EPA-450/2-77-037
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GUIDELINE SERIES

CONTROL OF VOLATILE ORGANIC COMPOUNDS FROM USE OF CUTBACK ASPHALT

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

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Emission Standards and Engineering Division
Chemical and Petroleum Branch

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OAQPS GUIDELINE SERIES

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ABBREVIATIONS AND CONVERSION FACTORS

EPA policy is to express all measurements in agency documents in metric units. Listed below are abbreviations and conversion factors for British equivalents of metric units.

Abbreviations	Conversion Factors
l - liters	liters X .26 = gallons
kg - kilogram	kg X 2.2 = pound (lb) lb X 0.45 = kg
m^3 - cubic meter	m^3 X 0.16 - barrel (bbl) bbl X 6.29 = m^3
m^2 - square meter	m^2 X 10.8 = square feet (ft^2) ft^2 X 0.093 = m^2
m ton - metric ton	m ton X 1.1 = ton ton X 0.91 = m ton
Mg - megagram	Mg = m ton
$kg/10^3m^3$ - kilograms per thousand cubic meters	$kg/10^3m^3$ X 0.35 = $lb/10^3bbl$ $lb/10^3bbl$ X 2.86 = $kg/10^3m^3$
m^3/day - cubic meters per day	m^3/day X 0.16 = bbl/day bbl/day X 6.29 = m^3/day

1.0 INTRODUCTION

This document addresses the control of volatile organic compounds (VOC) from paving asphalts liquefied with petroleum distillate. Such liquefied asphalt is generally referred to as cutback asphalt. The substitution of emulsions for cutback asphalt nearly eliminates the release of VOC air pollutants from paving operations. The VOC emitted from the cutback asphalts are photochemically reactive (precursors to oxidants).

Methodology described in this document represents the presumptive norm or reasonably available control technology (RACT). RACT is defined as the lowest emission limit that a particular source is capable of meeting by the application of control technology that is reasonably available considering technological and economic feasibility. It may require technology that has been applied to similar, but not necessarily identical, source categories. It is not intended that extensive research and development be conducted before a given control technology can be applied to the source. This does not, however, preclude requiring a short-term evaluation program to permit the application of a given technology to a particular source. The latter effort is an appropriate technology-forcing aspect of RACT.

1.1 NEED TO REGULATE CUTBACK ASPHALTS

Control techniques guidelines are being prepared for source categories that emit significant quantities of air pollutants in areas of the country where National Ambient Air Quality Standards (NAAQS) are not being attained. Cutback asphalts are a significant source of VOC and tend to be concentrated in areas where the oxidant NAAQS are likely to be exceeded.

Nationwide VOC emissions from the use of cutback asphalts were estimated to be 655,000 metric tons in 1975. This represents 3.8 percent of total 1975 VOC emissions from stationary sources. In some States, cutback asphalts accounted for more than 15 percent of 1975 emissions.

Since asphalt paving operations occur predominantly during warm weather, when formation of oxidants is most prevalent, the decreased use of cutback asphalts could provide major assistance in oxidant attainment and maintenance strategies.

1.2 SOURCES AND CONTROL OF VOLATILE ORGANIC COMPOUNDS FROM CUTBACK ASPHALTS

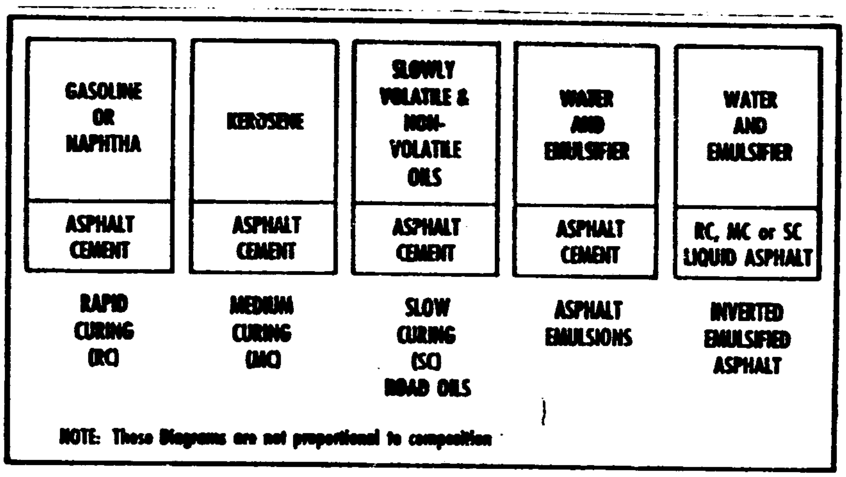
Liquefied asphalts are generally prepared by cutting back or blending asphalt cement with petroleum distillate or by emulsifying asphalt cement with water and an emulsifying agency. Heated asphalt cement is generally used to make asphalt pavements such as asphalt concrete. Cutback and emulsified asphalt are used in nearly all paving applications. In most applications cutback and emulsified asphalt are sprayed directly on the road surface; the principal other mode is in cold mix applications normally used for winter time patching.

VOC evaporate to the atmosphere as the cutback asphalts cure. The VOC in cutback asphalt will range from 20 to 50 percent by volume averaging 35 percent. Emulsified asphalts, on the other hand, consist of asphalt suspended in water containing an emulsifier. The petroleum distillate (VOC) substitute is approximately 98 percent water and 2 percent emulsifier. The water in emulsified asphalt evaporates during curing while the emulsifier is retained in the asphalt. The emulsifier is composed of non-volatile organic chemicals. The substitution of an emulsified asphalt for cutback asphalt reduces VOC emissions by 0.078 tons per ton of slow cure asphalt, 0.209 tons per ton of medium cure asphalt, and 0.204 tons per ton of rapid cure asphalt, or about a 100 percent reduction.

2.0 SOURCE OF EMISSIONS AND APPROACH TO EMISSION REDUCTION

Cutback asphalts are mixtures of solvent and a base asphalt of selected hardness or viscosity. Solvent is of high, medium, or low volatility depending on construction purposes. Of the liquid asphaltic products illustrated in Figure 1,[1] the first three are cutbacks.

Figure 1. Liquid Asphaltic Products



Upon exposure to atmospheric conditions, the highly volatile naphtha solvent in rapid curing blends evaporates quickly and leaves a hard viscous base asphalt. Less volatile kerosene evaporates more slowly from medium curing blends and leaves a base asphalt of medium hardness or viscosity. Slow curing blends contain a low volatility fuel oil type solvent hence they require the longest curing period; they leave a soft low viscosity asphalt on the aggregate. Slow curing cutback alternately may be made directly by distillation. Both the curing rate and characteristics of the residual asphalt are factors to be considered in the selection of liquid asphalts for various uses.[2] Cutback asphalts are applied either in a spray directly to the road surface or in a cold mix either prepared in advance of application, or at the job site.

Hydrocarbons evaporate from cutback asphalts at the job-site and mixing plant. At the job-site, hydrocarbons are emitted from equipment used for applying the asphaltic product and from road surfaces. At the mixing plant hydrocarbons are released during mixing and stockpiling. The largest source of emissions, however, is the road surface itself.

For any given asphalt/solvent mix, total emissions will remain the same regardless of stockpiling, mixing, and application time. The control technique requires the substitution of an emulsifying agent and water for the petroleum distillate resulting in an emission reduction at all the sources. Switching to an emulsion does not result in any equipment changes or application procedure changes. The major consideration is that the emulsion mixes properly with the aggregate resulting in a pavement of comparable durability. States with experience in applying asphalt report that emulsions can be used in almost all applications where cutback has heretofore been employed. In the past three to four years the State of New York cites little or no difficulty in converting 100 percent from cutback to emulsified asphalt.[3] The State of Pennsylvania is presently using 70 percent emulsified asphalt to 30 percent cutback asphalt; the State is committed to emulsions and expects to substitute in greater quantity.[4] The State of Indiana is a heavy user of emulsified asphalt, as well as a strong supporter of its use.[5] Some State highway departments have expressed concern over the use of emulsified asphalt during wet and cold weather and in applications which require stockpiling. States which experience wet and cold weather, however, have been able to switch from cutback to emulsified asphalt.

2.1 UNCONTROLLED EMISSIONS

It is the petroleum distillate (diluent) in the cutback asphalt that evaporates; the average diluent content in the cutback is 35 percent by volume. The percentage of diluent to evaporate is dependent on the cure type. The emission factors are: Slow cure (SC) - 20 to 30 percent of diluent content, average 25 percent; Medium cure (MC) - 60 to 80 percent, average 70 percent; Rapid cure (RC) - 70 to 90 percent, average 80 percent. These factors are independent of the percent of diluent in the mix within the normal range of diluent usage for cutback asphalts.[6]

2.2 REFERENCES

1. A Brief Introduction to Asphalt and Some of Its Uses, The Asphalt Institute, Manual Series No. 5 (MS-5), Seventh Edition, September 1974, p. 3.

2. ASTM, Designation D2399, Draft 12-3-75, Revision 7-22-76, p. 6.

3. Letter from William P. Hofmann, P.E., Deputy Chief Engineer, Department of Transportation, New York State to David W. Markwordt,

Section Engineer, Office of Air Quality Planning and Standards, Environmental Protection Agency, RTP, N.C. 27701, September 14, 1977.

4. Kirwan, Francis M. and Maday, Clarence, "Air Quality and Energy Conservation Benefits From Using Emulsions to Replace Asphalt Cutbacks in Certain Paving Operations," Draft, May 1977, Appendix E, p. E-3.

5. Letter from Roger Marsh, Executive Director, Indiana State Highway Commission to Richard Rhoads, Director, Control Programs Development Division, Office of Air Quality Planning and Standards, Environmental Protection Agency, RTP, N.C., 27701, June 28, 1977.

6. Memo from Francis Kirwan, Environmental Protection Agency, Office of Air Quality Planning and Standards, Energy Strategies Branch to the files, October 3, 1977.

3.0 COSTS OF APPLYING THE TECHNOLOGY

To address the costs of replacement of asphalt cutbacks with asphalt emulsions, this section focuses on the differences in unit operating costs between cutbacks and emulsions on a cents per gallon basis. The user of asphalt mixes does not have to undergo any capital expenditures in making the substitution. Generally, the same mixing plant that formulates cutback mixtures can prepare emulsion paving mixtures without any equipment changes. In addition, the same highway equipment used for application of cutback can be used to apply emulsions.

The comparison of asphalt cutbacks with emulsions is best stated in terms of a price per gallon for the total asphalt mix. State highway departments in their procurement of construction projects with paving contractors view costs in this manner. A typical example might be a reported price comparison for Waukesha County, Wisconsin.[1] The cost of emulsified asphalt was 33.75 cents per gallon versus 36.92 cents per gallon for cutback, a savings of approximately 10 percent for the emulsion mix. According to industry representatives each gallon of cutback in the total asphalt mix is normally replaced with one gallon of emulsion. Based on communications with 35 State highway departments, substitution of emulsions can result in savings up to 20 percent,[2] which is approximately 6 to 7 cents per gallon. Conversely, one State reported a cost penalty of 1 cent per gallon for the use of emulsions.[3] A review of price quotations in the Engineering

News Record[4] for 11 metropolitan areas finds that price differences for emulsions range from a 5 cent per gallon savings to a 1 cent per gallon penalty. These price quotations were based on materials used for surface treatment applications (Rapid cure cutback, for example). Based on the responses from the States and the literature, the conclusion is that overall replacement of cutbacks with emulsions will generally result in savings on the order of 3 cents per gallon.

It would appear that the most important factors that affect pricing of the two competing asphalts are the type of application (slow, medium, rapid cure), customer reluctance toward emulsions in some areas, and availability of distillates. However, the extent to which these factors apply is difficult to quantify. The size of the paving project is not a factor.

In terms of cost-effectiveness, a 1 cent per gallon differential represents a cost or a credit of 1.6 cents per kilogram of VOC emission reduction. The basis for this derivation is the following assumptions:

(1) a nationwide emission rate of 655,000 metric tons per year of VOC emissions from 3,729,000 metric tons of asphalt cutback sold in 1975 (see page 4-1) and

(2) a weight density of 7.82 pounds per gallon for medium cure cutback, which is the most common type cutback used.

3.1 REFERENCES

1. Kirwan, Francis M. and Maday, Clarence, "Air Quality and Energy Conservation Benefits From Using Emulsions to Replace Asphalt Cutbacks in Certain Paving Operations." Draft May 1977, Appendix E, page E-1.

2. Personal Communication from William Hofmann, Deputy Chief Engineer, Department of Transportation of New York, to David Markwordt, Emission Standards and Engineering Division, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, September 14, 1977.

3. Personal Communication from Robert N. Hunter, Chief Engineer, Missouri State Highway Commission to Roger Powell, Control Programs Development Division, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, June 3, 1977.

4. Engineering News Record, a McGraw-Hill Weekly Publication, October 6, 1977.

4.0 EFFECTS OF APPLYING THE TECHNOLOGY

4.1 IMPACTS ON ATMOSPHERIC EMISSIONS

The estimated uncontrolled hydrocarbon emissions in 1975 from the use of cutback asphalt were 655,000 metric tons per year. This represents 3.8 percent of the estimated 1975 total stationary source hydrocarbon emissions of 18 million metric tons per year.

The 1975 national sales of cutback asphalts for paving are as follows: Slow cure (SC) - 901,000 metric tons; Medium cure (MC) - 1,840,000 metric tons; and Rapid cure (RC) - 988,000 metric tons.[1]

Hydrocarbon emissions = cutback asphalt (metric tons/year)
X fraction diluent (assume 35% by volume. therefore, by weight SC = 31.1%; MC = 29.8%; RC = 25.5%)[2]
X fraction of diluent that evaporates

Total hydrocarbon emissions = (901,000) (.311) (.25) +
(1,840,000 (.298) (.70) +
(988,000) (.255) (.80) = 655,000 metric tons/year

The use of emulsified asphalt in place of cutback asphalts results in a 100 percent reduction of hydrocarbon emissions.

4.2 WATER AND SOLID WASTE IMPACT

There are no significant solid or liquid wastes associated with the use of emulsified asphalt.

4.3 ENERGY IMPACT

The total energy associated with manufacturing, processing, and laying one gallon of cutback asphalt is approximately 50,200 Btu. On the other hand, analysis of emulsified asphalts shows that about 98 percent of the petroleum diluents are replaced with water with the result that only 2,830 Btu are associated with each gallon of emulsified asphalt.[3] Based on the 1975 usage, the substitution of emulsions for the petroleum distillate would save approximately 1.6 billion liters of distillate for use as or conversion to fuels.

4.4 REFERENCES

1. Kirwan, Francis M. and Maday, Clarence, "Air Quality and Energy Conservation Benefits From Using Emulsions to Replace Asphalt Cutbacks in Certain Paving Operations," Draft May 1977, Appendix C, p. C-1.

2. Memo from David W. Markwordt, Environmental Protection Agency, Office of Air Quality Planning and Standards, Chemical and Petroleum Branch to the files, October 14, 1977.

3. Kirwan, Francis M. and Maday, Clarence, op.cit. p. D-2.

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16. ABSTRACT

This document addresses the control of volatile organic compounds (VOC) from paving asphalts liquefield with petroleum distillate. The recommended control technology consists of the substitution of emulsions for cutback asphalt.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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