1854   **ADJUSTED ASPHALT FILM THICKNESS (AFT)**

1854.1   SIGNIFICANCE AND USE

The Adjusted AFT is used to ensure an adequate effective asphalt volume (Vbe) in bituminous mixtures. The minimum effective asphalt volume requirement for AFT is based on the aggregate's surface area (represented by the gradation) as opposed to the max aggregate size used for VMA. The AFT calculation is based on the calculated aggregate surface area (SA) and the effective asphalt content. Any SA adjustment is based on the aggregate's surface area and bulk specific gravity. The Adjusted AFT will be greater than the AFT if the aggregate surface area is greater than 28.0 ft^2/lb, and will be less than the AFT if the SA is less than 28.0 SF/lb. In addition, the AFT is adjusted to basically allow the same Vbe range as the national VMA criteria.

1854.2   PROCEDURE

From a Bituminous Mixture Sample

A.   Determine the Asphalt content (Pb) according to AASHTO T 164 Extraction of Bitumen from Bituminous Paving Mixtures (Mn/DOT modified) Section 1851,1852. Or by AASHTO T 308, Determining the Asphalt Binder Content of Hot Mix Asphalt by the Ignition Method (Mn/DOT modified). Section 1853.

B.   Determine the extracted aggregate gradation according to AASHTO T30, Mechanical Analysis of Extracted Aggregate (Mn/DOT modified). Section 1203

C.   Determine the Max Specific Gravity (Gmm) according to AASHTO T 209, Maximum Specific Gravity of Bituminous Paving Mixtures (Mn/DOT modified). Section 1807

D.   Determine the asphalt binder specific gravity (Gb). Refer to the Asphalt Supplier's binder data sheet for the particular binder grade.

E.   Determine the Percent Absorbed Asphalt (Pba) according to Asphalt Institute's SP-2 manual.

$$Pba = 100 \times \frac{Gse - Gsb}{Gsb \times Gse} \times Gb$$

$$Gse = \frac{100 - Pb}{\frac{100}{Gmm} - \frac{Pb}{Gb}}$$

F.   Determine the Effective Asphalt Content (Pbe) of the aggregate weight in the mixture according to SP-2.

$$Pbe = Pb - \frac{Pba}{100} \times Ps$$

G.   Determine the total and minus #4 combined bulk specific gravity(Gsb) of the aggregate blend. Refer back to the mixture's job mix formula.

1854.3   CALCULATIONS

A.   AGGREGATE SURFACE AREA (SA)

The surface area for the aggregate is determined by multiplying the percent passing a given sieve by the surface area factor. These factors are from the Asphalt Institutes MS-2 Manual and are listed below. The surface area is determined for each sieve size and then summed to calculate a total surface area.

1) The aggregate surface area is calculated by the following formula:

SA = 2 + 0.02a + 0.04b + 0.08c + 0.14d + 0.30e + 0.60f + 1.60g

Where: SA = aggregate surface area in ft^2/lb of dry aggregate. And **a,b,c,d,e,f** and **g** = the percent of total aggregate passing the #4, #8, #16, #30, #50, #100 and #200 sieves respectively.

Note 1: The percent passing each sieve is rounded to the nearest 1 percent, except for the #200 sieve, which will be rounded to the nearest 0.1 percent.

Note 2: The SA is calculated to the nearest 0.1 ft^2/lb .

B.   SURFACE AREA ADJUSTMENT

The surface area factors are generally based on a specific gravity (Gsb) of 2.650. Aggregates that have higher Gsb's will have less SA per pound than those with lower Gsb's.

The total surface area is then adjusted as follows:

1) Mixtures with a combined minus #4 Gsb less than 2.580 or greater than 2.700 will have the calculated SA adjusted accordingly:

The SA will be increased for mixtures with a combined minus #4 Gsb less than 2.580, and decreased for mixtures with a combined minus #4 Gsb greater than 2.700.

There is <u>no</u> SA adjustment for mixtures with a combined minus #4 Gsb between 2.580 and 2.700.

2) When required, the SA adjustment procedure is as follows:

Adjusted SA = SA x (2.650 ÷ combined minus #4 Gsb)

C.   ASPHALT FILM THICKNESS (AFT)

The AFT is calculated by the following formula:

$$\text{AFT} = \frac{\text{Pbe x 4870}}{\text{Ps x adj SA}}$$

Where:
   AFT = Asphalt Film Thickness in microns
   Pbe = Effective Asphalt Content as a percent of total mixture
   4870 = Constant conversion factor (microns)
   Ps   = Percent Aggregate in Mixture or (100-Pb)
   Pb   = Percent Total Asphalt Binder in Mixture
   SA   = Calculated Aggregate Surface Area in ft^2/lb

Note 3: The AFT is calculated to the nearest 0.1 micron.

D.   ADJUSTED ASPHALT FILM THICKNESS (Adj AFT)

The Adjusted AFT is calculated by the following formula:

Adj. AFT = AFT + [0.06 x (adj SA – 28)]

1854.4   EXAMPLE of ADJUSTED AFT CALCULATION

Assume: Pb = 5.9%
             Pbe= 4.9
             Minus #4 Gsb = 2.640
             Gradation as follows:
             % passing #4 sieve = 73%
             % passing #8 sieve = 58%
             % passing #16 sieve = 42%
             % passing #30 sieve = 28%
             % passing # 50 sieve =17%
             % passing#100 sieve = 7%
             % passing#200 sieve = 5.4%

Step 1: Determine Surface Area (SA) from the gradation.

SA = 2 + (0.02x73) + (0.04x58) + (0.08x42) + (0.14x28) + (0.30x17) + (0.60x7) + (1.60x5.4)

SA = 2 + 1.46 + 2.32 + 3.36 + 3.92 + 5.10 + 4.20 + 8.64

SA = 31.0 ft^2/lb

Step 2: Determine the SA adjustment.

Since the minus #4 aggregate Gsb is between 2.580 and 2.700 there is <u>no</u> adjustment to the calculated SA.

Step 3: Calculate the AFT

$$\text{AFT} = \frac{\textbf{4.9} \times 4870}{(100\textbf{-5.9)} \times \textbf{31.0}}$$

$$\text{AFT} = \frac{23863}{94.1 \times 31.0}$$

AFT = 8.2 microns

Step 4: Calculate the Adjusted AFT

Adj. AFT = 8.2 + [0.06 x (31.0 – 28.0)]

Adj. AFT = 8.2 + 0.2

Adj. AFT = 8.4 microns

1854.5　　　　ADJUSTED AFT WORKSHEET

ADJUSTED ASPHALT FILM THICKNESS (AFT) CALCULATION
and Fines /Effective AC

		%Passing	Multiplication	
(Mix)Gsb=	2.670			
%AC(Pb)=	5.9	#4 = 73	0.02	1.46
Gmm=	2.500	#8 = 58	0.04	2.32
AC SpG(Gb)=	1.032	#16 = 42	0.08	3.36
Gsb (-4)	2.640　Gse= 2.745	#30 = 28	0.14	3.92
%Stone(Ps)=	94.1	#50 = 17	0.30	5.10
	Pba= 1.06	#100 = 7	0.60	4.20
		#200 = 5.4	1.60	8.64
	Pbe= 4.9			

Surface area (SA)　=　31.0　ft2/lb

Adj. Surface area (SA)　=　31.0　ft2/lb

Fines/Effective AC(F/Pbe)
=　1.1　ratio

Asphalt Film Thickness (AFT) =　8.2　microns

Adjusted AFT =　8.4　microns

Guideline notes based on Bituminous Office Consultation

* Use Combined Mix Aggregate for Gsb　　　　　*Surface Area (SA) Calculates to Tenth ex. (27.8)

* %AC Must be Tenth ex.(5.4)　　　　　　　　* Asphalt Film Thickness (AFT) is Calculated to Tenth ex.(8.3)

* Gmm Must be to Thousandth ex.(2.497)　　　　*Fines to Effective % AC is calculated to the tenth ex.(0.9)

* AC SpG Must be to Thousandth ex.(1.030)

* % Stone will Calculate to Tenth ex.(94.6)

* Gse Calculates to Thousandth ex.(2.718)

* Pba is a mid-step calculation.(not rounded)

* Pbe Calculates to Tenth ex.(4.5)

* % Passing Sieves must be entered to Whole Number ex.(66)

* % Passing #200 sieve must be entered to Tenth ex.(3.6)