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Tech Brief

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Steps to Reduce Use of Cutback Asphalt in Pavement Maintenance and Preservation

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This Technical Brief provides information to facilitate better understanding of the current usage levels of cutback asphalt in pavement construction, maintenance, and preservation as well as State DOT specifications that may allow use of cutback asphalt. Areas where use of cutback asphalt can be reduced and alternatives to cutback asphalt are identified.

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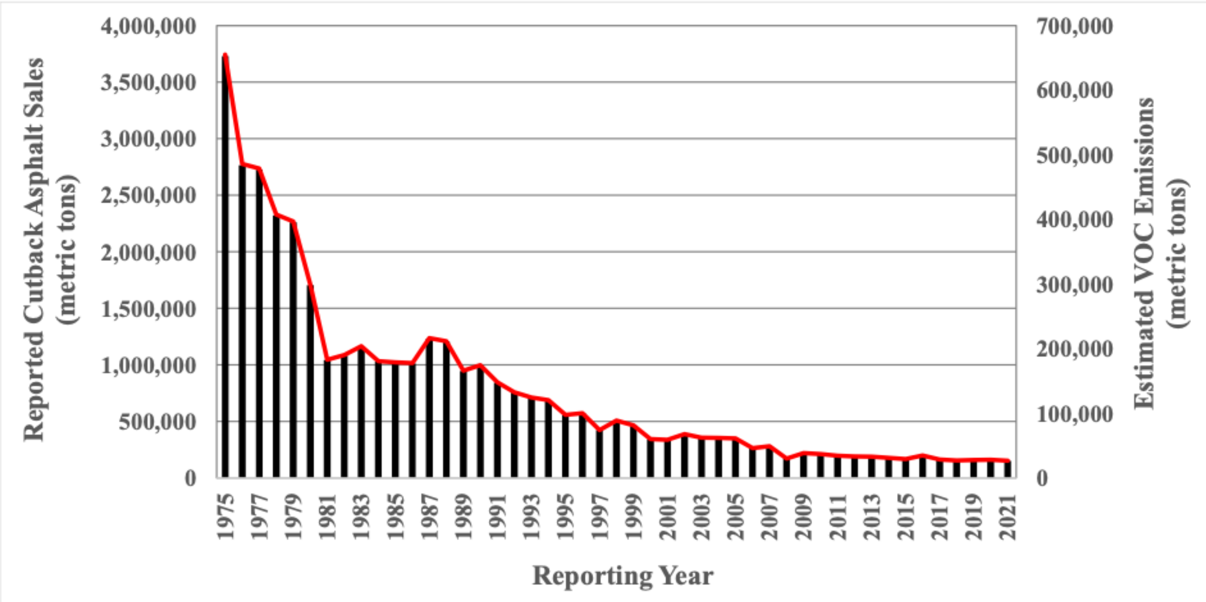
Introduction

Engineers and environmentalists are concerned with the use of cutback asphalt for three primary reasons: environmental issue, fire hazards, and potential health risks posed to construction workers. An early Environment Protection Agency (EPA) publication estimated that uncontrolled hydrocarbon emissions in 1975 from the use of cutback asphalt were greater than 655,000 metric tons, representing 3.8 percent of total volatile organic compounds (VOC) emissions from stationary sources.[(1)] It was reported that, in some States, cutback asphalt accounted for more than 15 percent of the 1975 emissions.[(1)]

The estimated annual emission of VOC from cutback asphalt was about 17.5 percent of the 3.7 million metric tons of cutback asphalt sold in 1975. Reported total sales of cutback asphalt in the U.S. in 2021 was slightly more than 0.15 million metric tons at 152,843 metric tons. [(2)] This represents an approximate 96 percent reduction of annual cutback asphalt sales compared to 1975. Using the same criteria for estimated cutback asphalt VOC emissions used by the EPA in 1975, this would account for an estimated 26,847 metric tons of VOC from cutback asphalt. Figure 1 presents the trend in cutback asphalt sales since 1975.



Note: Sales for 2009 were not reported, data point is an average of three years prior to and three years after 2009.

Figure 1. Cutback asphalt sales and estimated VOC emissions. (Figure source PTSi, data source ref. 1, 2)

Today cutback asphalt sales and uncontrolled hydrocarbon emissions are considerably less than the middle 1970's; however, there remains room for further reduction in uncontrolled hydrocarbon emissions from cutback asphalt.[2] Estimates indicate that usage of as little as 10 percent cutback asphalt products in total asphalt product usage may contribute as much as 60 percent of total uncontrolled hydrocarbon emissions.[1] To date, focus on reduction of VOC emissions from cutback asphalt seems to be on a regulatory compliance mindset rather than focus on change of practice. Inducing change in practice might be facilitated by identification of possible lower emission alternatives.

Background

Cutback asphalt is made by blending a diluent, typically a petroleum distillate, to an asphalt binder. Various types and quantities of diluents are used to extend curing or hardening time of the asphalt binder. Table 1 presents typical liquid asphalts including the three types of cutback asphalt: rapid curing (RC), where 70 to 90 percent of very volatile gasoline or naphtha is the diluent; medium cure (MC), where 60 to 80 percent of less volatile kerosene is the diluent; and slow curing (SC), where 20 to 30 percent of a low to nonvolatile oil is the diluent. Cure time of cutback asphalt is a function of diluent type, content, and evaporation.

Also presented in Table 1 is information for asphalt emulsion, a mixture of two normally immiscible components, asphalt and water blended with an emulsifying agent. In contrast to the evaporation of volatile organic solvents from cutback asphalt, asphalt emulsion relies on a breaking phenomenon and evaporation of water to yield an asphalt binder as the residue. In this process, the asphalt reverts to the semisolid state when the emulsifying agent is neutralized or "breaks," allowing the particles to join together.[3]

Inverted emulsified asphalt is an asphalt emulsion of any of the three types of cutback asphalt. Inverted emulsified asphalt relies on the same breaking phenomenon and evaporation of water as asphalt emulsions; however, the cutback asphalt residue still contains volatile organic solvents that cure as a function of diluent evaporation.

Table 1. Liquid asphalt products and their components

Rapid Curing (RC) Cutback Asphalt	Medium Curing (MC) Cutback Asphalt	Slow Curing (SC) Cutback Asphalt (Road Oils)	Asphalt Emulsion	Inverted Emulsified Asphalt
Asphalt Binder	Asphalt Binder	Asphalt Binder	Asphalt Binder	Liquid Asphalt RC, MC, or SC
Gasoline or Naphtha	Kerosene	Slowly Volatile & Non-Volatile Oils	Water And Emulsifier	Water And Emulsifier

The primary pollutants of concern from asphalt and asphalt paving operations are VOC. Among the three types of asphalt used in paving operations (i.e., asphalt binder, emulsified asphalt, and cutback asphalt), cutback asphalt is the major contributor to VOC. Relatively, minor amounts of VOC's are emitted from emulsified asphalt and asphalt binder.[1]

Diluents in cutback asphalt and inverted emulsified asphalt are VOC and are considered as precursors to tropospheric or ground-level ozone formation. VOC emissions from cutback asphalt binder occur at the job site and the mixing plant. At the job site, VOCs are emitted from the equipment used to apply the cutback asphaltic product and from the road surface. At the mixing plant, VOC are released during mixing and stockpiling. The largest source of emissions is the road surface itself, due to thin films applied to large surface areas.

Cutback Asphalt Usage

Cutback asphalt has reportedly been used in road construction since the 1800s, and there was a major expansion of cutback asphalt from the 1930s through the 1970s.[4,5] Although still utilized for various applications, new advances over time and ultimately a push to mitigate uncontrolled hydrocarbon emissions in the U.S. specifically led to a push for further development, education, and use of the more sustainable alternatives.

A 2022 review of published State DOT specifications conducted by the authors revealed twenty State DOTs, the District of Columbia, and FHWA restricted usage of cutback asphalt. The remaining thirty State DOTs allow usage of cutback asphalt, typically for use as a prime coat (i.e., a coating applied directly to a prepared unbound layer before the placement of an asphalt mixture layer). Thirteen of these thirty States DOTs do not indicate specific use, and eight allow use as prime coat only. Specifications of the remaining nine State DOTs permitting use of cutback asphalt indicate that it may be allowed for other treatments or as specified by each State DOT. Of these nine State DOTs, three allow use for prime and seal, one for prime and tack, one for cold patch, one for precoat, with two allowing general use, and one use as specified. Alternative materials and techniques to cutback asphalt, specifically asphalt emulsions, providing equal or better performance are available for all the uses indicated. Figure 2 shows cutback asphalt allowance by State DOTs.

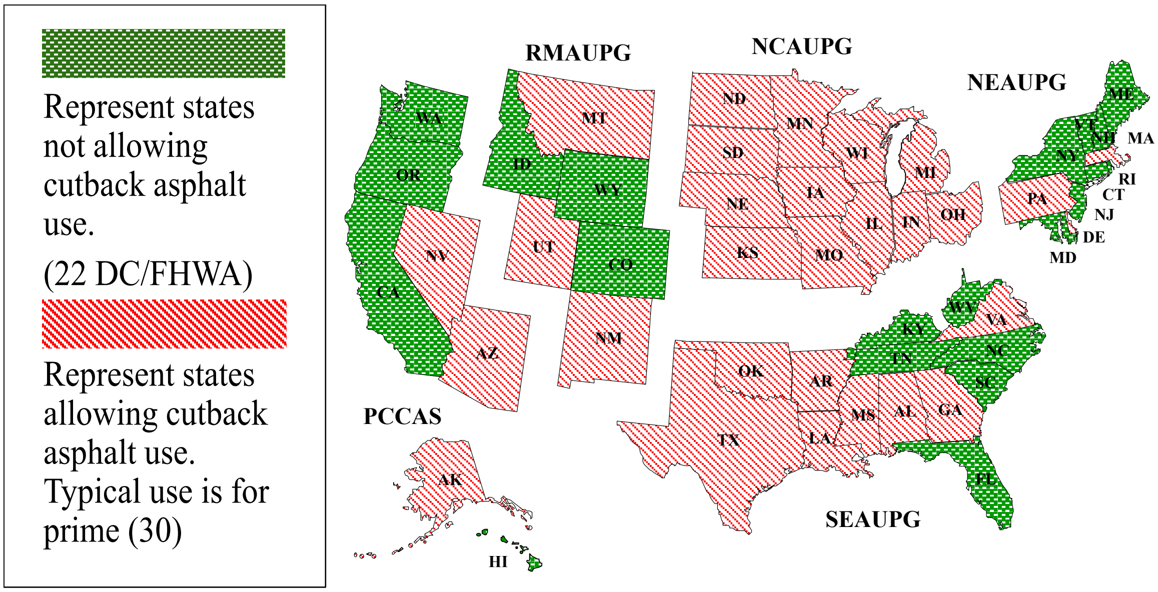


Figure 2. Cutback asphalt allowance by State DOTs. (Figure source PTSi)

Alternatives to Cutback Asphalt

With today's environmental and social governance focus, there is increased concern over environmental impacts from all facets of the road construction industry. Energy consumption and greenhouse gas (GHG) emissions are a critical issue for development of sustainable pavements. Engineers, environmentalists, and major companies are concerned with the impact of construction methods and materials on workers and the environment. As discussed, cutback asphalt releases GHG emissions because of the large amount of fossil fuels required and the evaporation of diluents from cutback asphalt applications. Asphalt emulsions are a suitable alternative to cutback asphalt in pavements construction and preservation. Ozone depletion is not considered a problem with emissions from non-solvent containing, low temperature, asphalt applications like asphalt emulsion.(12)

In 1975, estimates of uncontrolled hydrocarbon emissions from the use of cutback asphalt were 655 kilotons per year. Pursuant to the 1977 publication of a guideline series, "*Control of Volatile Organic Compounds from Use of Cutback Asphalt*," and establishment of the U.S. National Ambient Air Quality Standards (NAAQS), a large-scale national conversion from use of solvent cutback asphalt to asphalt emulsions was initiated. The advantages of converting from cutback asphalt to asphalt emulsions in terms of conservation of energy and reduction of air pollution were, and are, accepted by all concerned. Use of asphalt emulsion has grown over the past century, more specifically in the last half-century.

The first reported use of asphalt emulsion in pavement construction was in 1903, with the first asphalt emulsion patents issued to Leonard Schade van Westrum in the United Kingdom and then in the United States in late 1903 and early 1904, UK No. 21,195 October 1903 and US No. 752,486 February 1904.(6,7) Westrum was issued a later patent in 1911 as well, US No. 992,313 May 1911.(8) Modern asphalt emulsions in use today were patented by Hugh Alan McKay with the UK patent No. 202,021 in August 1923.(9)

Patented technology prior to 1923 primarily focused on oil emulsions for road applications; however, a distinction can be made. Westrum's approach to emulsifying oil contained a greater component of water and a lesser component of oil/asphalt. In Westrum's first work, the water component was more than 75 percent. Furthermore, the dispersed oil component was a blend of oil and asphalt, much like what is referred to as "*road oil*" today.[10,11] The 1923 McKay patent describes in detail an emulsion consisting of 70 percent asphalt binder and 30 percent water. This is a bit more like the asphalt emulsion produced and used today.

Since the middle 1970s, asphalt emulsions have been used extensively as an alternative to cutback asphalt for surface treatments such as: tack coats (diluted emulsified asphalt), *fog seals* (emulsified asphalt and other hydrocarbon/bio oils), *rejuvenating scrub seals* (emulsified asphalt and other hydrocarbon/bio oils), *sand seals* (emulsified asphalt and fine aggregate), micro surfacing (emulsified asphalt, water, fine aggregate, mineral filler, other additives) and *slurry seals* (emulsified asphalt, fine aggregate, and portland cement). *Polymer-modified asphalt* and *rubberized asphalt emulsions* are also used for these and other applications. Asphalt emulsion has also been mixed with aggregate at an asphalt mixing plant to create *cold-mix asphalt* or in situ for *cold in-place recycling*.

More recently, *rejuvenating scrub seal* type emulsions have been utilized as an alternative to cutback asphalt prime coat used in new pavement construction and emulsified asphalt tack coat emulsions have been manufactured to provide a quick breaking, high bond, less tracking tack/bond coat option to cutback asphalt. Asphalt emulsion continues to emerge as a suitable alternative to cutback asphalt providing for reduced VOC emissions worldwide. While VOC emissions are of primary concern in cutback asphalt use, research indicates that replacing cutback asphalt with asphalt emulsion lowers the amount of carbon dioxide produced by almost two-thirds while reducing formation of ground level ozone and diminished air quality.[13] Conclusions are that asphalt emulsions have a lower impact on the environment in terms of pollution and toxicity relative to cutback asphalt making asphalt emulsions a safer alternative to cutback asphalt with respect to worker health and safety. However, observations are that transporting asphalt emulsions may result in greater fuel usage and related GHG emissions, which is considered insignificant compared to the impact of cutback asphalt emissions.[13]

Summary

Volatile diluents used in cutback asphalt, classified as VOCs, are precursors to tropospheric or ground-level ozone formation and reduced air quality. Use of cutback asphalt in asphalt pavement construction was identified as a primary contributor to uncontrolled hydrocarbon VOC. Informed awareness and concerted action in reduction of cutback asphalt usage over the past half-century have led to an approximate 96 percent reduction in associated VOC emissions.

Asphalt emulsion is a reasonable replacement for cutback asphalt and can be used during construction or as a part of a maintenance and preservation program. During construction, asphalt emulsion prime coats can be used to prepare surfaces and bind granular layers prior to addition of asphalt layers. Additionally, asphalt emulsion tack or bond coats may be used between successive pavement layers. The bulk of asphalt emulsion usage addresses pavement maintenance and preservation applications. Treatments used depend on pavement age and condition and have been adapted globally to consider local climatic and traffic conditions.

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