benefit from either tarps or insulation, regardless of ambient conditions.
- For haul distances of 60 to 70 miles in cooler temperatures, the tarps provide a significant benefit.
- For haul distances of 100 miles, the insulation becomes a major factor.

For the long haul, the insulation resulted in less cold corner chunks in the windrow. Temperature differentials in the windrow, between areas with and without tight tarps and insulation, were on the order of 20 to 30 °F in 40 °F weather and 15 to 20 °F when ambient temperatures reached 60 °F. Texas DOT compared windrow temperatures of trucks with and without insulation over a 13-day period with ambient temperatures ranging from 53 to 90 °F. All of the trucks were tarped. The haul distance on this project was approximately 20 miles. The windrow temperature for the insulated trucks averaged 5 °F higher for Superpave mixes and 8 °F higher for porous friction course.

Based on their investigations, Dale Rand, Texas DOT's Flexible Pavement Branch Director, believes truck tarps to be more beneficial and cost-effective than truck body insulation. Texas DOT now requires waterproof tarps on all trucks hauling HMA. A number of other agencies have similar specifications, particularly for SMA and open-graded mixtures. The overall benefit from tightly tarping trucks will vary with haul distance, ambient temperature, and mix type. However, if a 10 °F reduction in mix temperature (at the plant) is the goal, tarps are a 5 °F step (or more) in the right direction.

## *Lift thickness*

Recent research, completed as part of NCHRP 9-27, "Relationships of HMA In-Place Air Voids, Lift Thickness, and Permeability," recommended a minimum layer thickness to nominal maximum aggregate size of 3:1 for fine graded mixes and 4:1 for coarse graded mixtures [5]. Thicker lifts are easier to compact and cool slower, allowing more time available for compaction. Time available for compaction is the amount of time after the mixture is laid by the paver before it cools to the cessation temperature. Basically, the cessation temperature is a minimum temperature below which additional rolling does not result in increased density. The cessation temperature is a function of the mix type and binder grade. SMA would tend to have a higher cessation temperature than a dense-graded mix, and a stiffer binder such as a PG 76-22 would likely have a higher cessation temperature than a less stiff binder such as a PG 64-22.

Time available for compaction is the time that rollers have to do their work. Time available for compaction is a function of the temperature the HMA is delivered to the paver, ambient temperatures (air and surface), wind speed, solar gain, mix type, and lift thickness. Typically, time available for compaction would be of greater concern in cool or windy conditions when HMA, particularly thin lifts, cool very quickly. Under such conditions, the only options are to add extra rollers, increase the temperature at which the HMA is delivered to the paver, or simply not pave.

Recently, a software program, Multicool 3.0 was developed by Timm et al [4]. Multicool calculates the time available for compaction for various weather conditions. Lift thickness is one of the most significant factors on time available for compaction. Using Multicool, it is possible to

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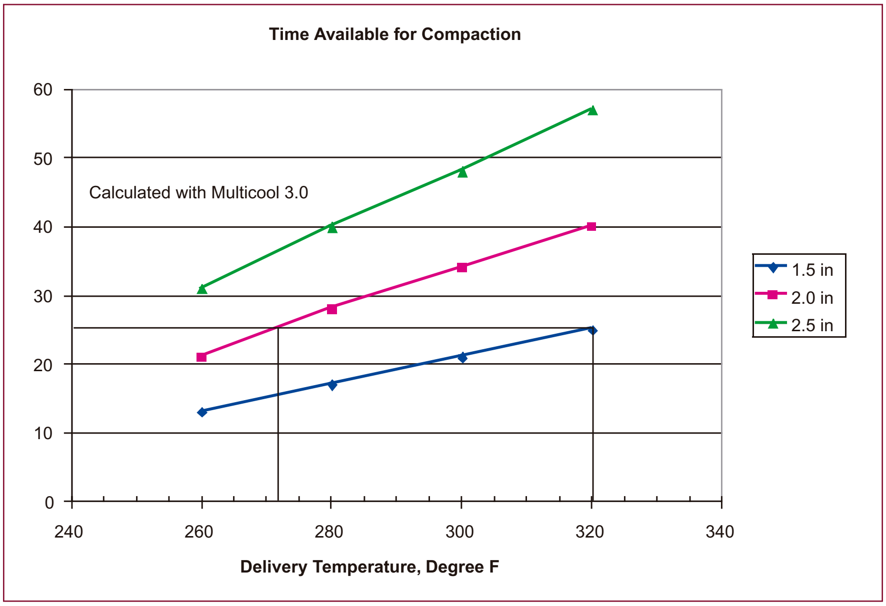


**Figure 3: Time available for compaction as a function of lift thickness.**

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demonstrate that by slightly increasing the lift thickness, say from 1.5 to 2.0 inches, it is possible to significantly reduce the temperature at which the HMA is delivered to the paver without decreasing the time available for compaction. The example shown in Figure 3 was calculated with the following parameters:
Ambient Temperature = 50 ºF
(air and ground)
Wind Speed = 5 mph
Latitude = 38 degrees north
(Berkeley, CA or just north of Richmond, VA)
Time = Noon, March 15, 2005
Materials = aggregate base, dense graded mix with PG 64-22

In this example, simply increasing the lift thickness by 0.5 inches would allow the delivery temperature to be almost 50 ºF lower (from 320 to 270 ºF) and still allow the same time available for compaction. Similar differences of 40 to 50 ºF are found with other wind speeds, ambient temperatures, and latitudes. The down side to paving with thicker lifts is that it is generally easier to build a smooth pavement with more, thinner lifts than it is with fewer thicker lifts. However, many overlay or mill and inlay projects only consist of a single lift.

### Summary

The HMA industry has started on a strategic path to reduce production and placement temperatures of asphalt mixtures. The use of best practices is the way to begin. At the 2005 NAPA Convention, former NAPA Chairman Michael Mangum said it best, "Reducing temperatures is the right thing to do." Reductions in temperatures can result in large reductions in emissions. The "right" method to get started will vary from one operation to another. Except for simply reducing temperatures to more reasonable levels, all of the alternatives have costs, but also additional benefits. Consider what you can do to begin reducing temperatures today. *HMAT*

### References


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