4.5 Asphalt Paving Operations

4.5.1 General[1-3]

Asphalt surfaces and pavements are composed of compacted aggregate and an asphalt binder. Aggregate materials are produced from rock quarries as manufactured stone or are obtained from natural gravel or soil deposits. Metal ore refining processes produce artificial aggregates as a byproduct. In asphalt, the aggregate performs 3 functions: it transmits the load from the surface to the base course, takes the abrasive wear of traffic, and provides a nonskid surface. The asphalt binder holds the aggregate together, preventing displacement and loss of aggregate and providing a waterproof cover for the base.

Asphalt binders take the form of asphalt cement (the residue of the distillation of crude oils), and liquified asphalts. To be used for pavement, asphalt cement, which is semisolid, must be heated prior to mixing with aggregate. The resulting hot mix asphalt concrete is generally applied in thicknesses of from 5 to 15 centimeters (2 to 6 inches). Liquified asphalts are: (1) asphalt cutbacks (asphalt cement thinned or "cutback" with volatile petroleum distillates such as naptha, kerosene, etc.) and (2) asphalt emulsions (nonflammable liquids produced by combining asphalt and water with an emulsifying agent, such as soap). Liquified asphalts are used in tack and seal operations, in priming roadbeds for hot mix application, and for paving operations up to several inches thick.

Cutback asphalts fall into 3 broad categories: rapid cure (RC), medium cure (MC), and slow cure (SC) road oils. SC, MC, and RC cutbacks are prepared by blending asphalt cement with heavy residual oils, kerosene-type solvents, or naptha and gasoline solvents, respectively. Depending on the viscosity desired, the proportions of solvent added generally range from 25 to 45 percent by volume.

Emulsified asphalts are of 2 basic types: 1 type relies on water evaporation to cure, the other type (cationic emulsions) relies on ionic bonding of the emulsion and the aggregate surface. Emulsified asphalt can substitute for cutback in almost any application. Emulsified asphalts are gaining in popularity because of the energy and environmental problems associated with the use of cutback asphalts.

4.5.2 Emissions[1,2]

The primary pollutants of concern from asphalts and asphalt paving operations are volatile organic compounds (VOC). Of the 3 types of asphalts, the major source of VOC is cutback. Only minor amounts of VOCs are emitted from emulsified asphalts and asphalt cement.

VOC emissions from cutback asphalts result from the evaporation of the petroleum distillate solvent, or diluent, used to liquify the asphalt cement. Emissions occur at both the job site and the mixing plant. At the job site, VOCs are emitted from the equipment used to apply the asphaltic product and from the road surface. At the mixing plant, VOCs are released during mixing and stockpiling. The largest source of emissions, however, is the road surface itself.

For any given amount of cutback asphalt, total emissions are believed to be the same, regardless of stockpiling, mixing, and application times. The 2 major variables affecting both the quantity of VOCs emitted and the time over which emissions occur are the type and the quantity of petroleum distillate used as a diluent. As an approximation, long-term emissions from cutback

asphalts can be estimated by assuming that 95 percent of the diluent evaporates from rapid cure (RC) cutback asphalts, 70 percent from MC cutbacks, and about 25 percent from SC asphalts, by weight percent. Some of the diluent appears to be retained permanently in the road surface after application. Limited test data suggest that from RC asphalt, 75 percent of the total diluent loss occurs on the first day after application, 90 percent occurs within the first month, and 95 percent in 3 to 4 months. Evaporation takes place more slowly from MC asphalts, with roughly 20 percent of the diluent being emitted during the first day, 50 percent during the first week, and 70 percent after 3 to 4 months. No measured data are available for SC asphalts, although the quantity emitted is believed to be considerably less than with either RC or MC asphalts, and the time during which emissions take place is expected to be considerably longer (Figure 4.5-1). An example calculation for determining VOC emissions from cutback asphalts is given below:

Example: Local records indicate that 10,000 kg of RC cutback asphalt (containing 45 percent diluent, by volume) was applied in a given area during the year. Calculate the mass of VOC emitted during the year from this application.

To determine VOC emissions, the volume of diluent present in the cutback asphalt must first be determined. Because the density of naptha (0.7 kg/L) differs from that of asphalt cement (1.1 kg/L), the following equations should be solved to determine the volume of diluent (x) and the volume of asphalt cement (y) in the cutback asphalt:

$$10,000 \text{ kg cutback asphalt} = (x \text{ liter, diluent}) \cdot \left(\frac{0.7 \text{ kg}}{\text{liter}}\right) + (y \text{ liter, asphalt cement}) \cdot \left(\frac{1.1 \text{ kg}}{\text{liter}}\right)$$

and

$$x \text{ liter, diluent} = 0.45 (x \text{ liter, diluent} + y \text{ liter, asphalt cement})$$

From these equations, the volume of diluent present in the cutback asphalt is determined to be about 4900 liters, or about 3400 kg. Assuming that 95 percent of this is evaporative VOC, emissions are then: 3400 kg x 0.95 = 3200 kg (i. e., 32%, by weight, of the cutback asphalt eventually evaporates).

These equations can be used for medium cure and slow cure asphalts by assuming typical diluent densities of 0.8 and 0.9 kg/liter, respectively. Of course, if actual density values are known from local records, they should be used in the above equations rather than typical values. Also, if different diluent contents are used, they should also be reflected in the above calculations. If actual diluent contents are not known, a typical value of 35 percent may be assumed for inventory purposes.

In lieu of solving the equations in the above example, Table 4.5-1 may be used to estimate long-term emissions from cutback asphalts. Table 4.5-1 directly yields long-term emissions as a function of the volume of diluent added to the cutback and of the density of the diluents and asphalt cement used in the cutback asphalt. If short-term emissions are to be estimated, Figure 4.5-1 should be used in conjunction with Table 4.5-1.

No control devices are employed to reduce evaporative emissions from cutback asphalts. Asphalt emulsions are typically used in place of cutback asphalts to eliminate VOC emissions.
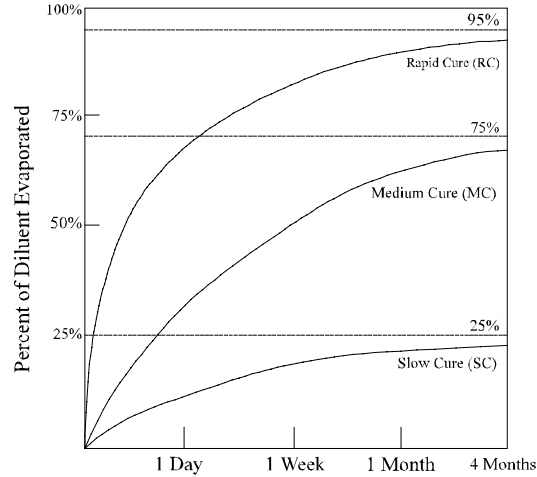
Figure 4.5-1. Percent of diluent evaporated from cutback asphalt over time.

Table 4.5-1. EVAPORATIVE VOC EMISSIONS FROM CUTBACK ASPHALTS AS A
FUNCTION OF DILUENT CONTENT AND CUTBACK ASPHALT TYPE[a]

EMISSION FACTOR RATING: C

Type Of Cutback[b]	Percent, By Volume, Of Diluent In Cutback[c]		
	25%	35%	45%
Rapid cure	17	24	32
Medium cure	14	20	26
Slow cure	5	8	10

[a] These numbers represent the percent, by weight, of cutback asphalt evaporated. Factors are based on
   References 1-2.
[b] Typical densities assumed for diluents used in RC, MC, and SC cutbacks are 0.7, 0.8, and
   0.9 kg/liter, respectively.
[c] Diluent contents typically range between 25 - 45%, by volume. Emissions may be linearly
   interpolated for any given type of cutback between these values.

References For Section 4.5

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2.   F. Kirwan and C. Maday, *Air Quality And Energy Conservation Benefits From Using
        Emulsions To Replace Asphalt Cutbacks In Certain Paving Operations*, EPA-450/2-78-004,
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3.   David W. Markwordt, *Control Of Volatile Organic Compounds From Use Of Cutback Asphalt*,
        EPA 450/2-77-037, U. S. Environmental Protection Agency, Research Triangle Park, NC,
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