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AIR QUALITY ISSUES AND BEST MANAGEMENT PRACTICES WITH THE PRODUCTION OF ASPHALT-RUBBER ASPHALTIC CONCRETE

Asphalt concrete made with asphalt rubber binders (wet process – site blended) may present special considerations relative to air quality issues and permit operating conditions for air quality. Asphalt concrete using asphalt rubber binders will have higher binder percentages than conventional mixes. Due to the higher viscosities which are characteristic of these binders, the mixes must typically be handled and placed at higher temperatures. Laydown temperatures of around 290F behind the screed are generally recommended. Breakdown compaction is recommended to be complete before the mat cools below 250 F to 260 F. These requirements frequently lead producers and pavers to have the mix heated to as high a temperature as can be tolerated, sometimes above the Caltrans specification limit of 325 F. Almost any paving grade asphalt will begin to smoke at this temperature and the addition of as much as 20% crumb rubber modifier by weight may exacerbate the situation. While no hard and fast rules can be drawn for all situations due to the various characteristics of the many asphalt sources in the marketplace, the following may help to mitigate objectionable smoking at the plant and at the laydown machine:

- Produce the mix at the lowest tolerable temperature. Mix temperatures above 325 F should be avoided and in some specifications, notably Caltrans, temperatures above 325 F are prohibited.
- In drum dryer mixers, it is important that the flights of the drum are in good working order. The falling veil of aggregates in front of the flame helps the efficiency of drying production but it also retards the extent to which the flame and heat can reach the binder near the coating operation further down the drum.
- In stack-up plants, a longer residence time allows the skin temperatures of the aggregates to mediate prior to the drop into the pugmill. This will prevent scorching of the binder at its introduction.
- Lower rates of production will reduce visible emissions.
- Cooler mix temperatures can be accommodated with the use of tarped trucks, shortened windrows for belly dump operations, and possibly the use of mix transfer devices. The use of end dumps for lower production work is recommended when temperature is a consideration.
- If weather conditions are marginal, use common sense. When the weather is cool and windy, it is doubtful that the mix can be properly handled without excessive heating. Decision-makers need to weigh the benefits of running against the likelihood of a poorly compacted mix and the possibility of an air quality violation.
- Odors from asphalt rubber mixes are sometimes found to be objectionable. Fortunately, there are asphalt additives introduced at the plant that can significantly mediate this problem. Ask the supplier of the asphalt rubber binder about this.

Asphalt rubber is a very environmentally friendly product. One lane, one mile long of AR mix typically uses between 1500 and 2000 scrap tires. The resulting road will last longer and be quieter than a road built with a conventional binder. The AR product has also been researched for worker exposure to fumes and it has been found to be no worse than conventional mixes. However, sensible precautions against excessive smoking and emissions must be observed in order to fully comply with air quality permit conditions.

Environmental Studies and Permitting Practices in Arizona, California, Florida and Texas

The states of Arizona, California, Florida, and Texas have developed and specified the most rubberized asphalt products in roadway construction since the last of the patents on the wet process material expired in 1992. All four Departments of Transportation together have beneficially reused over 35.6 million tires in asphalt paving applications from 1995 to 2001. Florida DOT has consumed the most tires at 12.4 million over the period followed by Arizona at 9.9 million, California at 8.3 million and Texas at 4.9 million. These figures exclude the usage, if any, of the counties and cities within each state. Typically, only the state departments of transportation specify the rubberized material in Florida and Texas and the counties and cities do not. However, the counties and cities in Arizona and California specify amounts nearly equivalent to the DOTs in those states. It is likely that including the counties and cities of Arizona and California over 42 million tires have been beneficial reused in these four states since 1995.

It is often thought that the presence of the hot rubber odor in asphalt rubber mixes indicates that the stack emission at a hot plant of asphalt-rubber blending site would be more harmful than when conventional, non-modified asphalt products are manufactured and placed. Additionally, it is commonly believed that pavements containing crumb rubber can not be recycled. These issues have been thoroughly researched as a result of objections raised to the Intermodal Surface Transportation Efficiency Act of 1995 that would have required each state to use granulated tire rubber in certain percentages of federally funded paving projects. The clause mandating the use of rubber was eventually repealed, but the issue of emissions was fully explored.

Among the many, three major studies have been conducted exploring the suspected differences between conventional asphalt materials and asphalt rubber materials. The first was administered by the Michigan Department of Transportation in 1994, the second study was conducted by the Texas Transportation Institute in 1995 and the third was conducted by the Northern California Rubberized Asphalt Technology Center in 2001.

The first, “**Evaluation of Exhaust Gas Emissions and Worker Exposure from Asphalt Rubber Binders in Hot Mix Asphalt Mixtures**” by Kathryn O’Connor Gunkel, Wildwood Environmental Engineering Consultants, Inc. Michigan Department of Transportation, 1994, identified the emissions from seven different mixtures. The mixtures were identified as follows: Control 1 – 85/100 Pen AC 30% RAP, Control 2 – No Rubber, No RAP, Control 3 – No Rubber, 20% RAP, RBR 1 – Wet Process, No RAP, RBR 2 – No Rubber, 20% RBR RAP, RBR 3 – Wet Process, 20% RBR RAP, RBR 4 – Dry Process, No RAP. RAP is the common acronym of reclaimed asphalt pavement. The study then compares the quantities of the emissions from each type of mix. To simplify the tables, the Control 2 mixture and the RBR 1 mixture can be isolated to compare the most common types of mixtures, a conventional mixture without RAP and an asphalt-rubber mixture without RAP. A comparison of the results are found in Table 1.

Table 1 - Comparison of conventional and asphalt rubber materials in Michigan 1994.

Operating Data/Conditions/ Measurements	Control 2	RBR 1
HMA Production Rate (tons per hour)	351	357
Dry Aggregate Rate (TPH)	330	333
Asphalt Cement Added (%)	5.75%	6.84%
Materials moisture content	4.17%	5.21%
Fuel Consumption (gal/hr)	655	690
Exhaust Gas Temperature (F)	311	324
Mix Temperature (F)	296	316
Sample Volume (SCF)	46.501	42.823
Sample Volume (cu. m)	1.317	1.213
Exhaust Gas Moisture (%)	27.0%	29.3%
Stack Temperature (F)	260	271
Actual Exhaust Gas Flow (ACFM)	89,540	95,450
Dry Exhaust Gas Flow (DSCFM)	47,076	47,836
Dry Exhaust Gas Flow (DSCMM)	1,333	1,355

Continuous Emissions Measurements and Method 18 Results	Control 2	RBR 1
CO ₂ , %, Orsat Result	5.79%	6.02%
O ₂ , %, Orsat Result	12.75%	12.10%
N ₂ , %, Orsat Result	81.46%	81.88%
Carbon Dioxide (CO ₂)	6.00%	6.48%
Oxygen (O ₂)	12.87%	12.18%
Carbon Monoxide (CO) PPM	430.5	259.5
Nitrogen Oxides (NO _x) PPM	139.3	124.4
Sulfur Dioxide (SO ₂) PPM	74.4	76.7
Non Methane Total Hydrocarbons (NMTHC) as Carbon PPM	225.5	183.0
Methane (CH ₄) as measured PPM	27.7	10.6
Methane as Carbon PPM	20.7	7.9
Total Hydrocarbons (THC) as Carbon PPM	245.1	191.3
NMTHC as Carbon PPM	225.5	183.0

PAH Emissions Measurements (lbs/hr)	Control 2	RBR 1
Acenaphthene	0.0018	0.0021
Acenaphthylene	0.0022	0.0026
Anthracene	0.0003	ND
Benzo Anthracene	0.0002	ND
Chrysene	0.0003	ND
Fluoranthene	0.0030	0.0024
Fluorene	0.0051	0.0055
Naphthalene	0.0502	0.0622
Naphthalene, 2-Methyl-	0.0578	0.0788
Phenanthrene	0.0120	0.0141
Pyrene	0.0030	0.0022
Cumene	0.0056	0.0069
o-Cresol (2-Methylphenol)	0.0029	0.0011
m-/p-Cresol (3-/4-Methylphenol)	0.0052	0.0058

The conclusions of the study were as follows:

- Rubber does not contribute significantly to any increase in undesirable compounds.
- The base asphalt and burner fuels will cause greater changes in emissions than rubber.
- Soft asphalt cement appears to result in increased emissions of BTEX.
- It is highly unlikely that an allowable fence-line concentration limit based on an annual averaging period would be exceeded.

The second study conducted by the Texas Transportation Institute specifically addressed the recyclability of asphalt rubber pavements but also thoroughly examined the emissions results from earlier studies in Texas and elsewhere. The report details: **“Recycling Crumb Rubber Modified Asphalt Pavements”** **Crockford, W.W., Makunike, D., Davison, R.R., Scullion, T. and Billiter, T.C. Report FHWA/TX-95/1333-1F, May 1995.** The conclusions:

- “...the material is recyclable and that the recycled material, if properly designed and constructed, should have acceptable long-term performance.”
- “...air quality does not seem to be any more severe a problem than it is with conventional asphalt.”
- “...the effect of CRM on emissions may be relatively small in comparison to the effects of other variables.”

The third study, conducted by the **Northern California Rubberized Asphalt Concrete Technology Center** <http://www.rubberizedasphalt.org> was recently conducted at the request of the Bay Area Air Quality Management District. The purpose of the study was to determine if asphalt rubber materials used in California were substantively different than asphalt rubber materials used elsewhere and to determine if additional permitting would be required when producing modified asphalt concrete products. The results were computed in pounds/ton and compared to the emission factors in the EPA's "HOT MIX ASPHALT PLANTS EMISSION ASSESSMENT REPORT" December 2000, commonly referred to as the EPA AP42 guideline.

Comparison of Toxic Emissions With AP-42

The measured emission factors of toxic compounds and other chemical species during the production of both conventional asphalt concrete and asphalt rubber concrete were consistently lower than the AP-42 emission factors for a drum-mix asphalt concrete plant. A comparison is made in Table 2.

Table 2 - A comparison of emission factors from conventional and asphalt-rubber materials to AP 42.

	Emission Factor (pounds per ton)		
	Conventional Asphalt Concrete	Asphalt Rubber Concrete	AP-42 (Drum Mix)
Benzene	4.23E-05	3.62E-05	3.90E-04
Toluene	2.03E-05	1.81E-05	1.50E-04
Ethyl Benzene	0	3.20E-06	2.40E-04
Xylene	1.97E-05	5.18E-05	2.00E-04
1,3-Butadiene	5.50E-06	6.82E-06	Not Avail.
Naphthalene	3.12E-06	5.87E-06	9.00E-05
2-Methylnaphthalene	7.78E-07	1.60E-06	7.40E-05
Acenaphthylene	1.71E-07	1.01E-07	8.60E-06
Acenaphthene	1.66E-08	1.86E-09	1.40E-06
Fluroene	5.27E-08	3.68E-08	3.80E-06
Phenanthrene	1.09E-07	8.02E-08	7.60E-06
Anthacene	1.19E-07	4.79E-09	2.20E-07
Fluoranthene	8.28E-09	4.04E-09	6.10E-07
Pyrene	1.16E-09	3.52E-09	Not Avail.
Benz(a)anthracene	0	0	2.10E-07
Chrysene	0	0	1.80E-07
Benzo(b)fluoranthene	0	0	1.00E-07
Benzo(k)fluoranthene	0	0	4.10E-08
Benzo(e)pyrene	0	0	1.10E-07
Benzo(a)pyrene	0	0	9.80E-09
Perylene	0	0	8.80E-09
Indeno(1,2,3-c,d)pyrene	0	0	7.00E-09
Dibenz(a,h)anthracene	0	0	Not Avail.
Benzo(g,h,l)perylene	0	0	4.00E-08

The permitting practices for hot mix asphalt production facilities in Arizona, California, Florida and Texas, where asphalt rubber is most commonly used, are not differentiated for the types of hot mix products that are produced. The standard emission factors for hot mix asphalt plants are applicable to the production of conventional and asphalt rubber products.

For more information, please contact the Rubber Pavements Association 480-517-9944 or through the internet at www.rubberpavements.org.