Why
Adjusted AFT ?

5 Basic Options for % AC

- Specify a Minimum % AC
- **Specify a Minimum VMA**
- Specify a Minimum V_{be}
- Specify a Minimum AFT
- **Specify a Minimum Adjusted AFT**

Adjusted AFT and VMA are both intended to provide an adequate effective AC volume (V_{be}).

VMA is based on the Nominal Maximum Aggregate Size

AFT is based on the calculated Aggregate Surface Area (SA), which is basically an "Index".

Why AFT instead of VMA?

There is little correlation between the nominal maximum aggregate size and overall gradation, or aggregate surface area (SA)

The Calculated “SA” represents a gradation similar to a Fineness Modulus

“SA” can account for changes in Aggregate Specific Gravity

- **VMA = V_{be} + V_a**
- **AFT = V_{be}/SA**
- "**SA**" represents the aggregate gradation
- As "**SA**" increases, **V_{be}** must also increase in order to maintain a specific **AFT**

- AFT, Aggregate SA and V_{be} are independent of the degree of compaction at Design (i.e. the number of blows or gyrations)

- VMA and VFA are dependent on the degree of compaction at Design

The Primary Difference

between

Asphalt Pavement Mixture

and

Aggregate Base

is

ASPHALT CEMENT

Inadequate

Asphalt Film Thickness (AFT)

or

Effective AC Volume (V_{be})

May Result in

"Stripping" or Raveling

Stripping on TH 12

Stripping on TH 10

Stripping on TH 101

More Stripping on TH 101

Stripping on TH 242

Stripping on TH 47

Stripping on TH 55

Stripping on TH 7

More Stripping on TH 7

Raveling on TH 12

More Raveling on TH 12

Raveling on Schmidt Lake Road

Raveling on TH 21

More Raveling on TH 21

Excessive

Asphalt Film Thickness (AFT)

or

Effective Asphalt Volume (V_{be})

May Result in

Rutting

Rutting on TH 41

Rutting on TH 41

Rutting on TH 494

Measures Tried to Provide Adequate Effective AC Volume

- Minimum Total Asphalt Cement Content
- Minimum Voids in Mineral Aggregate (VMA)
- Minimum Asphalt Film Thickness (AFT)

Minimum Total AC Content

Does Not Account for:

- Changes in AC Absorption
- Changes in Gradation or Aggregate Surface Area

Minimum VMA

- Accounts for Changes in AC Absorption
- Includes Both V_{be} and Air Voids
- Based on Very Poor Correlation with Aggregate Surface Area
- Encourages the Addition of Sand
- VMA is dependent on Design Compaction

Minimum AFT

Advantages

- Accounts for AC Absorption by using Effective AC Content
- Has a Direct Correlation with Aggregate Surface Area
- Can Account for Changes in Aggregate Specific Gravity

Minimum AFT
Problems

- "Normally" the Minimum Required Effective AC Volume (V_{be}) is Directly Proportional to the Aggregate Surface Area (This is probably not necessary).

- A Gradation is Required for Each AFT Calculation

MINIMUM VMA CRITERIA

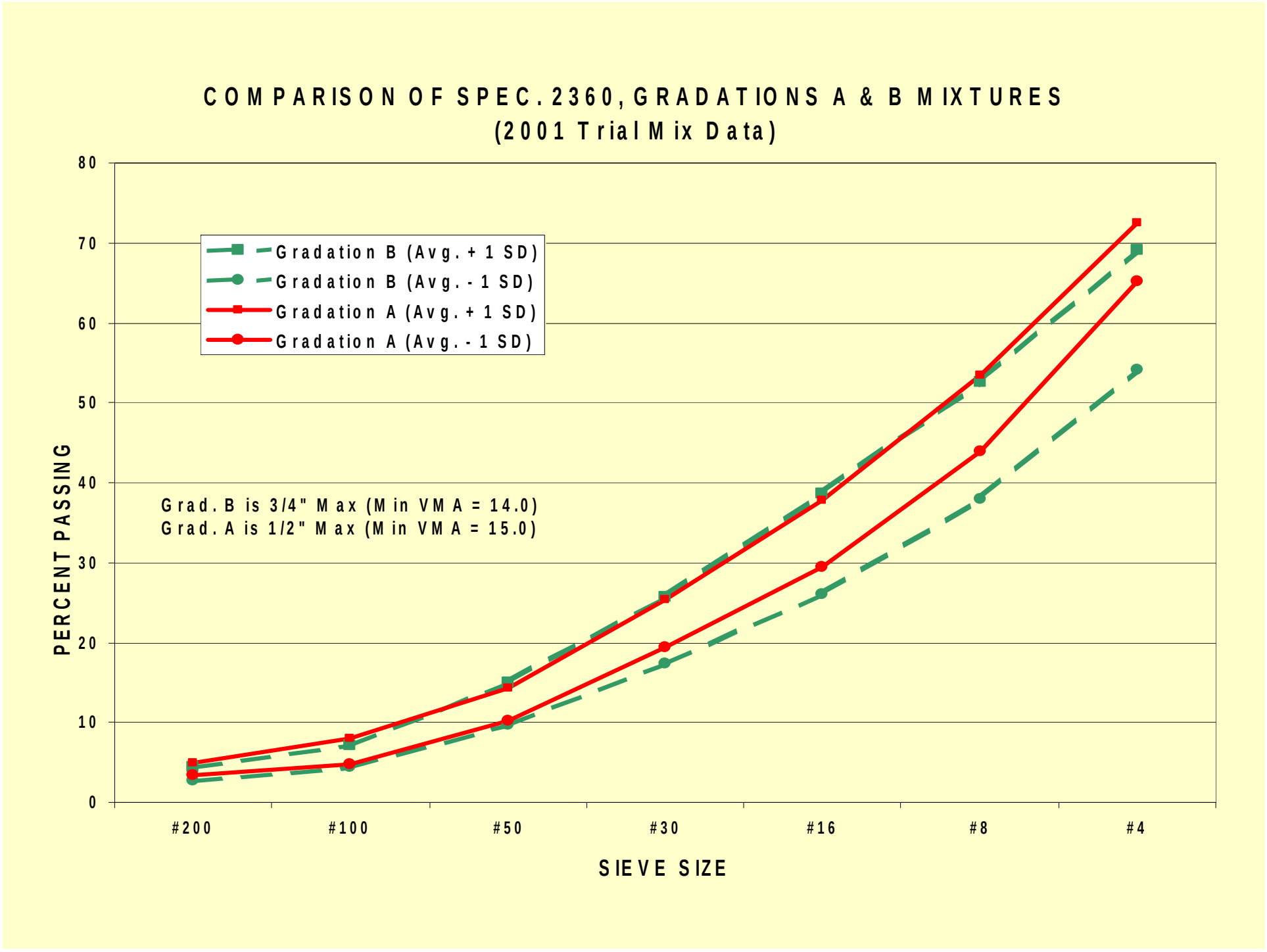
(Based on 4% Design Air Voids)

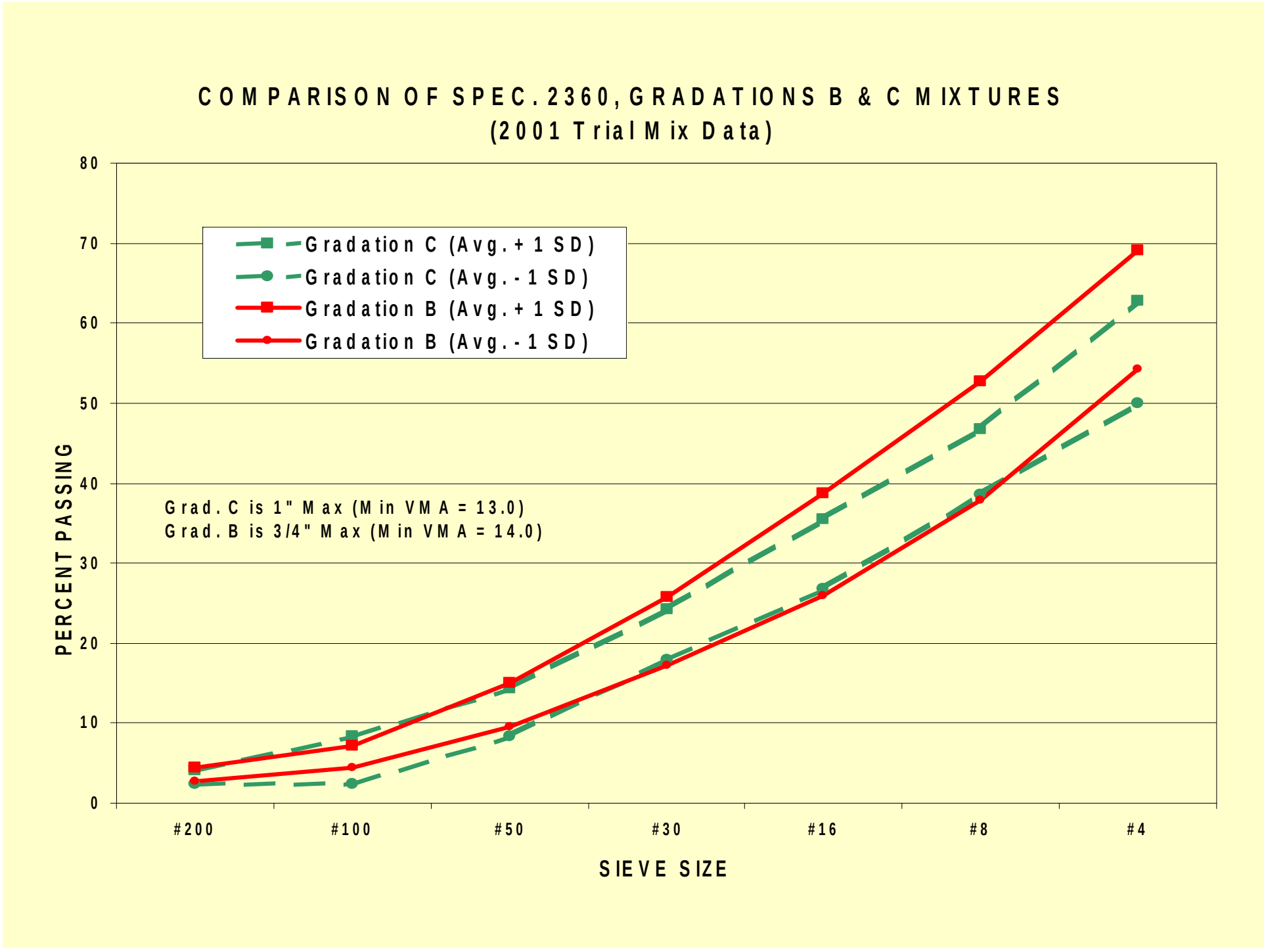
ASPHALT INSTITUTE

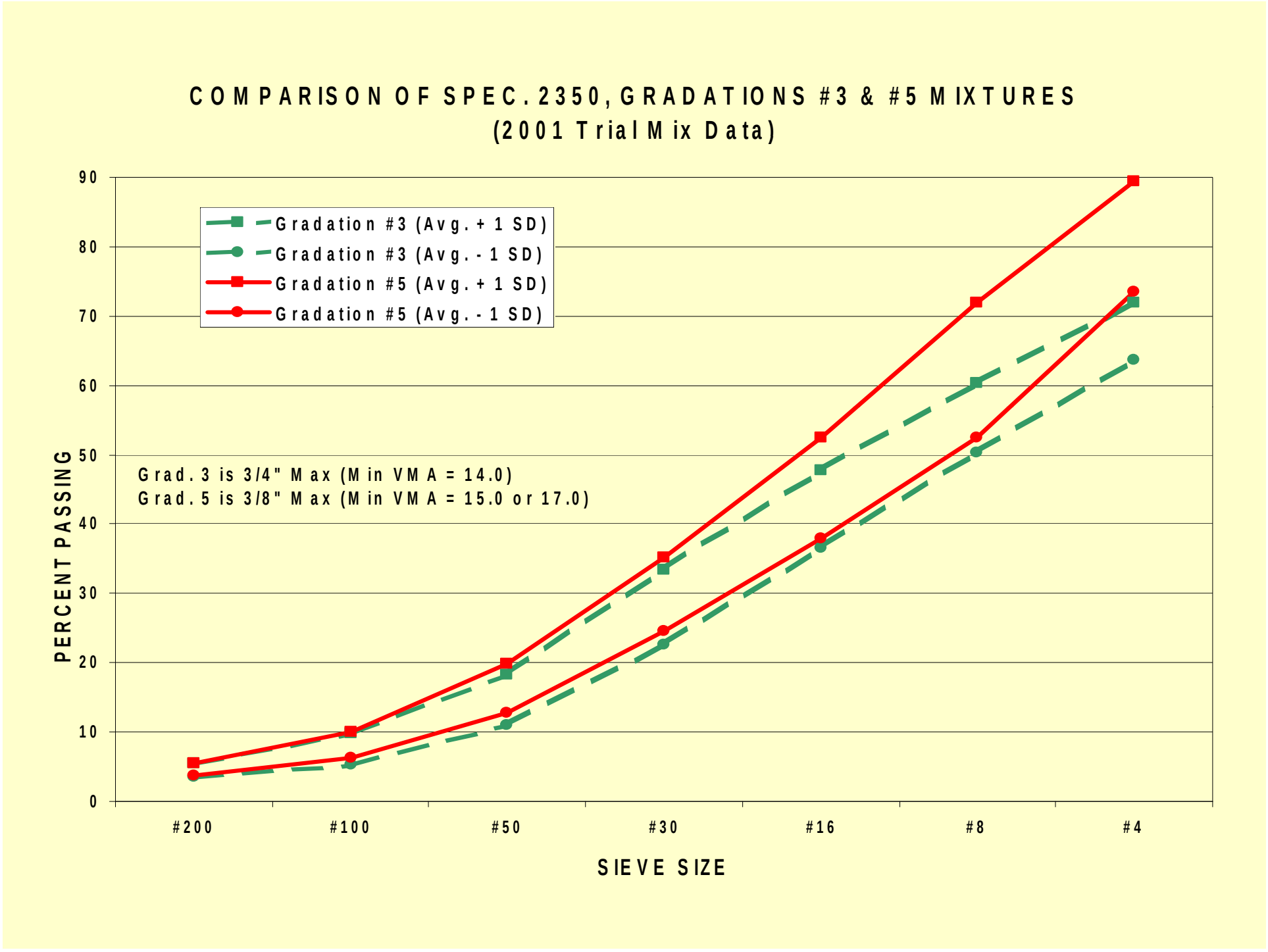
MIX DESIGN (MS-2)

Nominal Maximum Aggregate Size	Maximum Aggregate Size	Minimum % VMA
25.0 mm (1")	1.5"	12.0
19.0 mm (3/4")	1"	13.0
12.5 mm (1/2")	3/4"	14.0
9.5 mm (3/8")	1/2"	15.0
4.75mm (#4)	3/8"	17.0

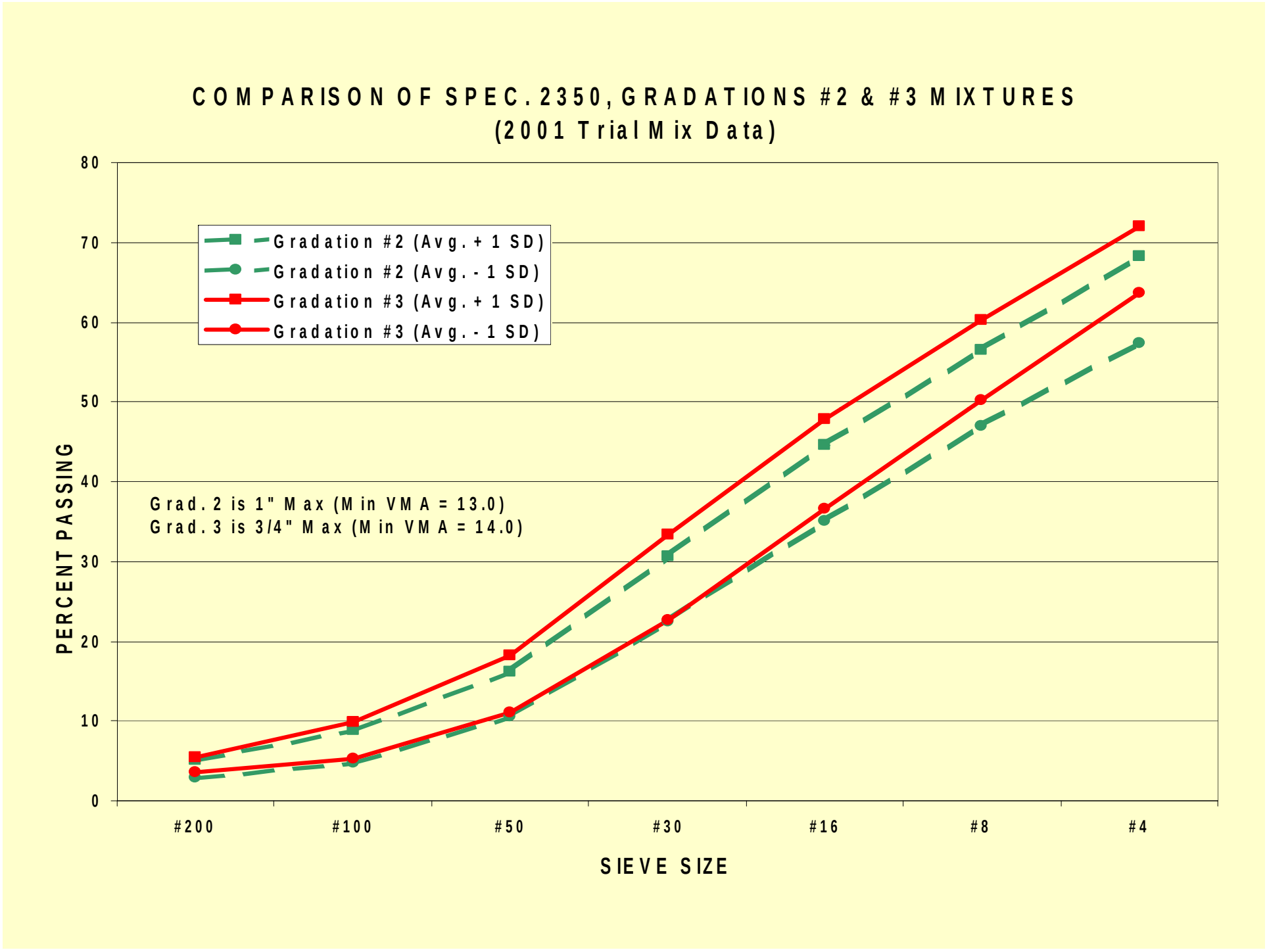
Illustrations of Poor Correlation between Maximum Aggregate Size and Aggregate Gradation


COMPARISON OF SPEC. 2360, GRADATIONS A & B MIXTURES
(2001 Trial Mix Data)
Gradation B (Avg. + 1 SD)
Gradation B (Avg. - 1 SD)
Gradation A (Avg. + 1 SD)
Gradation A (Avg. - 1 SD)
Grad. B is 3/4" Max (Min VMA = 14.0)
Grad. A is 1/2" Max (Min VMA = 15.0)
PERCENT PASSING
0
10
20
30
40
50
60
70
80
#200
#100
#50
#30
#16
#8
#4
SIEVE SIZE


COMPARISON OF SPEC. 2360, GRADATIONS B & C MIXTURES
(2001 Trial Mix Data)
Gradation C (Avg. + 1 SD)
Gradation C (Avg. - 1 SD)
Gradation B (Avg. + 1 SD)
Gradation B (Avg. - 1 SD)
Grad. C is 1" Max (Min VMA = 13.0)
Grad. B is 3/4" Max (Min VMA = 14.0)
PERCENT PASSING
0
10
20
30
40
50
60
70
80
#200
#100
#50
#30
#16
#8
#4
SIEVE SIZE

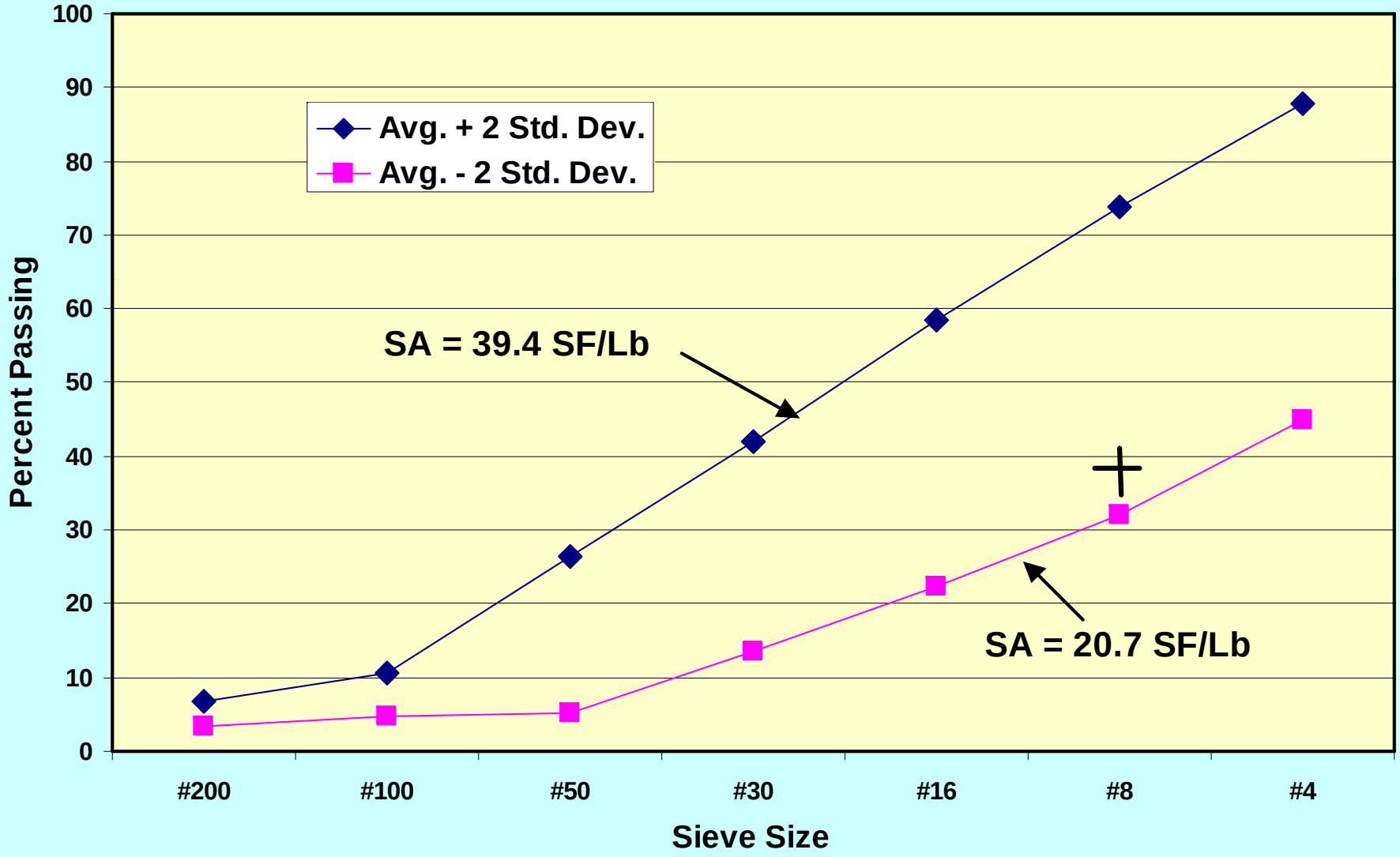

COMPARISON OF SPEC. 2350, GRADATIONS #3 & #5 MIXTURES
(2001 Trial Mix Data)
Gradation #3 (Avg. + 1 SD)
Gradation #3 (Avg. - 1 SD)
Gradation #5 (Avg. + 1 SD)
Gradation #5 (Avg. - 1 SD)
Grad. 3 is 3/4" Max (Min VMA = 14.0)
Grad. 5 is 3/8" Max (Min VMA = 15.0 or 17.0)
PERCENT PASSING
0
10
20
30
40
50
60
70
80
90
#200
#100
#50
#30
#16
#8
#4
SIEVE SIZE


COMPARISON OF SPEC.2350, GRADATIONS #3 & #4 MIXTURES
(2001 Trial Mix Data)
Gradation #3 (Avg. + 1 SD)
Gradation #3 (Avg. - 1 SD)
Gradation #4 (Avg. + 1 SD)
Gradation #4 (Avg. - 1 SD)
Grad. 3 is 3/4" Max (Min VMA = 14.0)
Grad. 4 is 1/2" Max (Min VMA = 15.0)
PERCENT PASSING
0
10
20
30
40
50
60
70
80
#200
#100
#50
#30
#16
#8
#4
SIEVE SIZE


COMPARISON OF SPEC. 2350, GRADATIONS #2 & #3 MIXTURES
(2001 Trial Mix Data)
Gradation #2 (Avg. + 1 SD)
Gradation #2 (Avg. - 1 SD)
Gradation #3 (Avg. + 1 SD)
Gradation #3 (Avg. - 1 SD)
Grad. 2 is 1" Max (Min VMA = 13.0)
Grad. 3 is 3/4" Max (Min VMA = 14.0)
PERCENT PASSING
0
10
20
30
40
50
60
70
80
#200
#100
#50
#30
#16
#8
#4
SIEVE SIZE

3/4" MAXIMUM SIZE AGGREGATE

(Based on 2003 Contractor Production Data)



How is Aggregate Surface Area Calculated?

It is based on the Aggregate Gradation, and Surface Area Factors listed in the Asphalt Institutes MS-2 as part of the Hveem Design Method

Based on the Asphalt Institutes MS-2

SA = Calculated Surface Area in SF/ Lb.

SA = 2 + .02a + .04b + 0.08c + .14d + .30e + .60f + 1.60g

Where:

a,b,c,d,e,f and g are % of total aggregate passing the #4, #8, #16, #30, #50, #100 and #200 sieves, respectively

Aggregate SA Adjustment

- The SA factors are generally based on an aggregate specific gravity (G_{sb}) of 2.650.
- Aggregates with higher G_{sb}'s will have less SA per pound than those with lower G_{sb}'s
- The aggregate SA can be adjusted based on the minus #4 G_{sb} As follows:

$$\text{Adjusted SA} = SA(2.650/\text{-}\#4G_{sb})$$

My Verification

AGGREGATE SURFACE AREA VS. SIEVE SIZE (Assuming Spherical Shape)

Sieve Size #/(mm)	Relative Surface Area (Per Unit Wt.)	Aggregate Surface Area (SF/Lb)
1" (25)	1.0	0.44
3/4" (19)	1.3	0.57
3/8" (9.5)	2.6	1.13
#4 (4.75)	5.3	2.31
#8 (2.36)	11	4.77
#16 (1.18)	21	9.16
#30 (0.60)	42	18.31
#50 (0.30)	83	36.19
#100 (0.15)	167	72.81
#200 (0.075)	333	145.19

Assuming Spherical particles with a Specific Gravity = 2.65

The calculated aggregate SA is not exact,

but generally reasonably represents the gradation.

SURFACE AREA CALCULATIONS

2001 TM Data **Mix Type** **2360 Grad. #B** **Avg. - 1 SD**

Sieve Size	% Passing	MS II SA Factor	MS II SA (SF/Lb)	% Retained	My Calculations SA Factor	My Calculations SA (SF/Lb)
3/4" (19mm)	100	0.02	2.00	0	0.006	0.00
3/8" (9.5mm)	79	NA	NA	21	0.011	0.24
#4 (4.75mm)	54	0.02	1.08	25	0.023	0.58
#8 (2.36mm)	38	0.04	1.52	16	0.048	0.76
#16 (1.18mm)	26	0.08	2.08	12	0.092	1.10
#30 (0.60mm)	17	0.14	2.38	9	0.183	1.65
#50 (0.30mm)	10	0.30	3.00	7	0.362	2.53
#100 (0.15mm)	4	0.60	2.40	6	0.728	4.37
#200 (0.075mm)	2.7	1.60	4.32	1.3	1.452	1.89
*** (0.038mm)**	1.8	NA	NA	0.9	2.9	2.74
**** (0.019mm)**	1.1	NA	NA	0.6	5.8	3.56
		MS II SA =	**18.78**		**My SA =**	**19.42**

***** Assumes **65%** of the Material Passing the 0.075mm Sieve Passes **0.038mm**
****** Assumes **65%** of the Material Passing 0.038mm Passes **0.019mm**

#200 (0.075mm)	2.7	1.60	4.32	1.3	1.452	1.89
*** (0.038mm)**	1.9	NA	NA	0.8	2.9	2.35
**** (0.019mm)**	1.3	NA	NA	0.6	5.8	3.29
		MS II SA =	**18.78**		**My SA =**	**18.75**

***** Assumes **70%** of the Material Passing the 0.075mm Sieve Passes **0.038mm**
****** Assumes **70%** of the Material Passing 0.038mm Passes **0.019mm**

SURFACE AREA CALCULATIONS

2001 TM Data **Mix Type** **2350 Grad. #5** **Avg. + 1 SD**

Sieve Size	% Passing	MS II SA Factor	MS II SA (SF/Lb)	% Retained	My Calculations SA Factor	My Calculations SA (SF/Lb)
3/4" (19mm)	100	0.02	2.00	0	0.006	0.00
3/8" (9.5mm)	100	NA	NA	0	0.011	0.00
#4 (4.75mm)	89	0.02	1.78	11	0.023	0.25
#8 (2.36mm)	72	0.04	2.88	17	0.048	0.81
#16 (1.18mm)	52	0.08	4.16	20	0.092	1.83
#30 (0.60mm)	35	0.14	4.90	17	0.183	3.11
#50 (0.30mm)	20	0.30	6.00	15	0.362	5.43
#100 (0.15mm)	10	0.60	6.00	10	0.728	7.28
#200 (0.075mm)	5.5	1.60	8.80	4.5	1.452	6.53
*** (0.038mm)**	3.6	NA	NA	1.9	2.9	5.58
**** (0.019mm)**	2.3	NA	NA	1.3	5.8	7.26
		MS II SA =	**36.52**		**My SA =**	**38.09**

***** Assumes **65%** of the Material Passing the 0.075mm Sieve Passes **0.038mm**
****** Assumes **65%** of the Material Passing 0.038mm Passes **0.019mm**

#200 (0.075mm)	5.5	1.60	8.80	4.5	1.452	6.53
*** (0.038mm)**	3.9	NA	NA	1.7	2.9	4.79
**** (0.019mm)**	2.7	NA	NA	1.2	5.8	6.70
		MS II SA =	**36.52**		**My SA =**	**36.74**

***** Assumes **70%** of the Material Passing the 0.075mm Sieve Passes **0.038mm**
****** Assumes **70%** of the Material Passing 0.038mm Passes **0.019mm**

Examples of

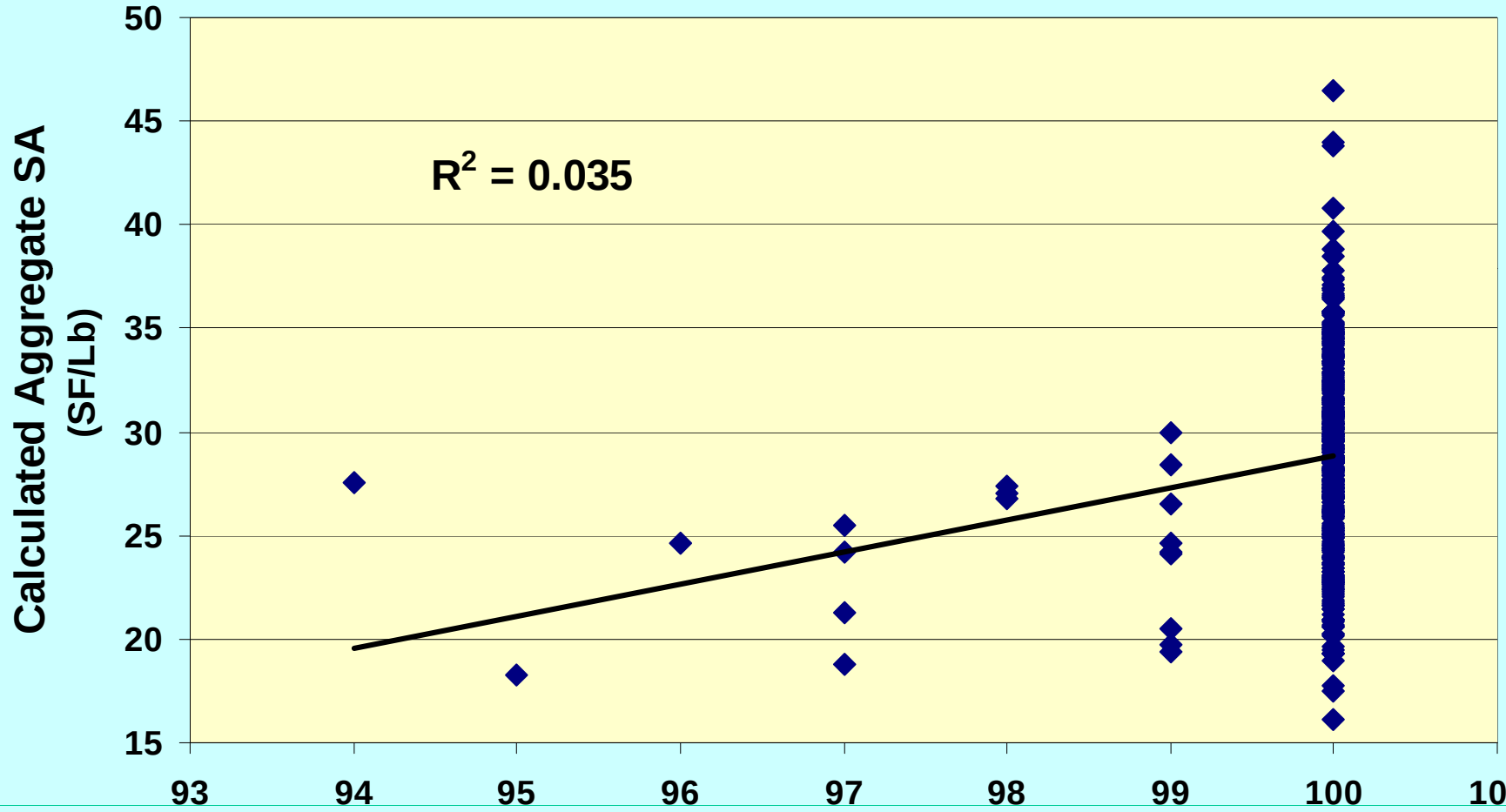
Aggregate SA

vs

% Passing Various Sieves

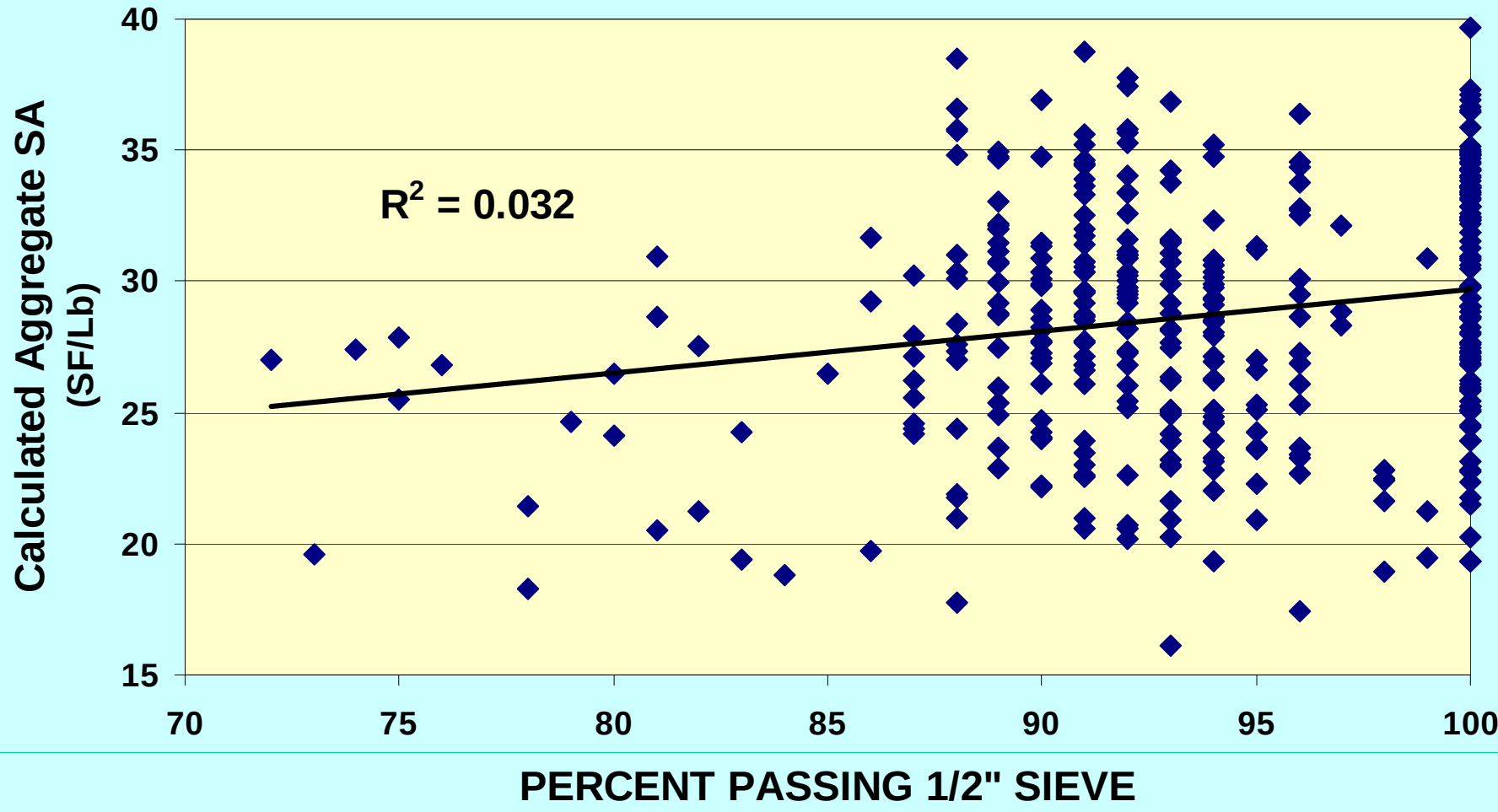
SA vs. % Passing 3/4" Sieve

(2003 Project Data)



SA vs. % Passing 1/2" Sieve

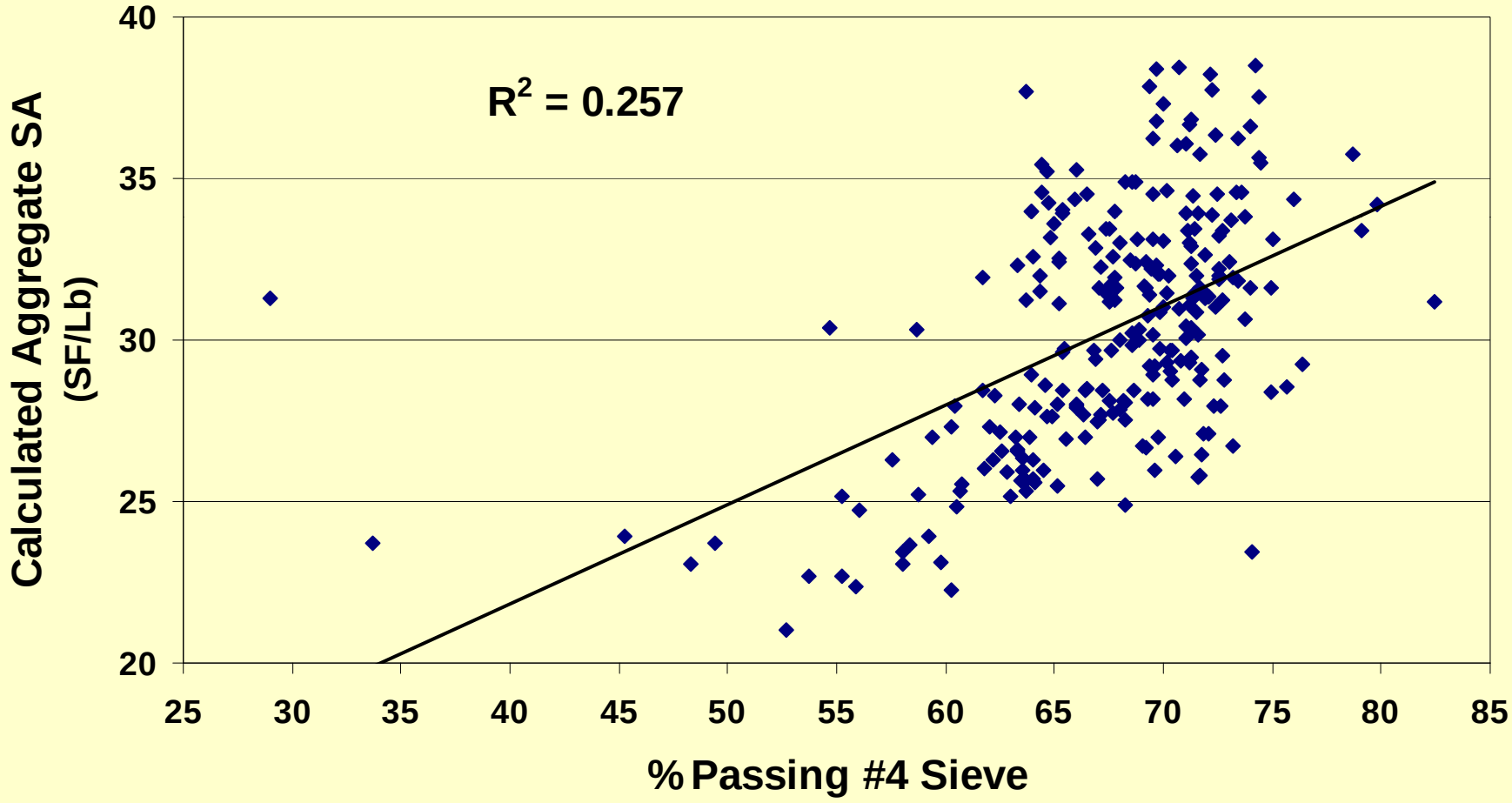
(2003 Project Data)



There is virtually no correlation between the percent passing the ¾” or ½” sieves and the Aggregate Surface Area (SA)

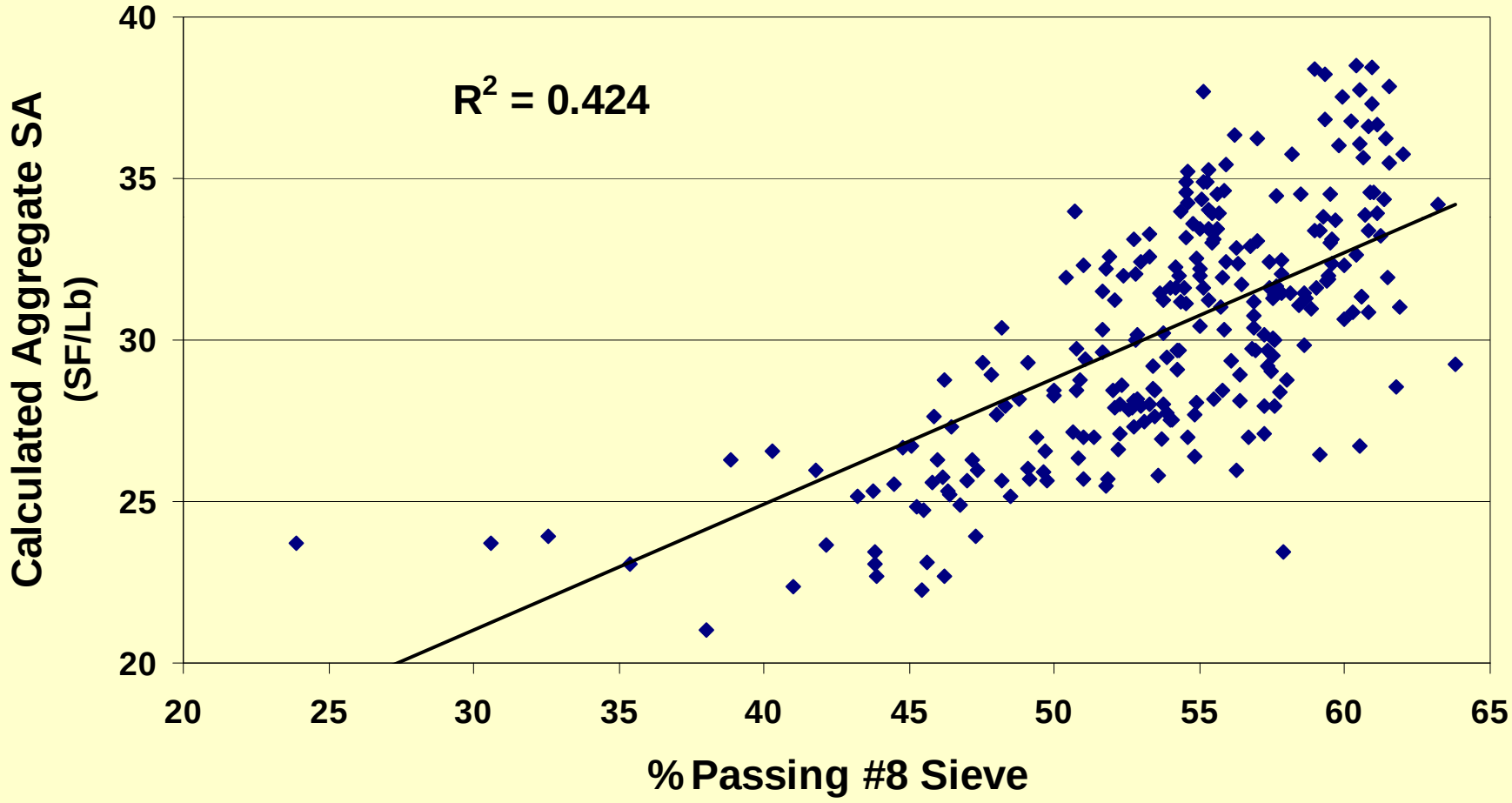
SA vs. % Passing #4 Sieve

(2004 Project Data)



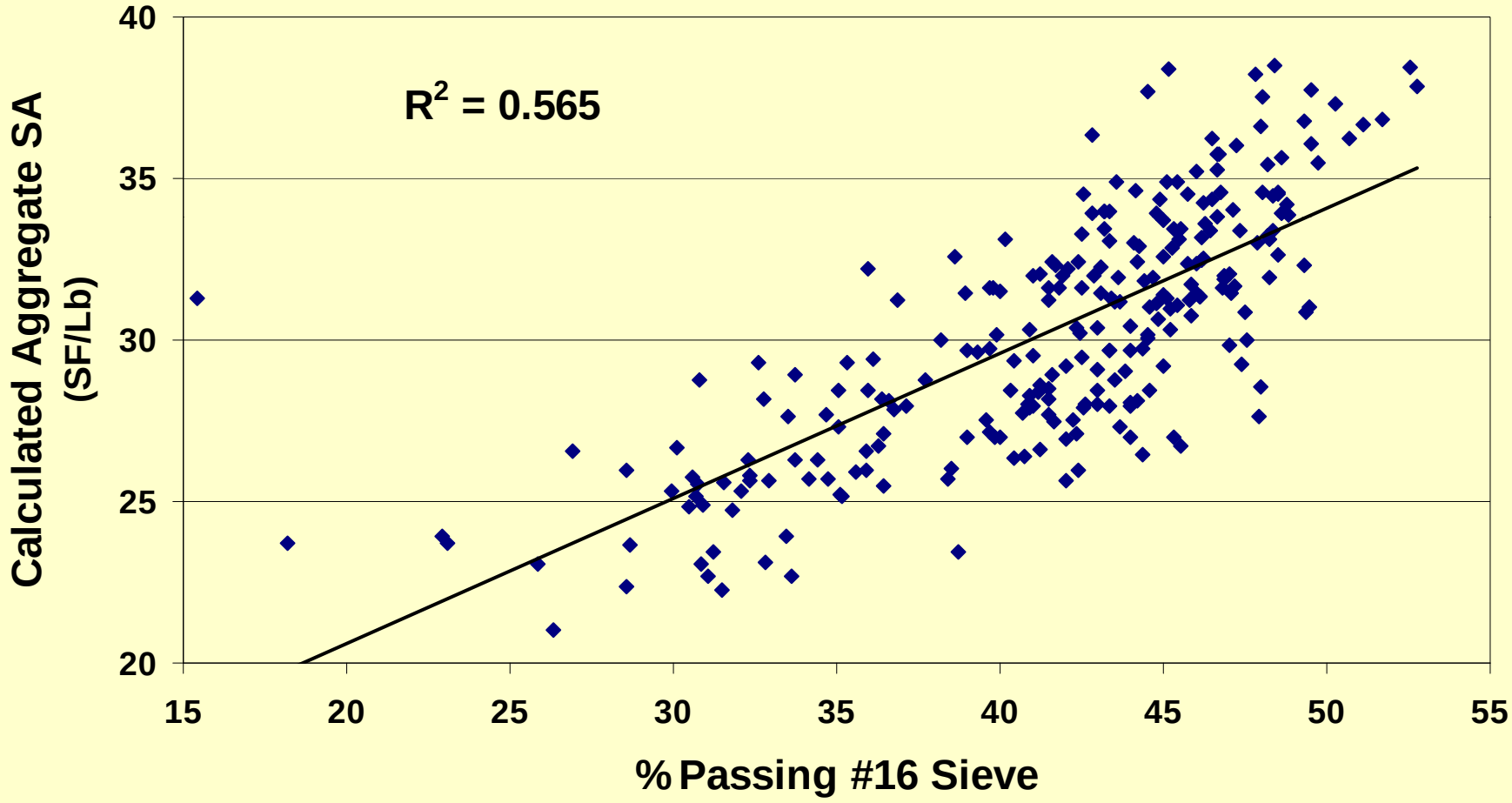
SA vs. % Passing #8 Sieve

(2004 Project Data)



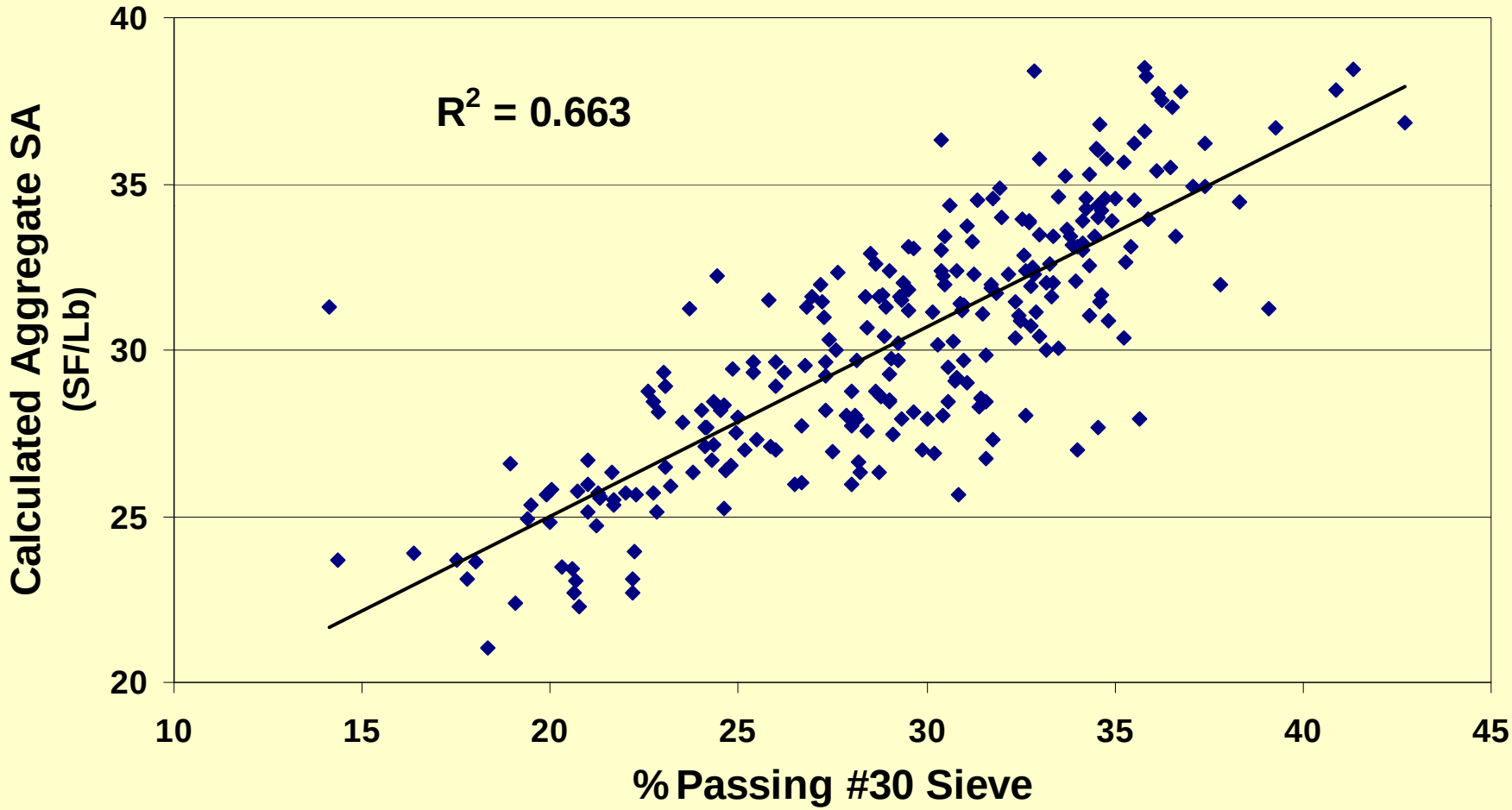
SA vs. % Passing #16 Sieve

(2004 Project Data)



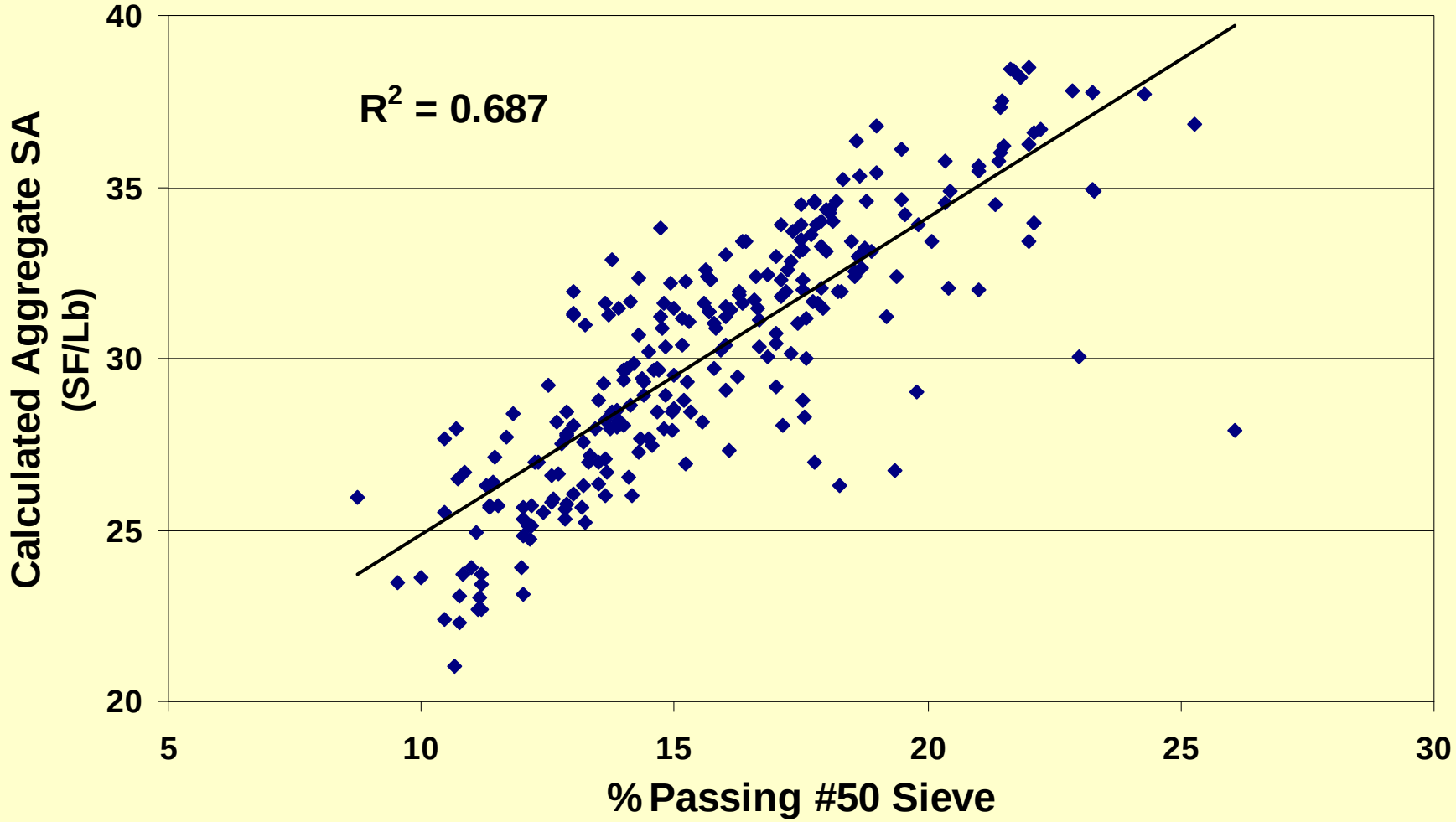
SA vs. % Passing #30 Sieve

(2004 Project Data)



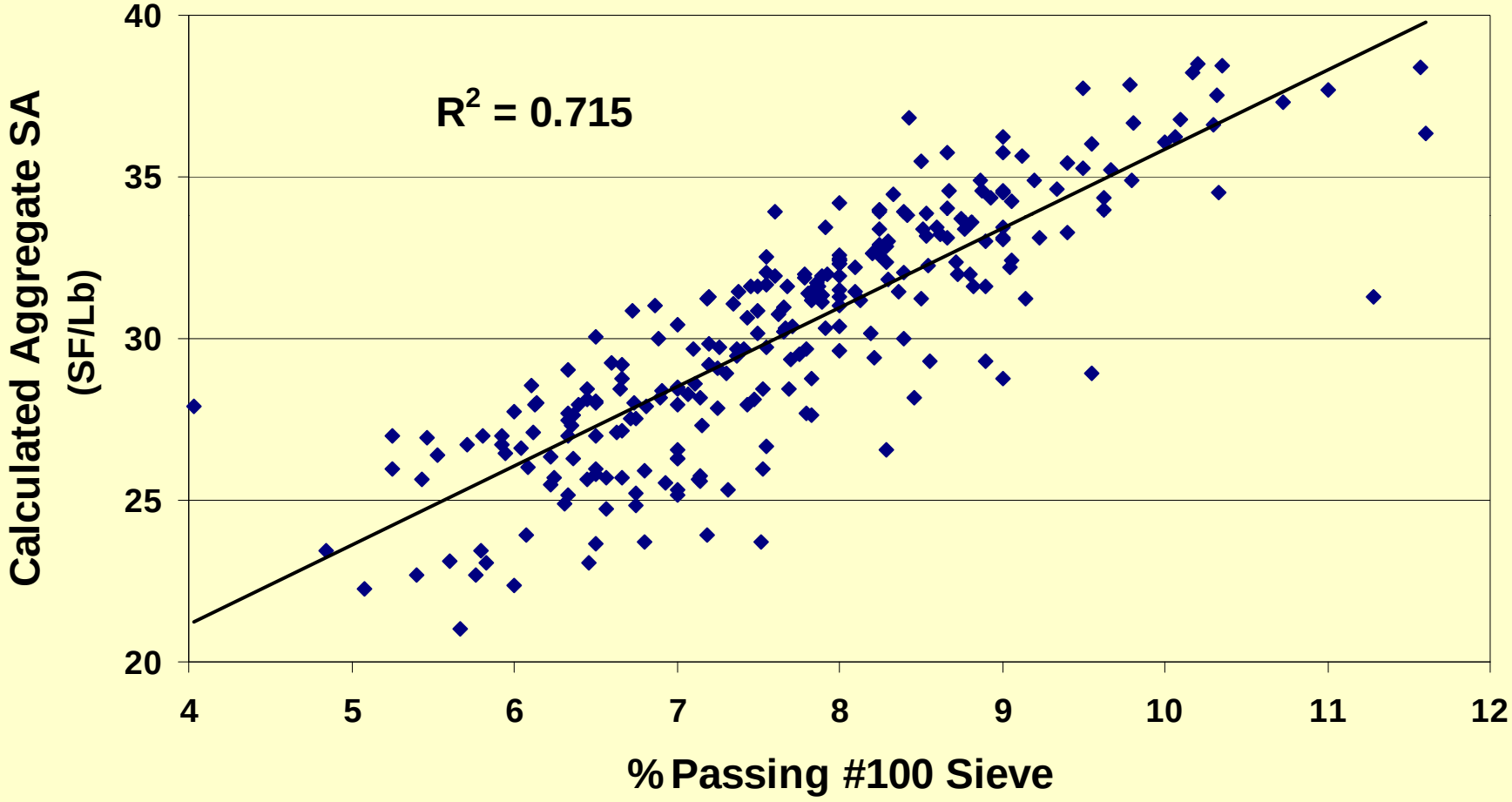
SA vs. % Passing #50 Sieve

(2004 Project Data)



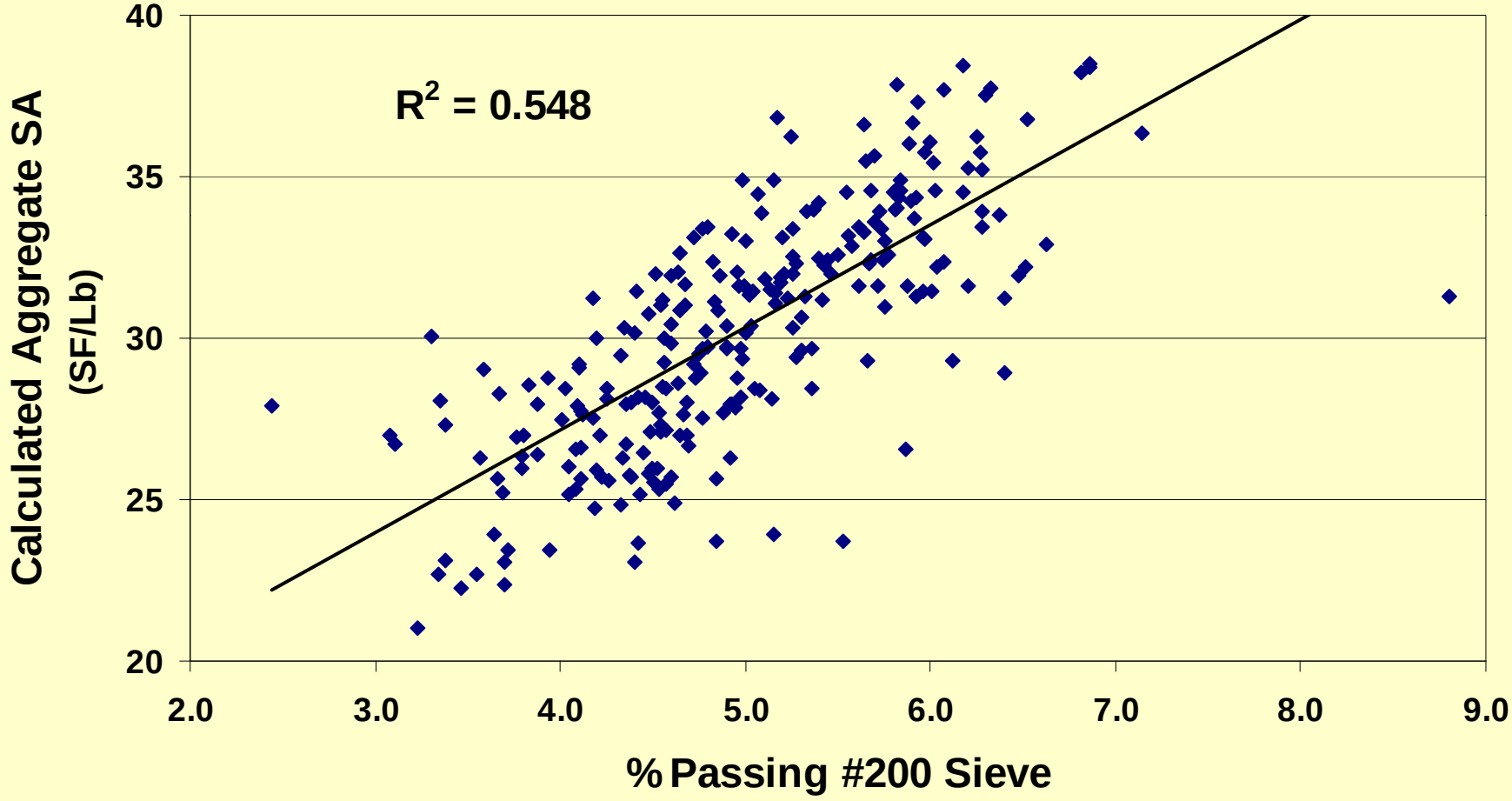
SA vs. % Passing #100 Sieve

(2004 Project Data)



SA vs. % Passing #200 Sieve

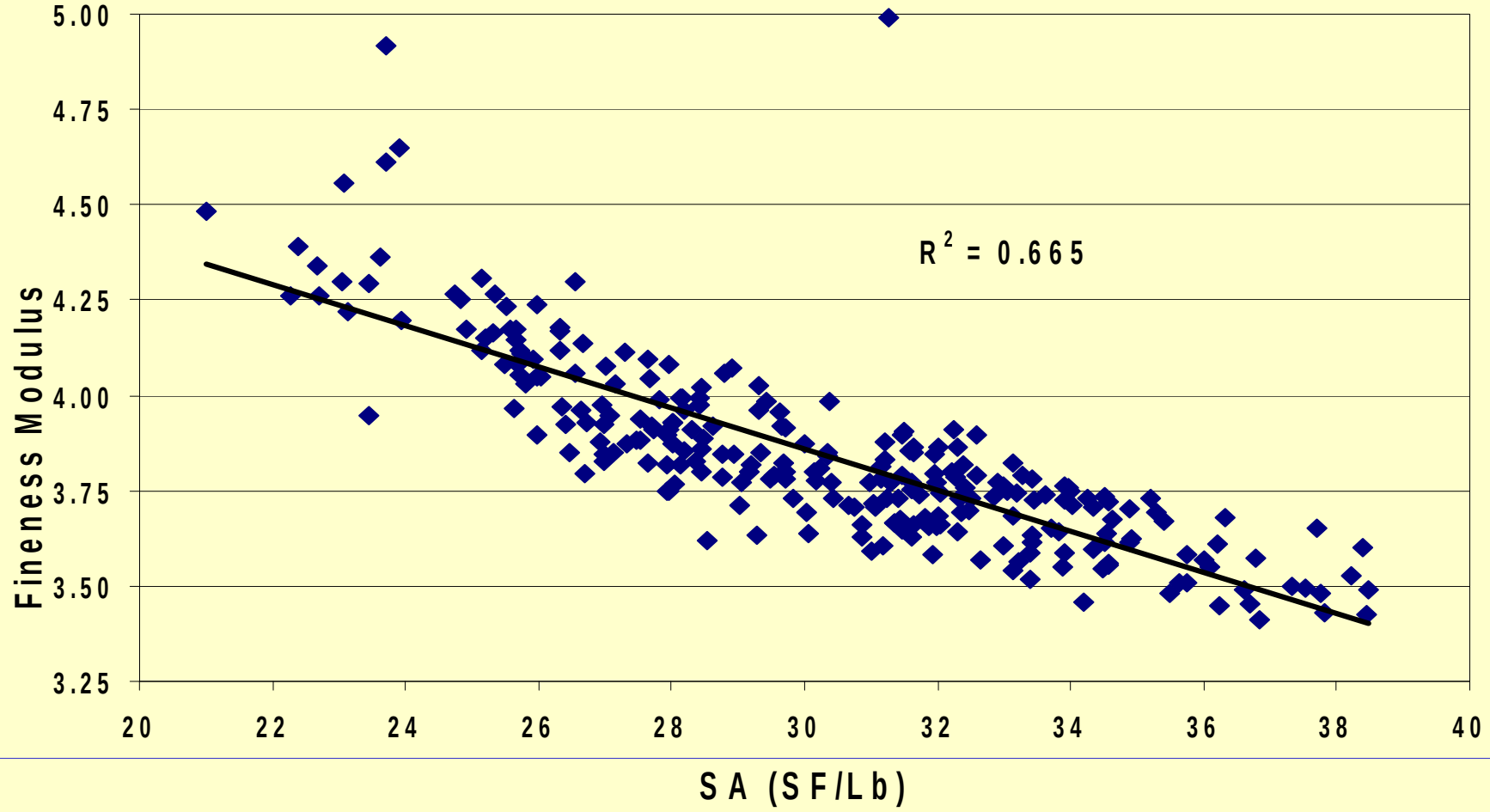
(2004 Project Data)



Another Option besides "SA"
that could have been used
to Represent
Aggregate Gradation
would have been
Fineness Modulus

FINENESS MODULUS Vs. SURFACE AREA

(2004 Project Data)



Consider:

AGGREGATE SURFACE AREA "INDEX"

Aggregate Surface Area in SF/Lb.

ASPHALT FILM THICKNESS "INDEX"

Asphalt Film Thickness in Microns

Asphalt Film Thickness (AFT)
is simply the:

Effective AC Volume (V_{be})

Divided by the

Aggregate Surface Area (SA)

ASPHALT FILM THICKNESS CALCULATION

$$AFT \text{ (in microns)} = \frac{P_{be} \times 4870}{100 \times P_s \times SA}$$

Where:

P_{be} = Effective Asphalt Content (% of Total Mixture Weight)

P_s = Percent Aggregate in Mixture/100
(ie. Decimal)

SA = Calculated Surface Area in SF/Lb.

$$SA = 2 + .02a + .04b + 0.08c + .14d + .30e + .60f + 1.60g$$

Where:

a,b,c,d,e,f and g are % of total aggregate passing the #4, #8, #16, #30, #50, #100 and #200 sieves, respectively

Examples of

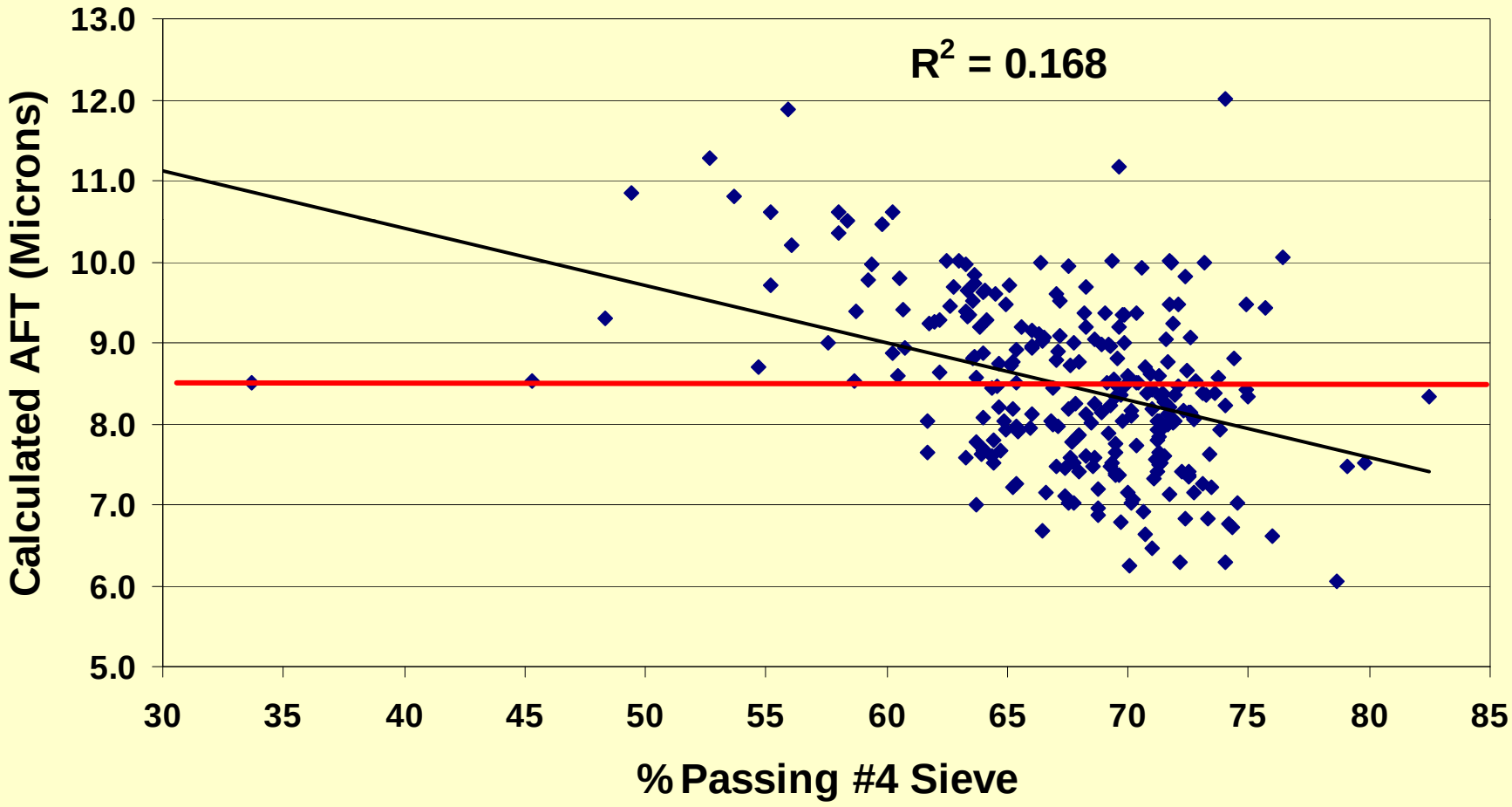
AFT

vs

% Passing Various Sieves

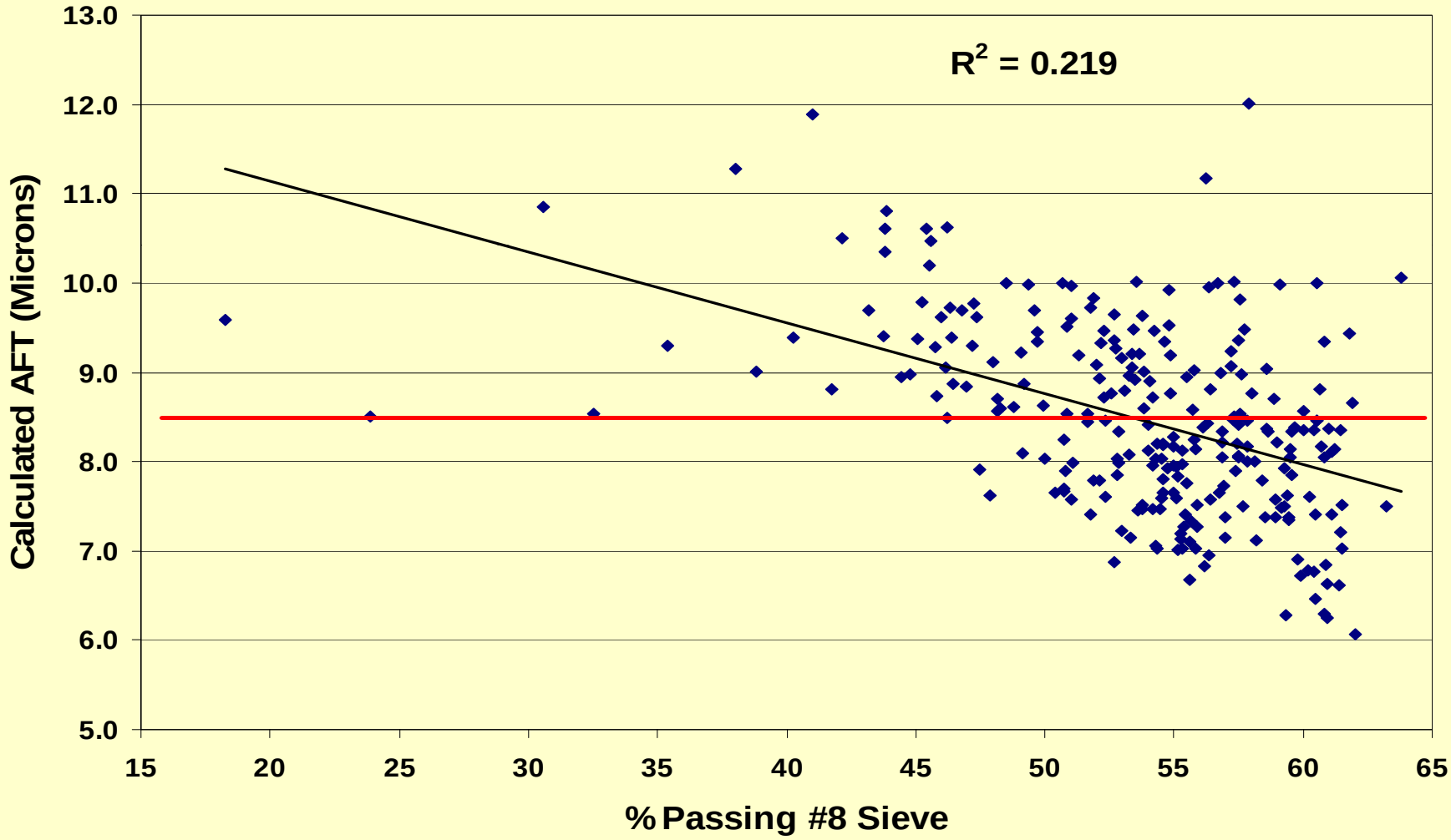
AFT vs. % Passing #4 Sieve

(2004 Projects)



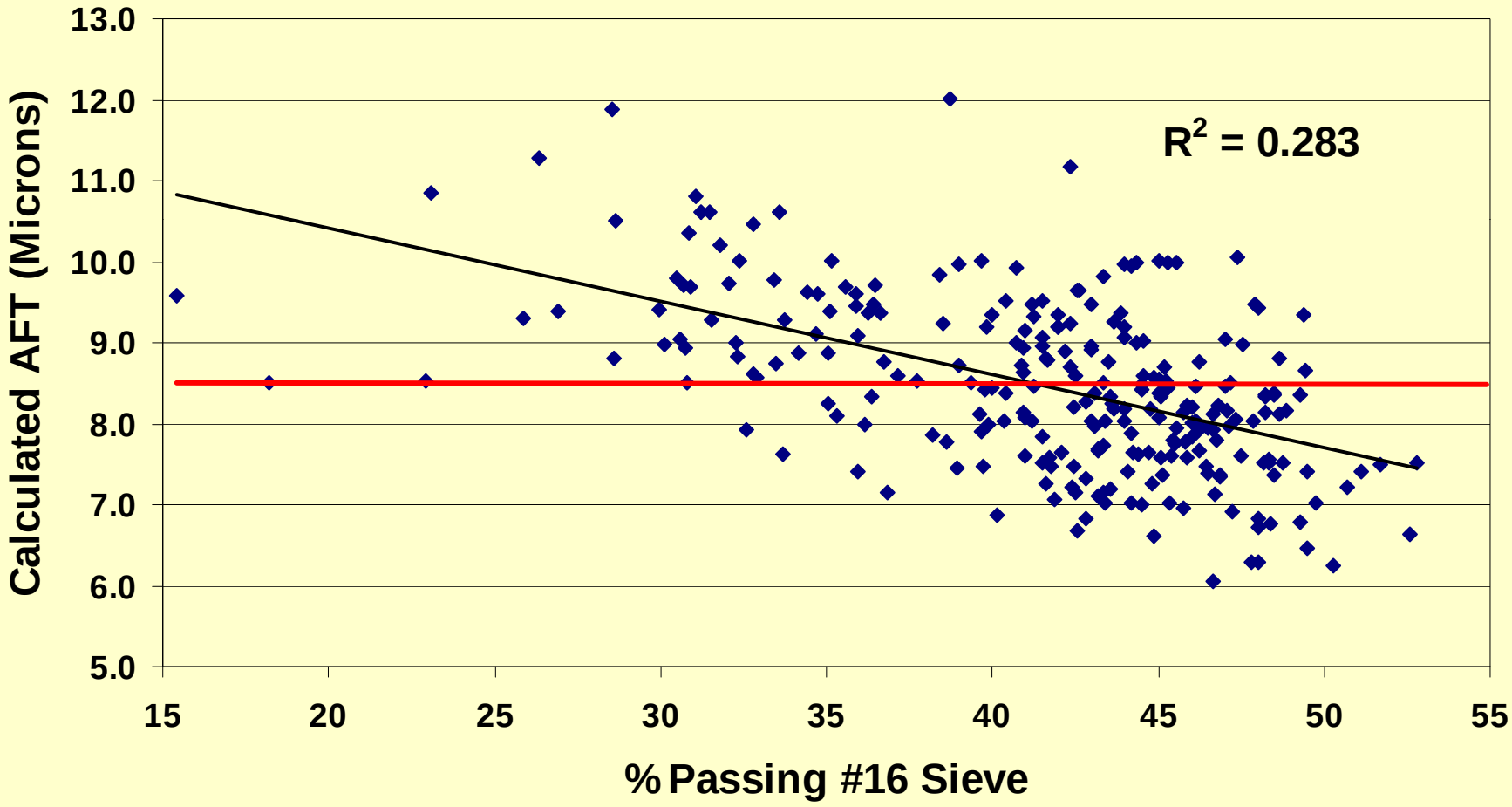
AFT vs. % Passing #8 Sieve

(2004 Projects)



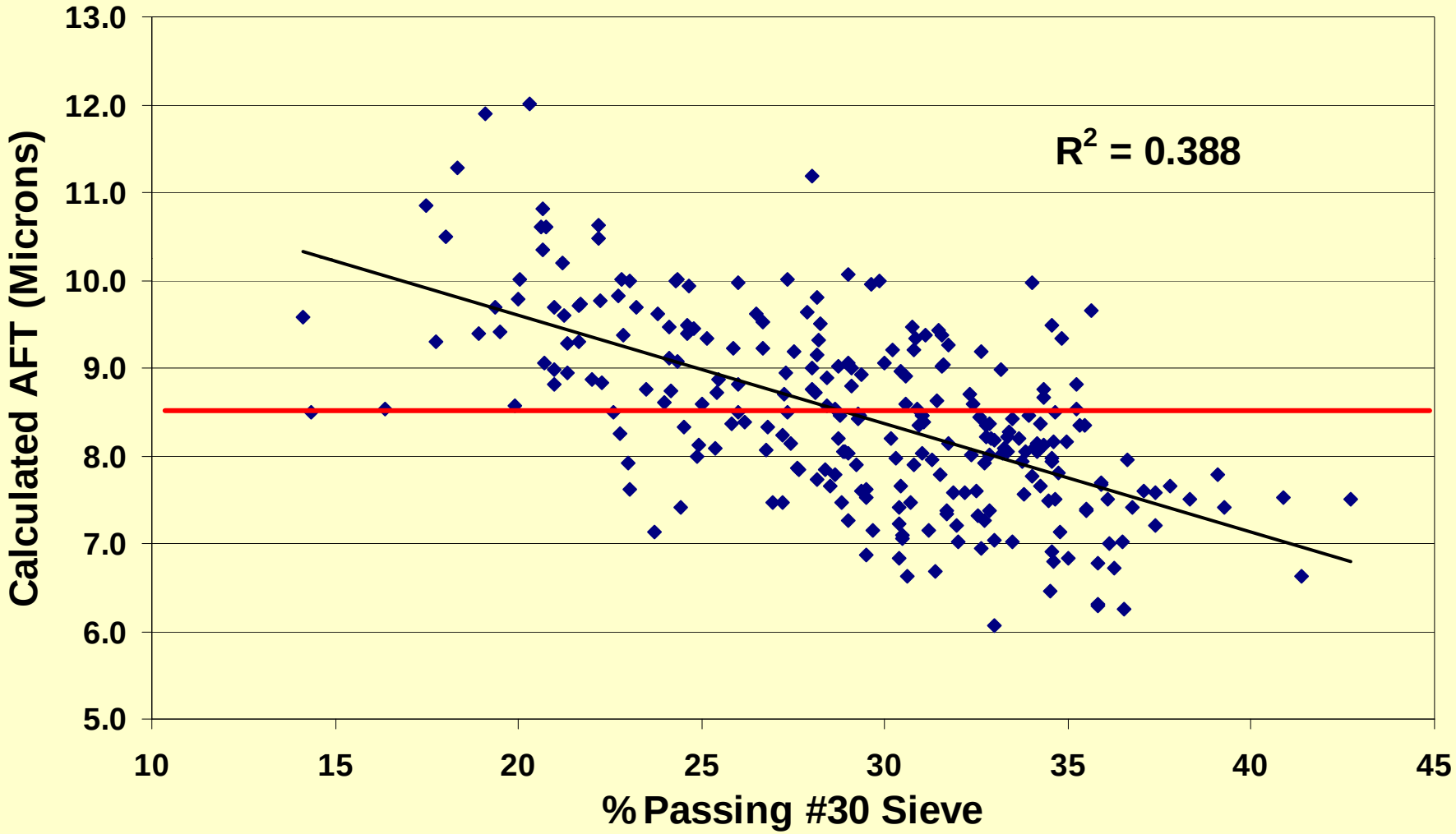
AFT vs. % Passing #16 Sieve

(2004 Projects)



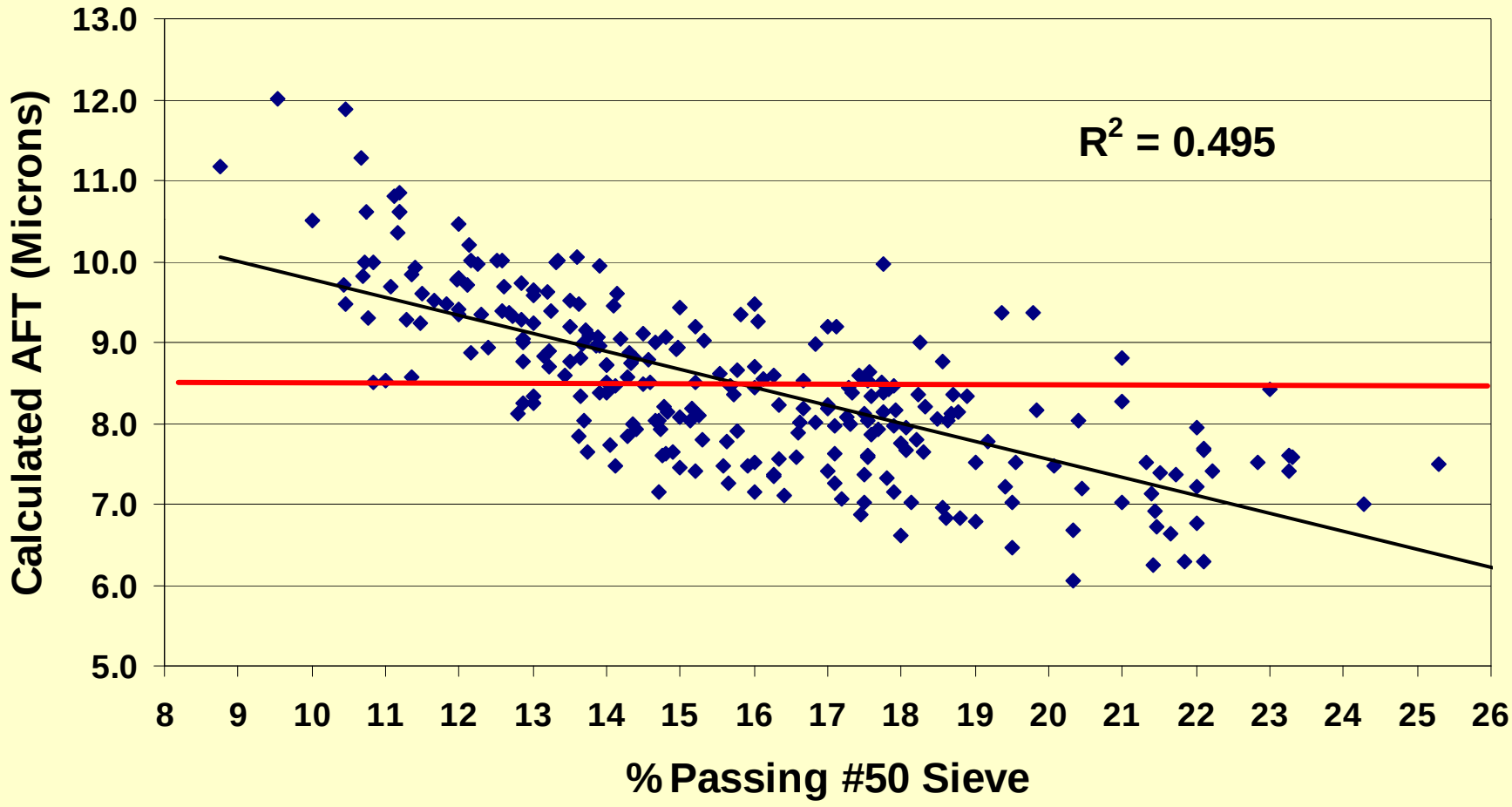
AFT vs. % Passing #30 Sieve

(2004 Projects)



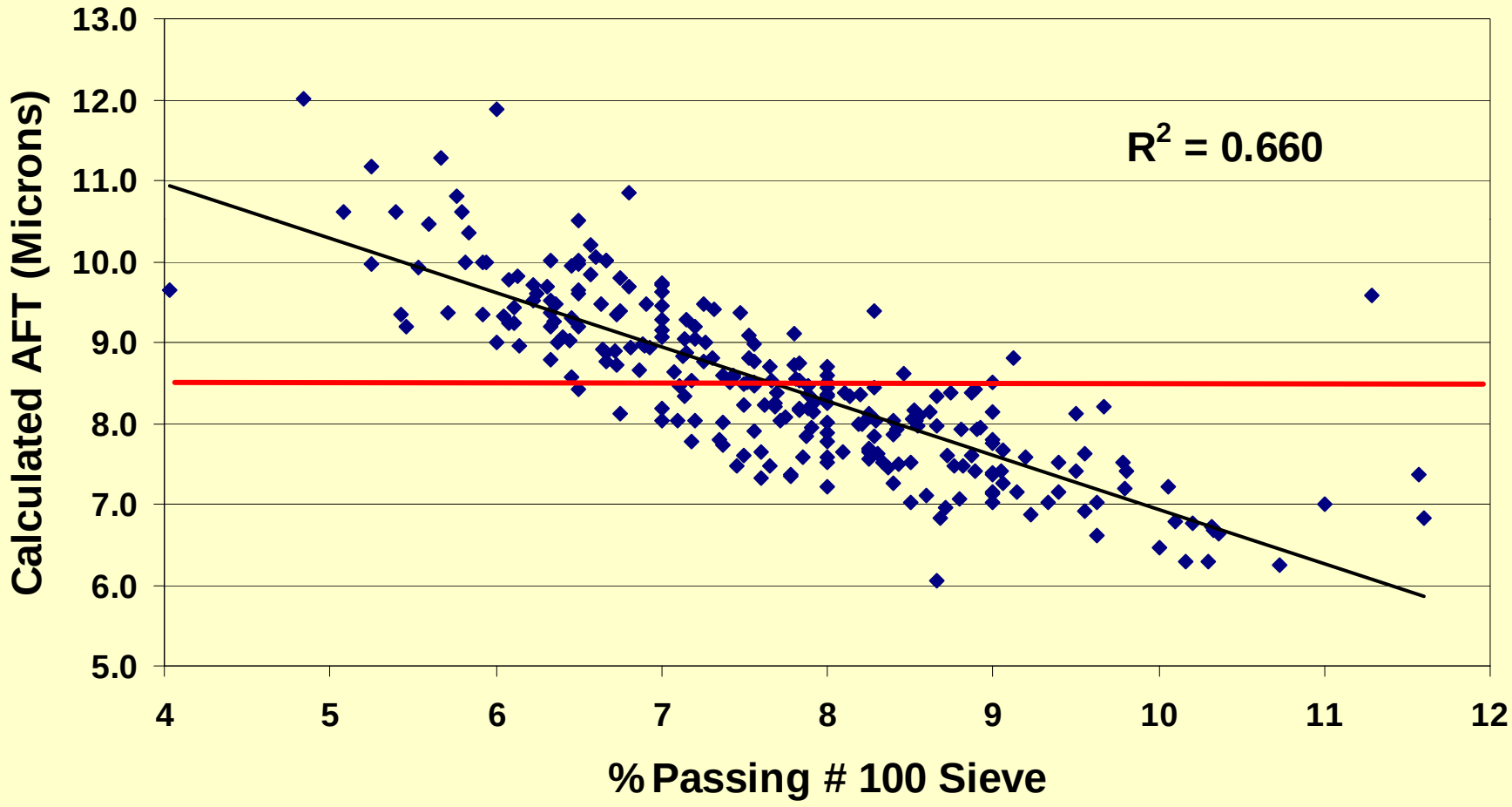
AFT vs. % Passing #50 Sieve

(2004 Projects)



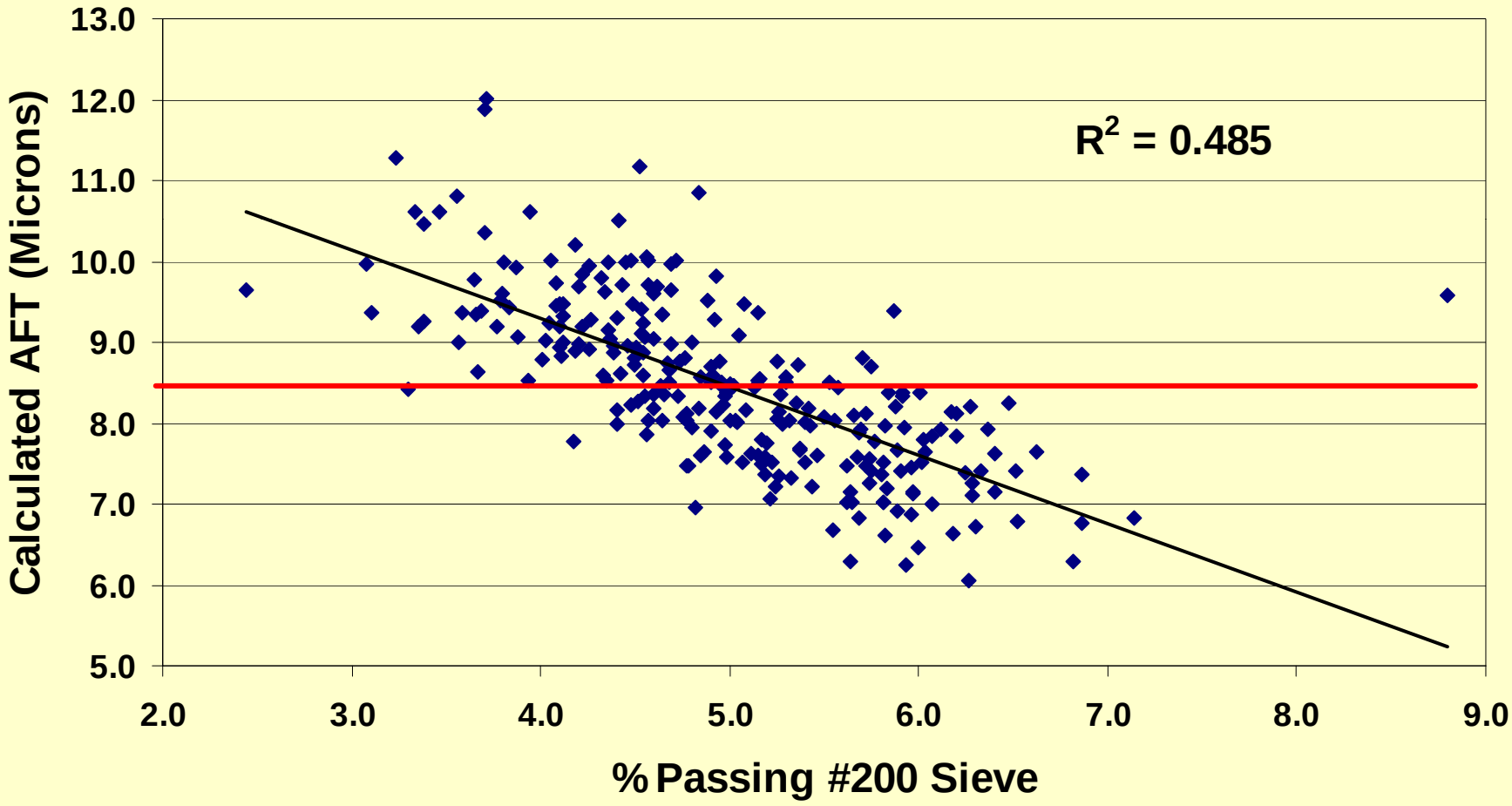
AFT vs. % Passing #100 Sieve

(2004 Projects)



AFT vs. % Passing #200 Sieve

(2004 Projects)



Some Methods to Increase AFT:

- Reduce the % passing the #30, #50, #100 and/or #200 sieves
- Increase the amount of crushed material
- Waste the baghouse fines
- Completely redesign the mixture

The Primary Difference

between

Asphalt Pavement Mixture

and

Aggregate Base

is

ASPHALT CEMENT

REDUCED PAY FACTORS
FOR
MIXTURE PRODUCTION FAILURES

Item	Pay Factors	
	Individual	Moving Average
Gradation	95%	75%
Coarse and Fine Aggrega Crushing	90%	NA
VMA	85%	75%
Asphalt Binder Content	85%	75%
Production Air Voids (Isolated and Individual)	70%	50%
Asphalt Film Thickness	No Current Requirement	

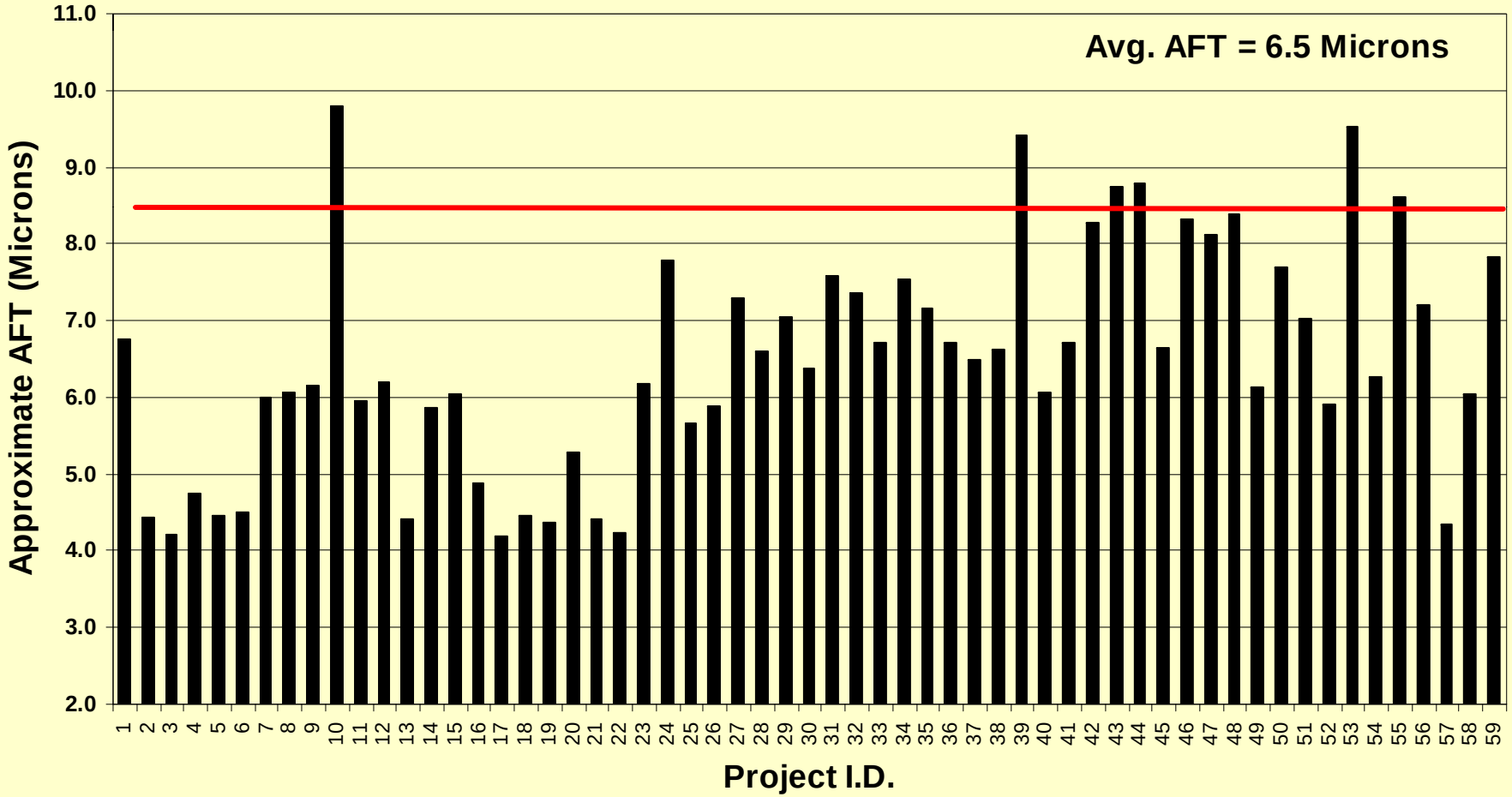
Approximate AFT's of some 1960', 70's and 80's Projects

(Based on Mn/DOT Test Results)

APPROXIMATE AFT

1963 Thru 1965 Projects

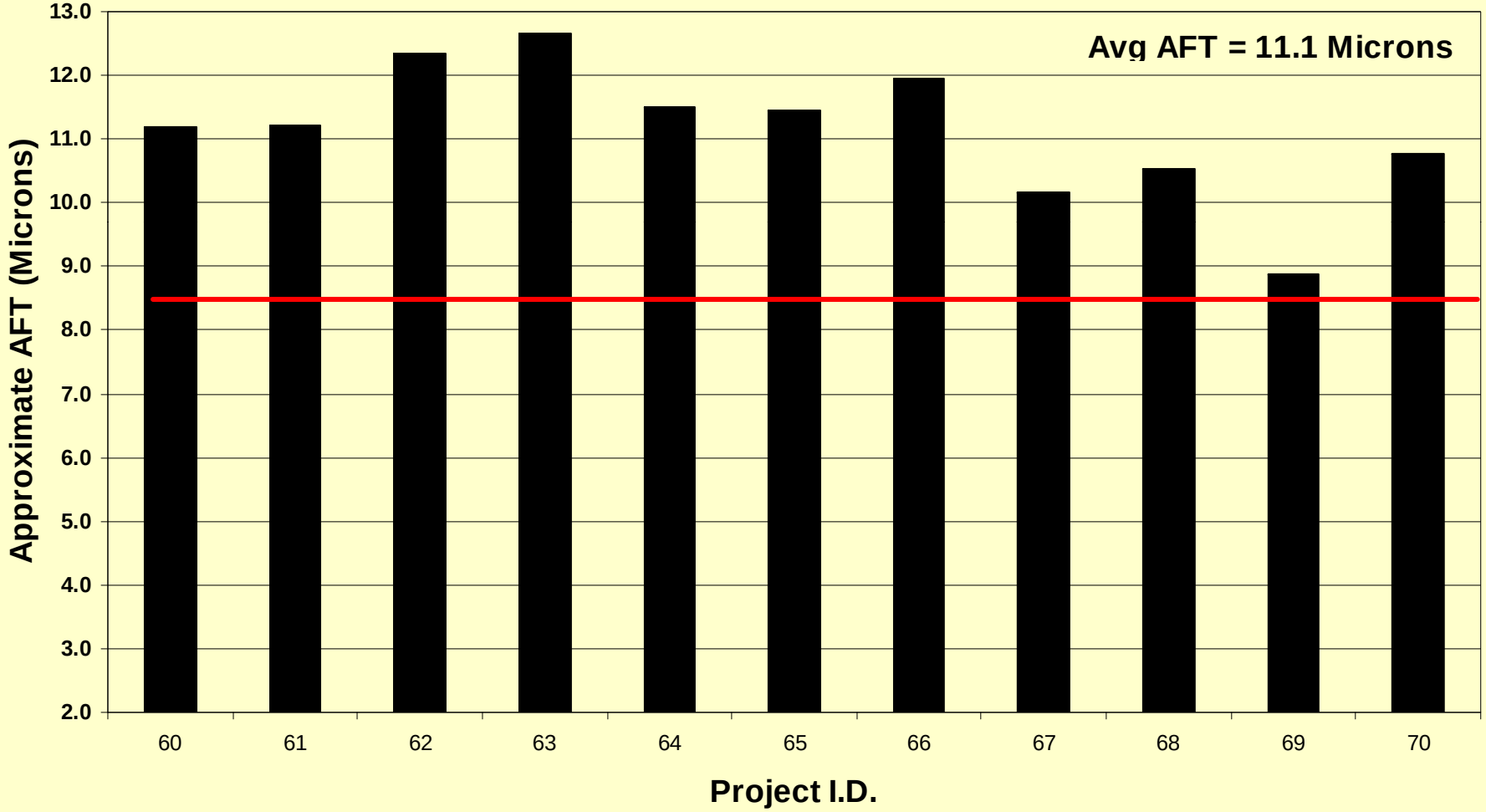
2331 & 2341 Non Wear



APPROXIMATE AFT

1963 Thru 1965 Projects

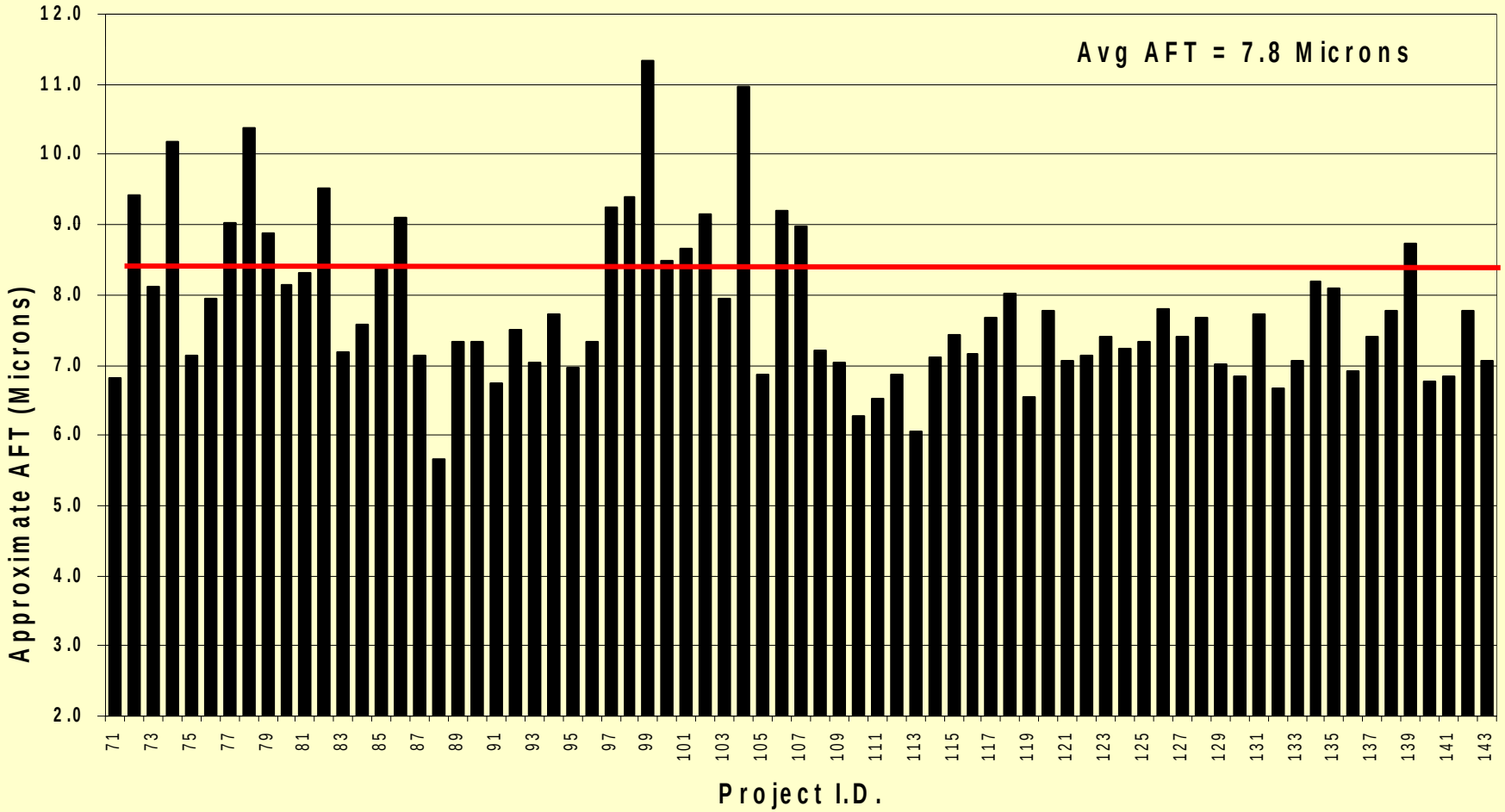
2351 Binder



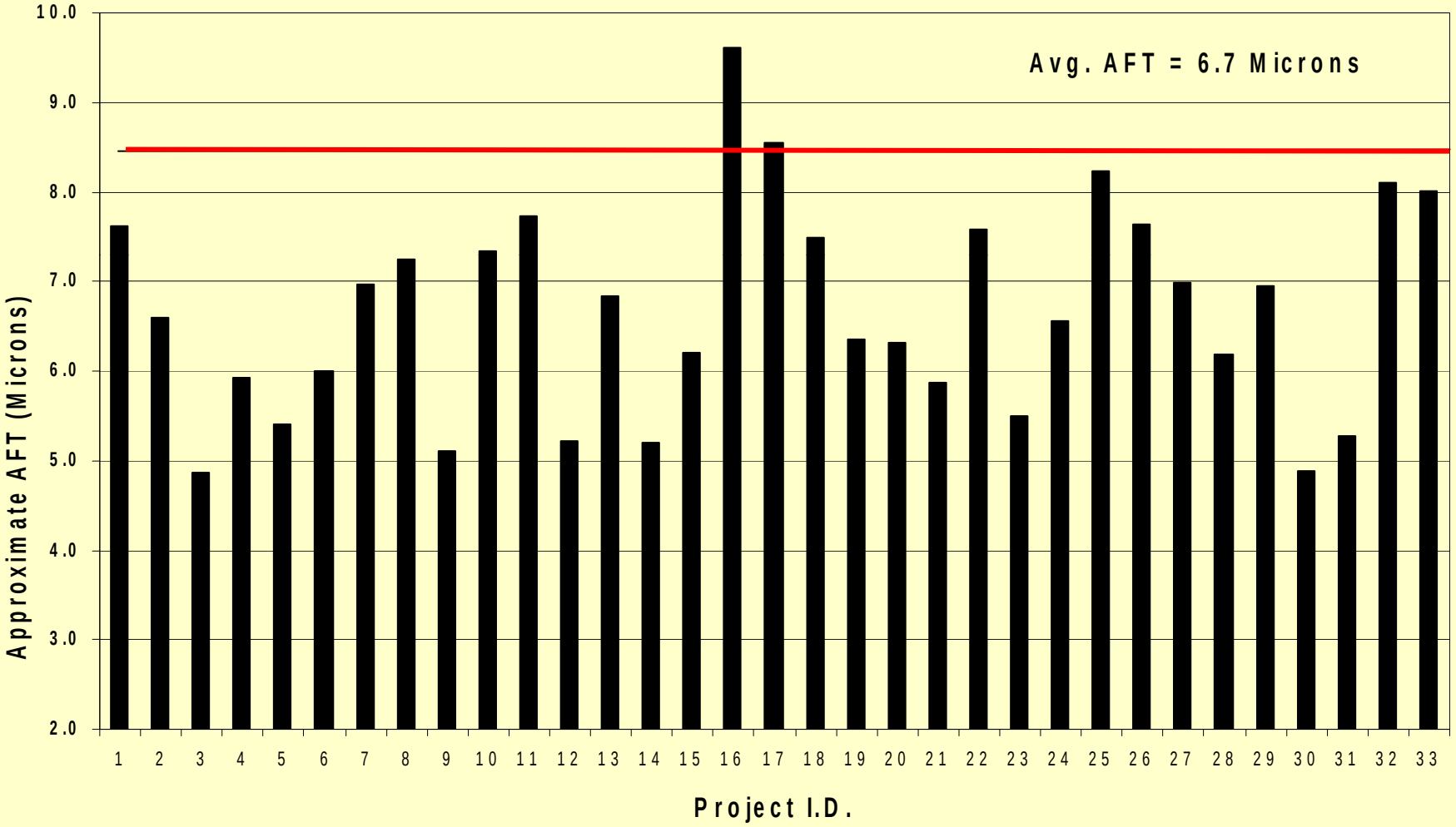
APPROXIMATE AFT

1963 Thru 1965 Projects

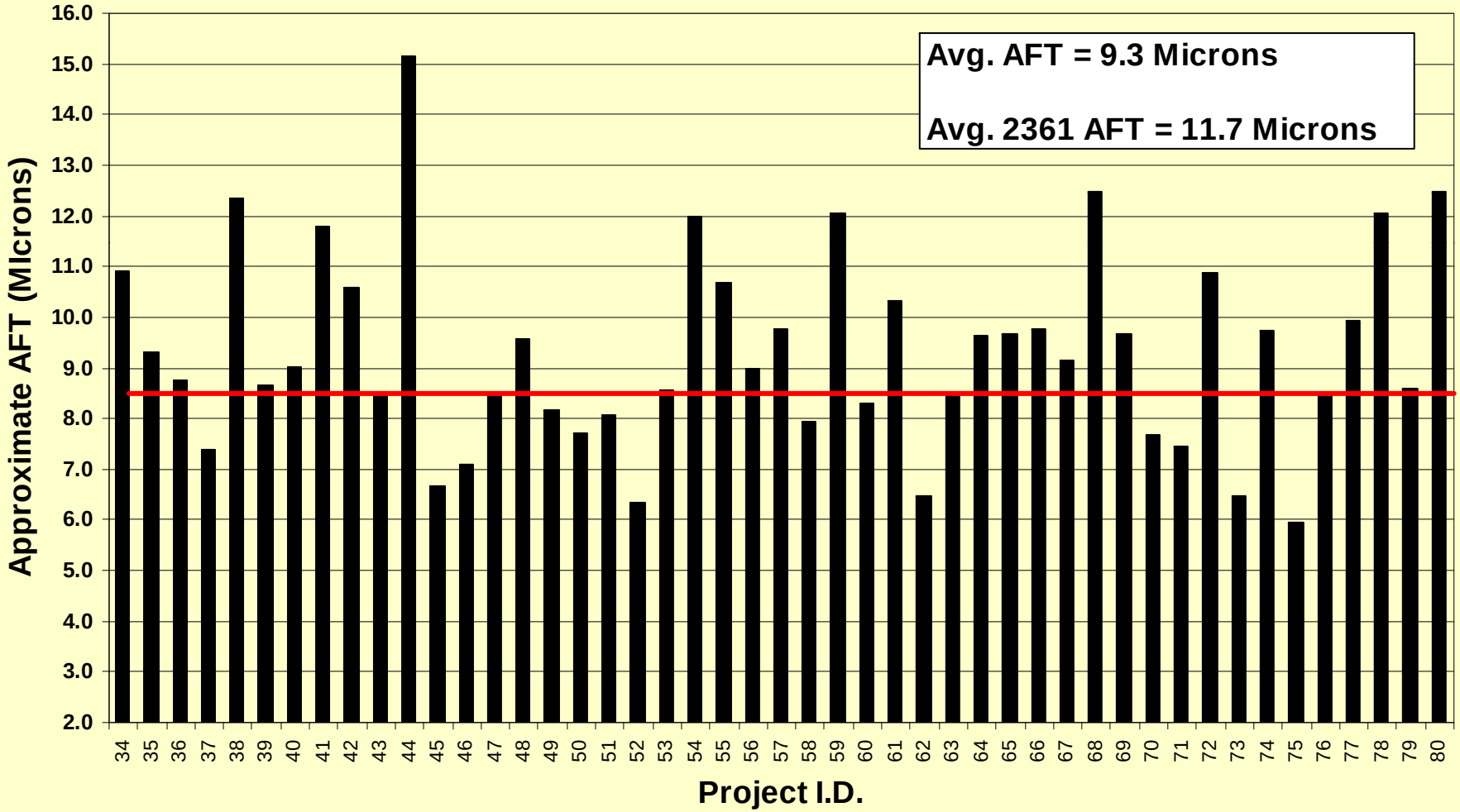
Wear Mixtures



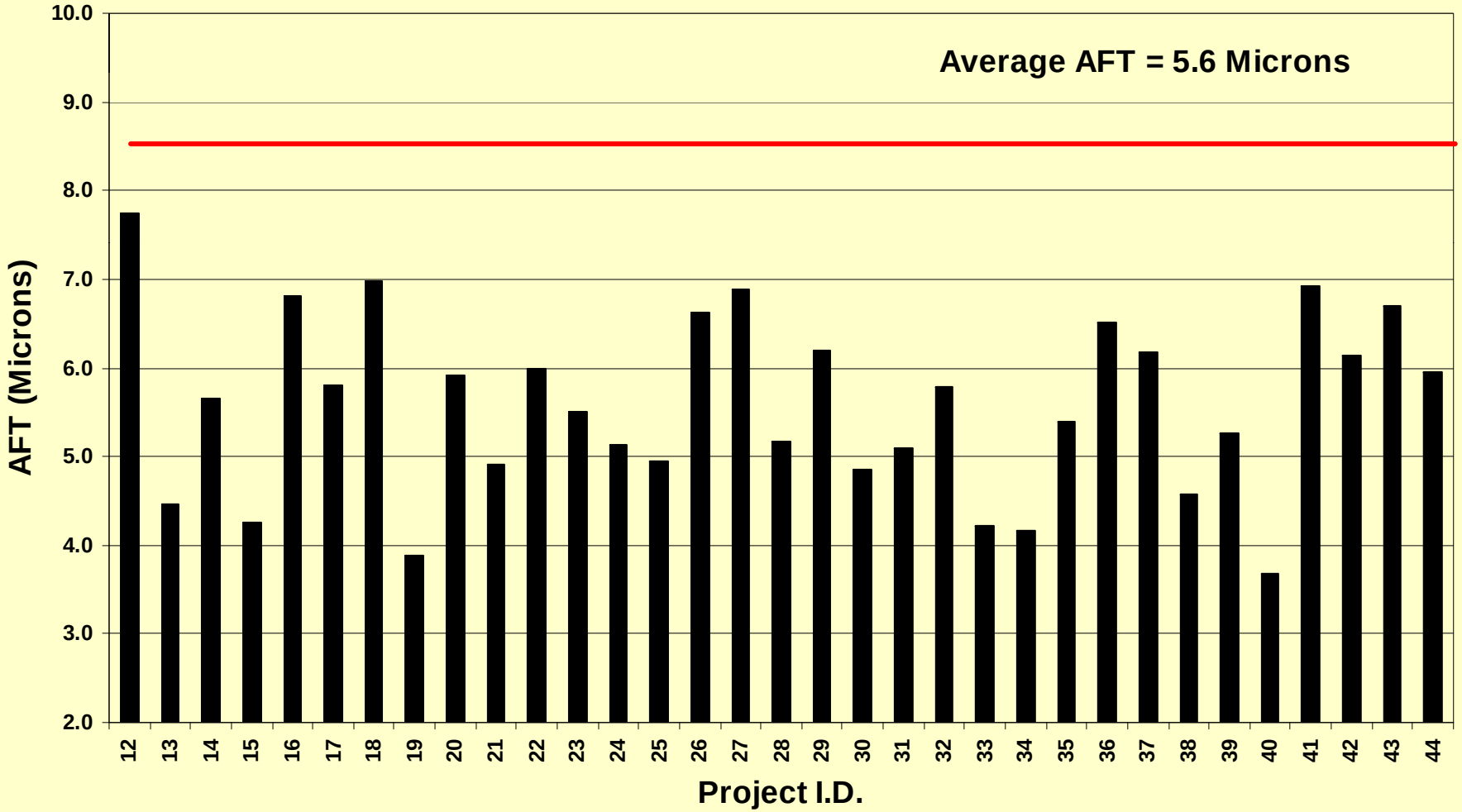
1978 TRIAL MIX AFT
(2331 Non Wear)



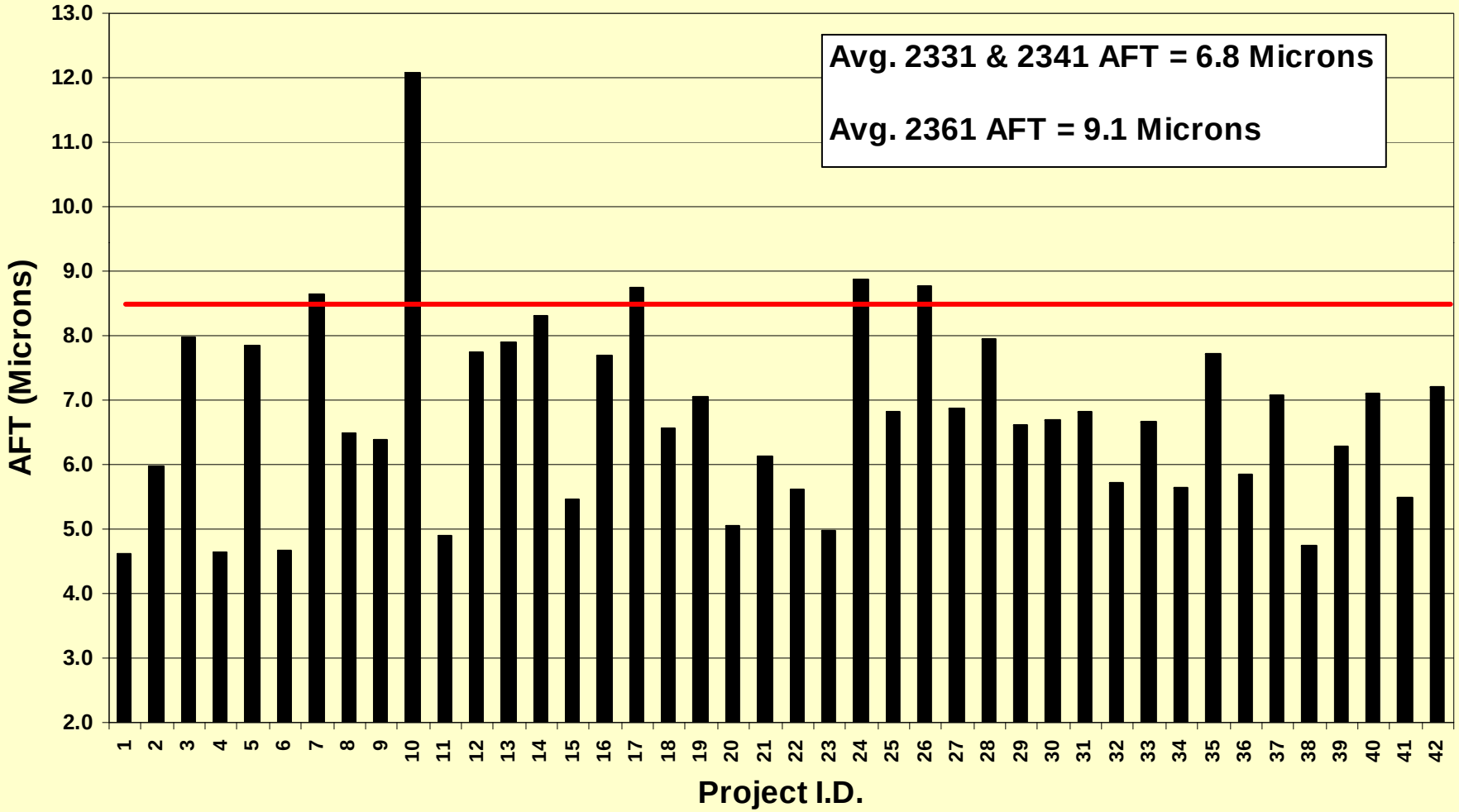
1978 TRIAL MIX AFT
(2331 & 2341 Wear)



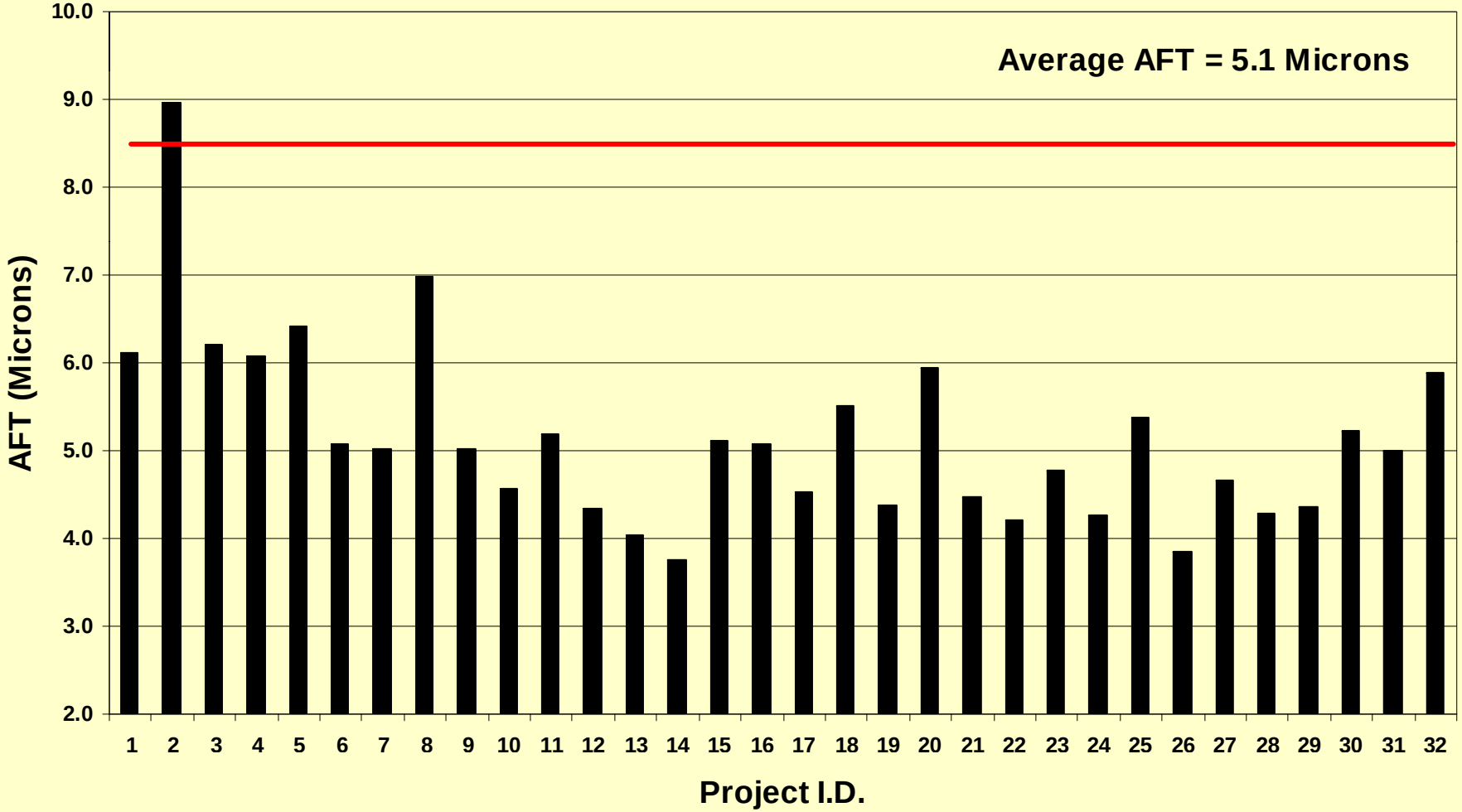
1980 PROJECT AFT
(Non Wear Mixtures)



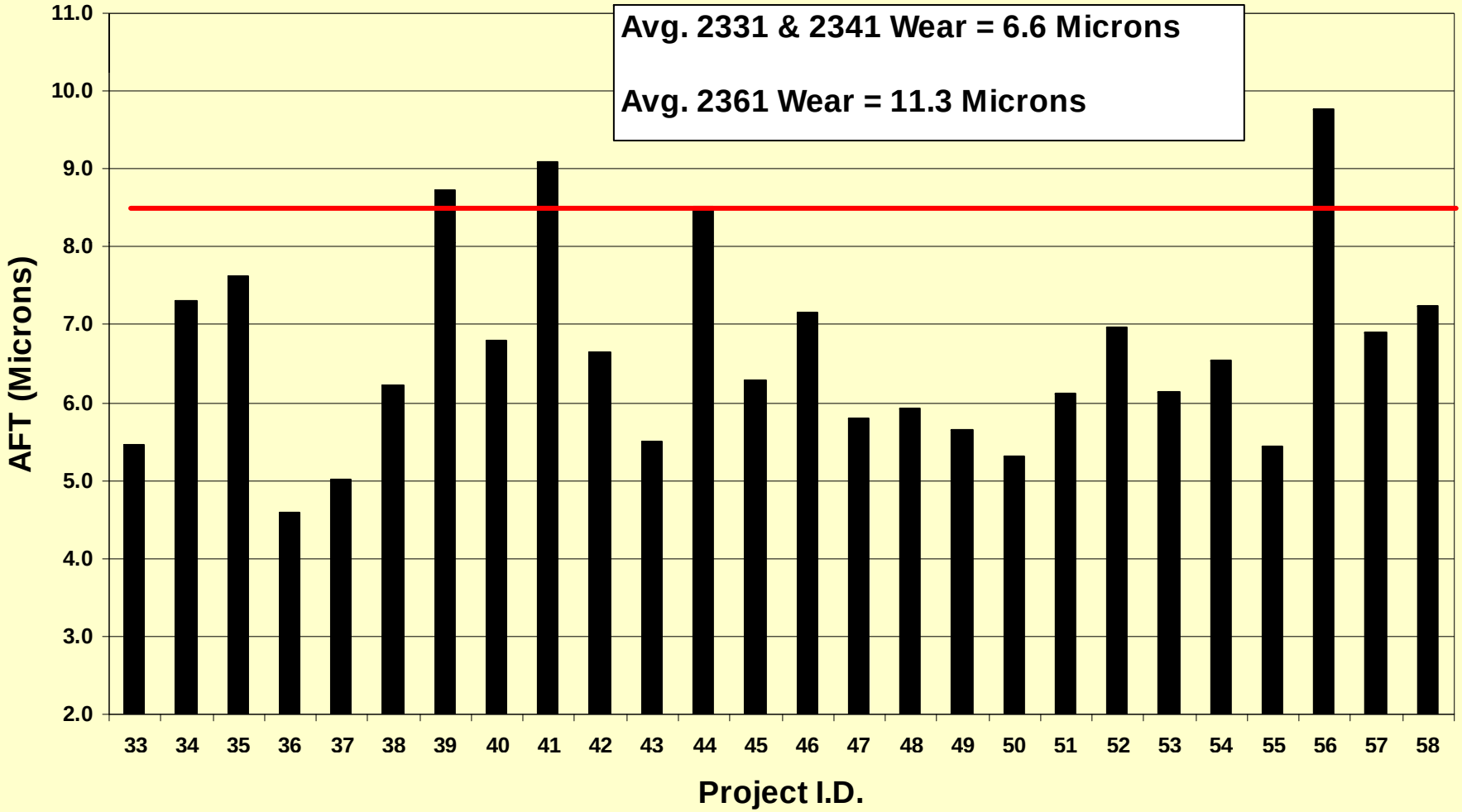
1980 PROJECT AFT
(2331 & 2341 Wear Mixtures)



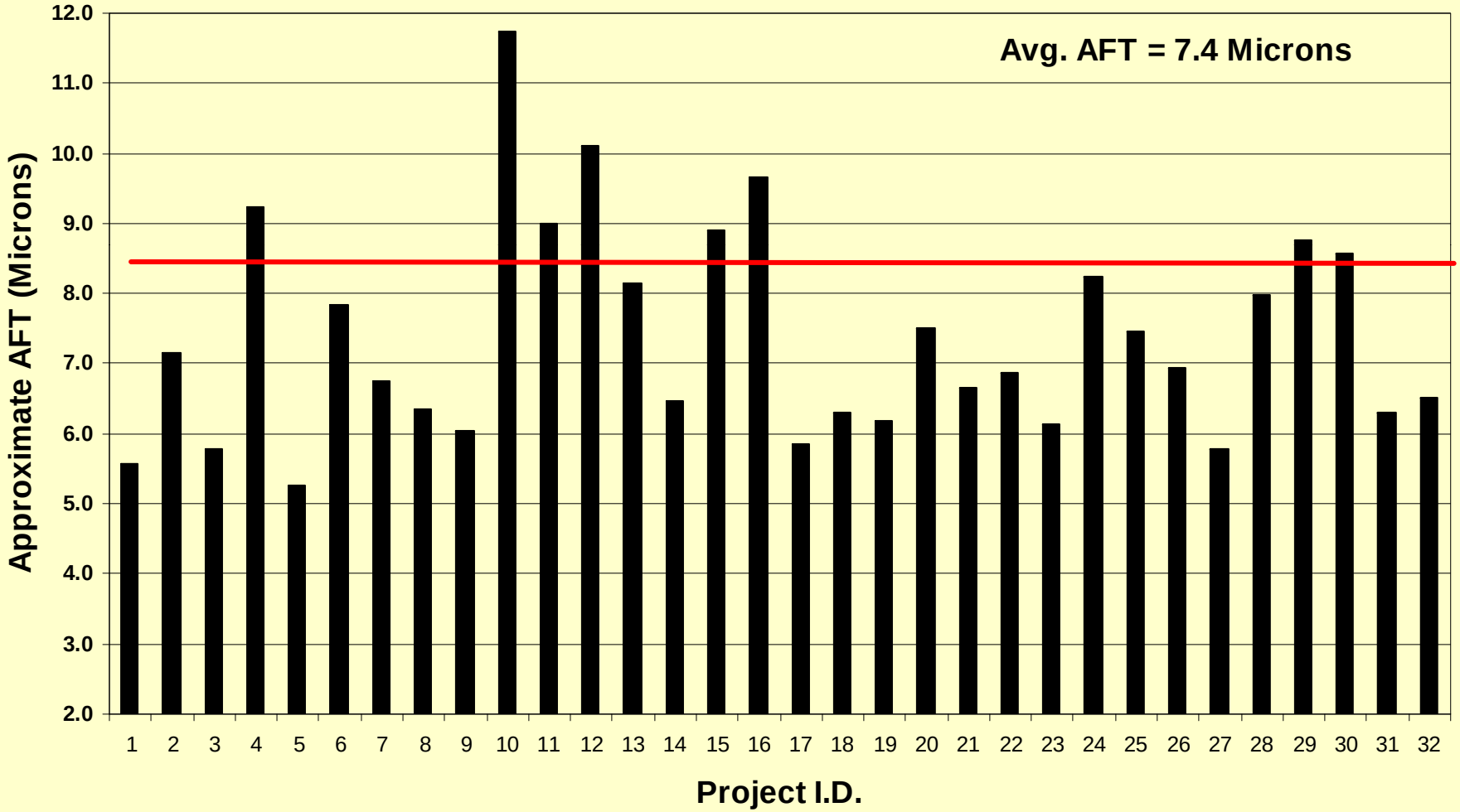
1982 PROJECT AFT
(Non Wear Mixtures)



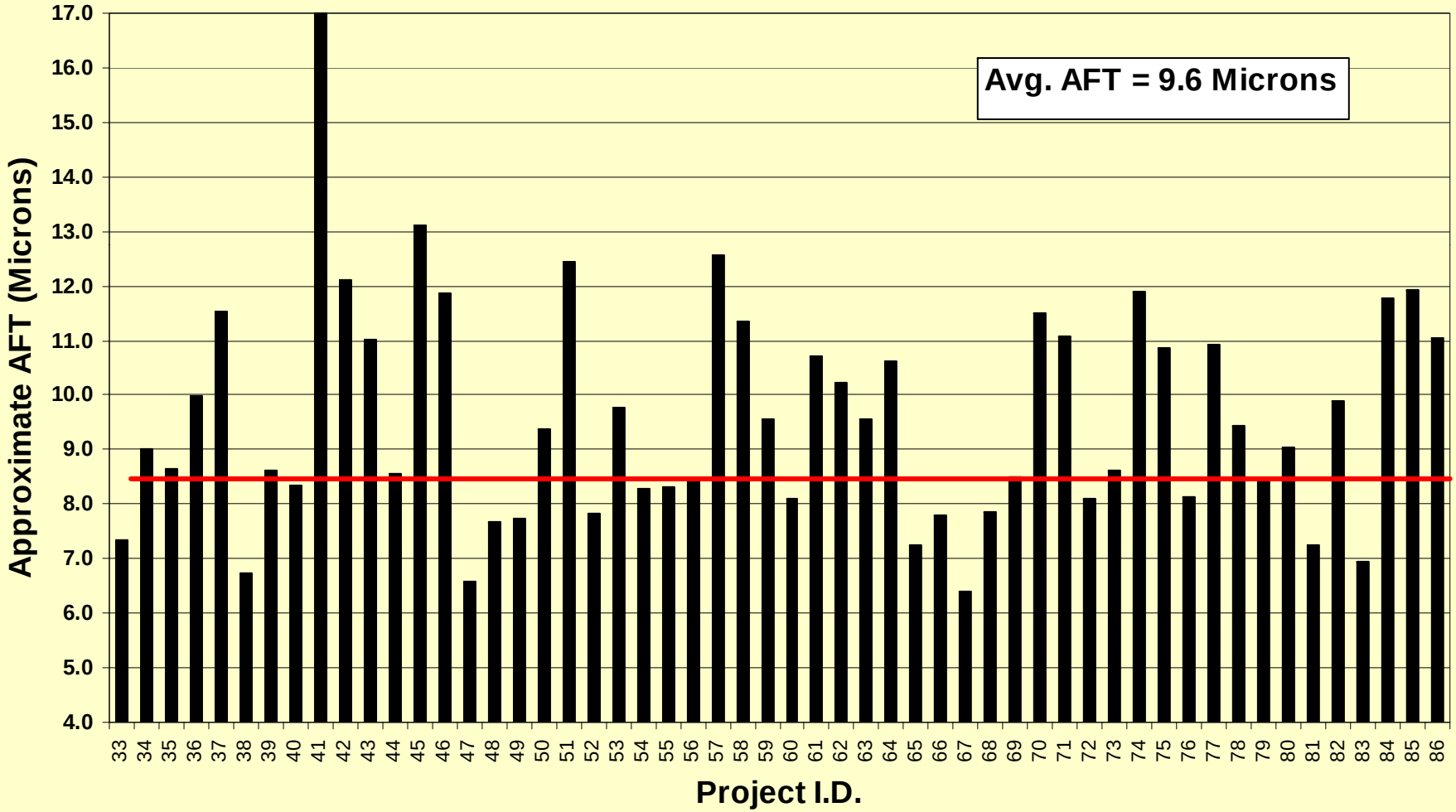
1982 PROJECT AFT
(2331 & 2341 Wear)



1984 TRIAL MIX AFT
(2331 Non Wear)

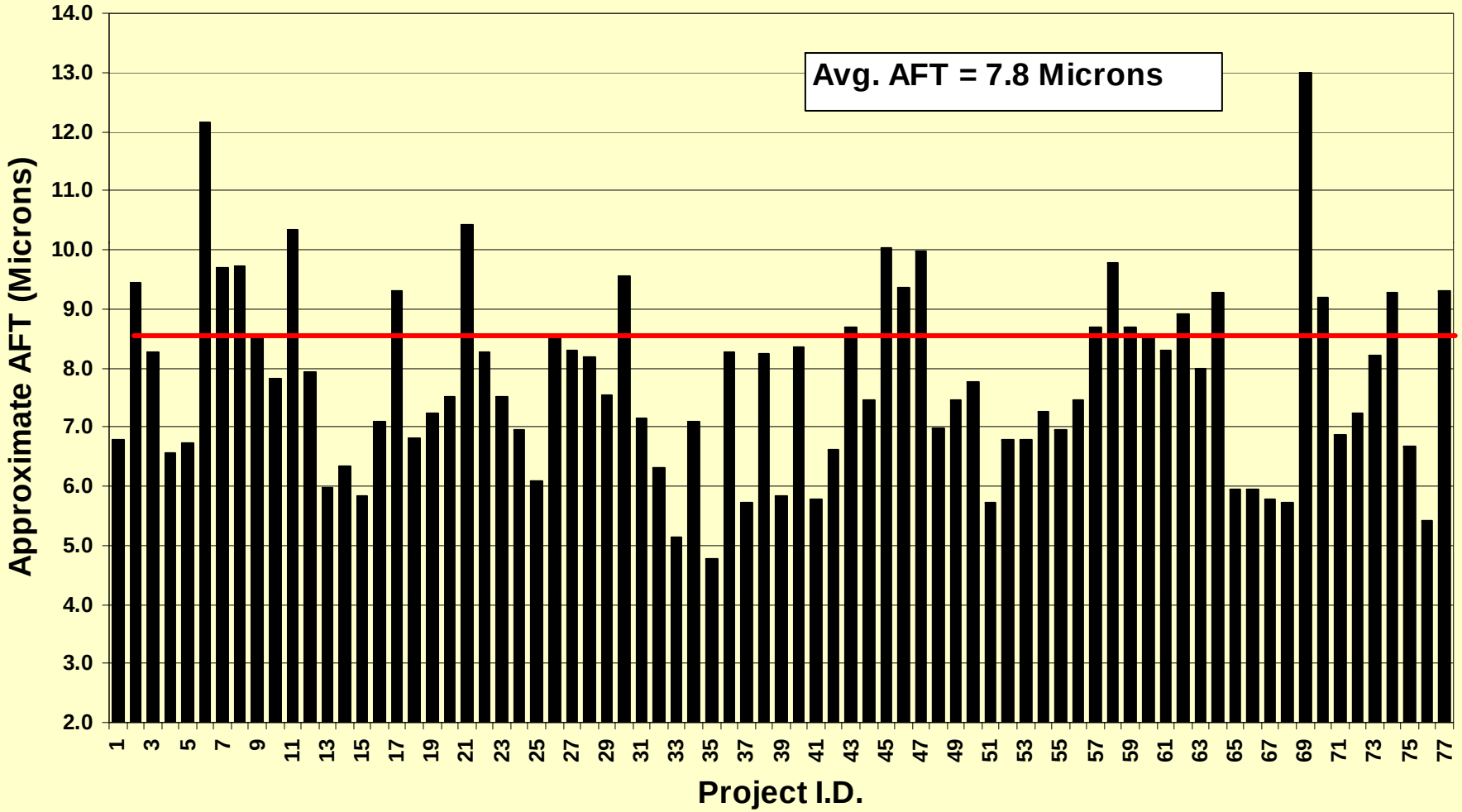


1984 TRIAL MIX AFT
(2331 & 2341 Wear)

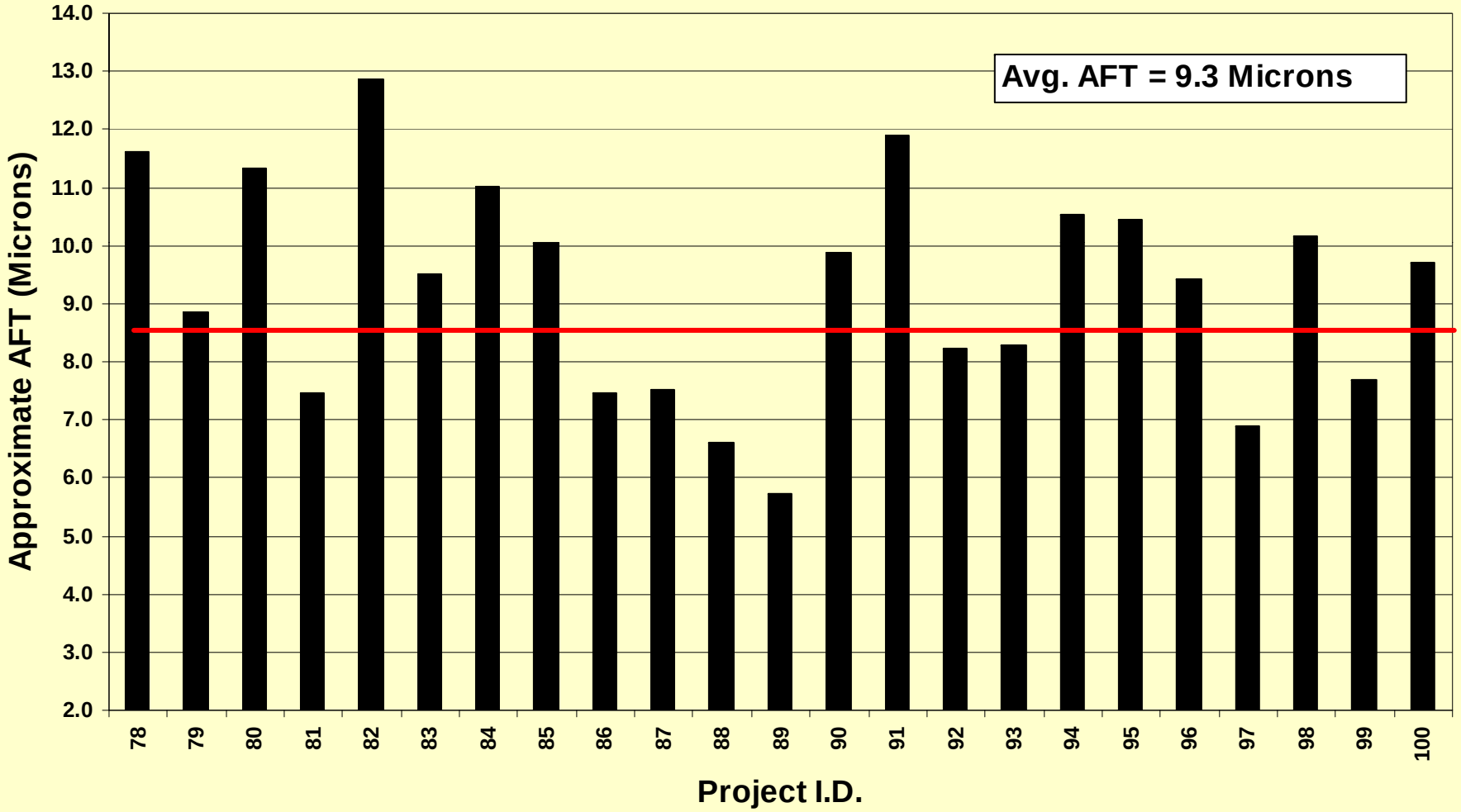


1986 TRIAL MIX AFT

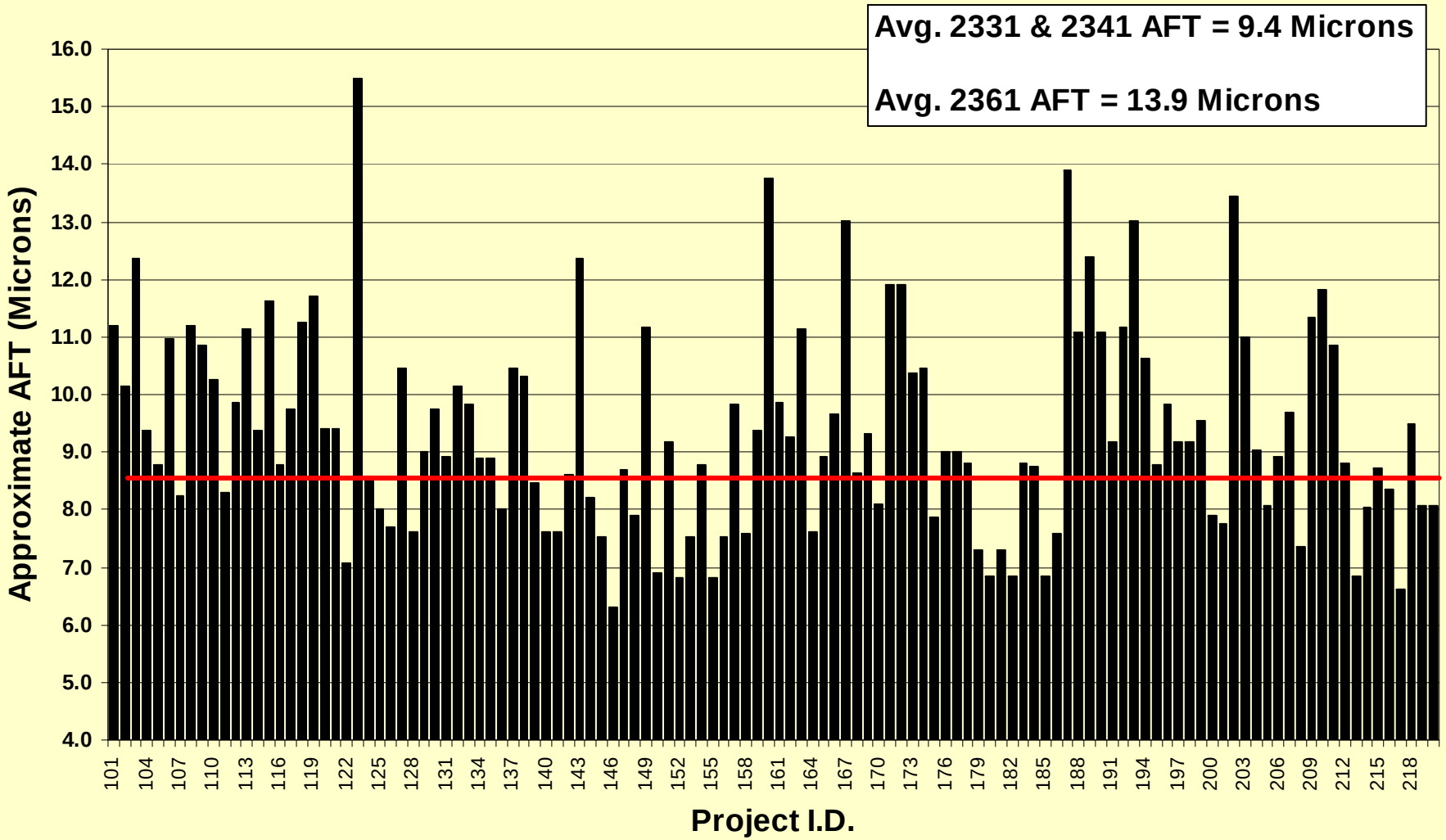
(2331 Non Wear)



1986 TRIAL MIX AFT
(2331 Shoulder Wear)



1986 TRIAL MIX AFT
(2331 & 2341 Wear)



AVERAGE AFT

YEAR	2331 & 2341 NON WEAR	2331, 2341 & 2351 WEAR	2351 NON WEAR	2361 WEAR
1963-65	6.5	7.8	11.1	NA
1978	6.7	9.3	NA	11.7
1980	5.6	6.8	NA	9.1
1982	5.1	6.6	NA	11.3
1984	7.4	9.6	NA	?
1986	7.8	9.4	NA	13.9

Some Comments

concerning

VMA, AFT and V_{be}

Mn/DOT's current minimum VMA requirements vary from 12.5% to 15.0%

Depending on max. aggregate size and percent passing #8 sieve.

The Sixth Edition of the Asphalt Institutes MS-2 also lists a Minimum VMA of 17%* for a Mixture with 3/8”Maximum Sized Aggregate

*** 4% Design Air Voids**

This results in a VMA Range of 4.5% (17.0 – 12.5) for our normally used Asphalt Mixture Gradations

MINIMUM VMA CRITERIA

(Based on 4% Design Air Voids)

ASPHALT INSTITUTE

MIX DESIGN (MS-2)

Nominal Maximum Aggregate Size	Maximum Aggregate Size	Minimum % VMA
25.0 mm (1")	1.5"	12.0
19.0 mm (3/4")	1"	13.0
12.5 mm (1/2")	3/4"	14.0
9.5 mm (3/8")	1/2"	15.0
4.75mm (#4)	3/8"	17.0

VMA includes both V_{be} and V_a

As a result, in order to achieve the desired minimum V_{be}:

The minimum required VMA should vary with the V_a during mix production

Example of VMA vs V_{be} as V_a Changes

- If VMA = 14.0 and V_a = 4.0; V_{be} = 10.0%
- If VMA = 14.0 and V_a = 5.0; V_{be} = 9.0%

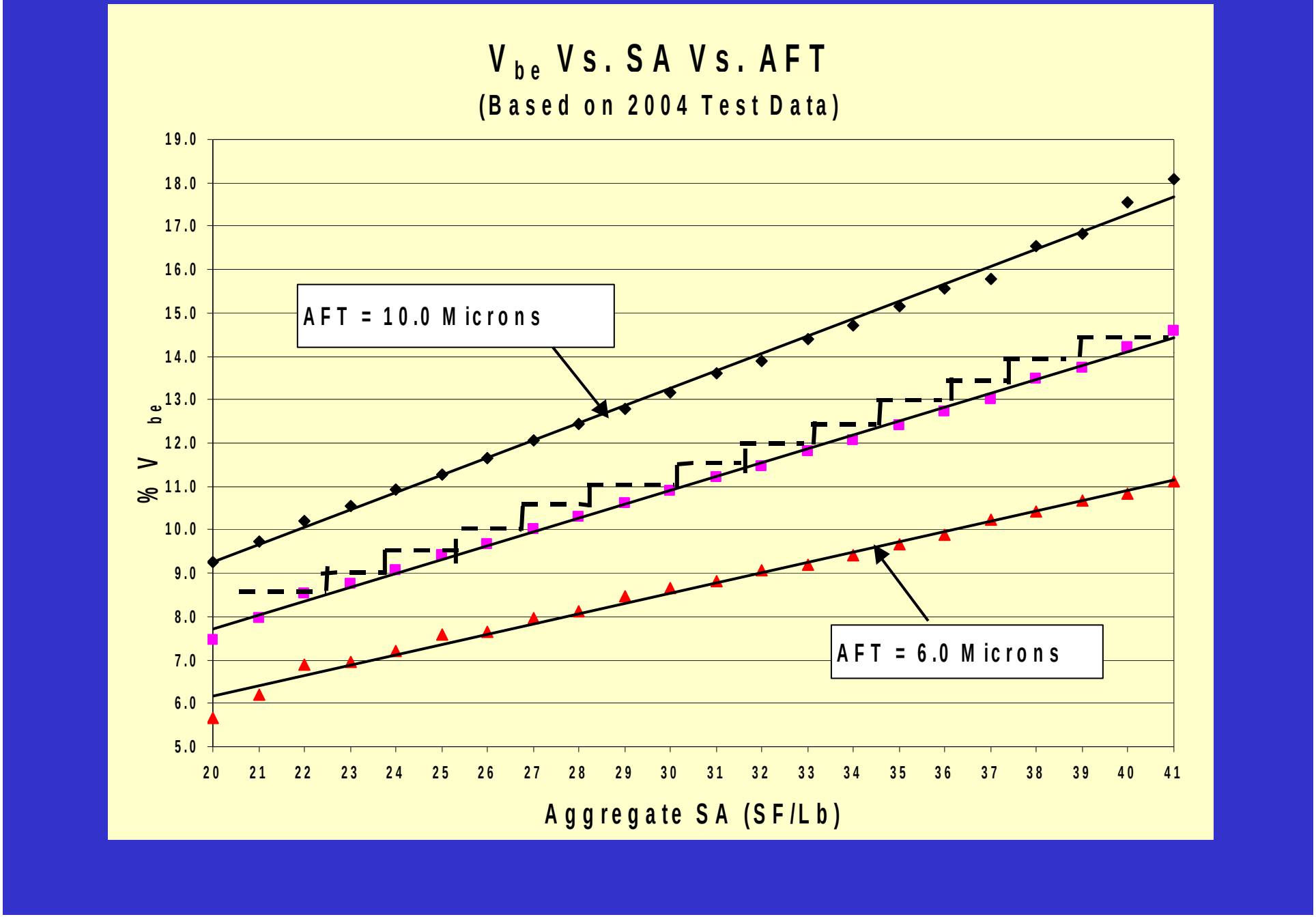
- If you assume that a V_{be} of 10% provides the desired amount of AC for a specific gradation, the mixture **could have 10% less V_{be} than desired** and still fully meet the VMA criteria if the V_a increases from 4.0 to 5.0%, while the VMA remains at 14.0%.

In order to maintain an AFT of 8.0 Microns over our normal range of aggregate surface areas the V_{be} would have a **Range of about 6.5%**

AFT Spec. vs. V_{be} Spec.

- A *"normal"* AFT spec. requires the V_{be} to be directly proportional to the aggregate surface area (SA).

- An Effective AC Volume (V_{be}) spec. would allow the V_{be} to be proportional, but not directly proportional, to the aggregate surface area. However, "Steps" would be required as the SA changed.


V_{be} Vs. SA Vs. AFT
(Based on 2004 Test Data)
% V_{be}
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
AFT = 10.0 Microns
AFT = 6.0 Microns
20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41
Aggregate SA (SF/Lb)

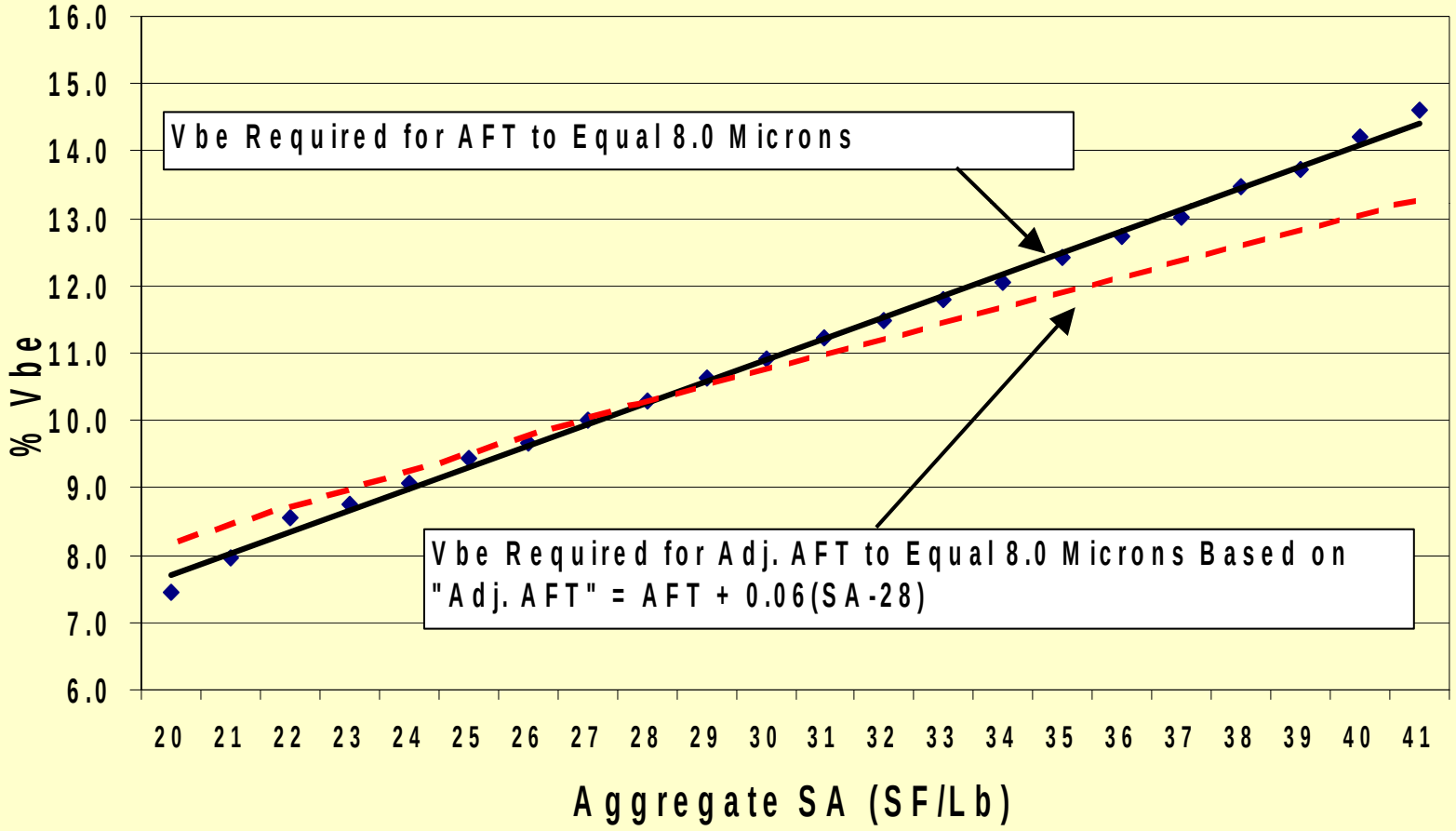
An "*Adjusted*" AFT Specification

- Allows the V_{be} to have a Range of about 4.5%, to basically match current Asphalt Institute VMA criteria
- Eliminates the need for "steps" in the minimum V_{be} required
- Allows both Individual and Moving Average Specification requirements

- **Example: Adj. AFT = AFT + 0.06(SA-28)**

Required V_{be} Necessary to Provide an AFT, or Adjusted AFT, of 8.0 Microns

(Based on 2004 Project Test Data)



Approximate V_{be} Ranges:

4.5% for **VMA** Criteria

6.5% for **“*Normal*” AFT**

4.5% for **“*Adjusted*” AFT**

Some "Experts" believe that VMA combined with VFA and Fines/Effective AC is adequate for specifying the minimum V_{be}.

We've already discussed the problems with VMA. Now we'll cover VFA and P_{200}/P_{be}

VFA

VFA stands for the “voids filled with asphalt” and is the Percent V_{be} as compared to the total Percent VMA.

If a mixture has a V_{be} of 9.5% and a VMA of 14.0%, the VFA would be 68%.

VFA Criteria

- VFA criteria is usually based on Mixture Type or Traffic Level, and is listed as a range.
- VFA criteria is not based on the gradation: either maximum aggregate size or aggregate surface area
- Our VFA specs require between 65% and 78% for Wear, and between 70% and 83% for Non-Wear at Design

MINIMUM VMA VS. AGGREGATE SURFACE AREA
(Mixtures with 8 Microns AC Film Thickness and 3% Air Voids)

SA (SF/Lb.)	Aggregate SA (SF)	Min. Req. AC_{eff} Volume (gal/CF)	Min. Req. AC_{eff} Volume (CF/CF)	Min. VMA for AC_{eff}	Minimum Total VMA (for 3% Voids and AC_{eff})	% of VMA Which is AC_{eff} (VFA)
15	2256	0.443	0.059	5.9	8.9	66
20	2949	0.579	0.077	7.7	10.7	72
25	3612	0.709	0.095	9.5	12.5	76
30	4250	0.834	0.112	11.2	14.2	79
35	4865	0.955	0.128	12.8	15.8	81
40	5462	1.072	0.143	14.3	17.3	83

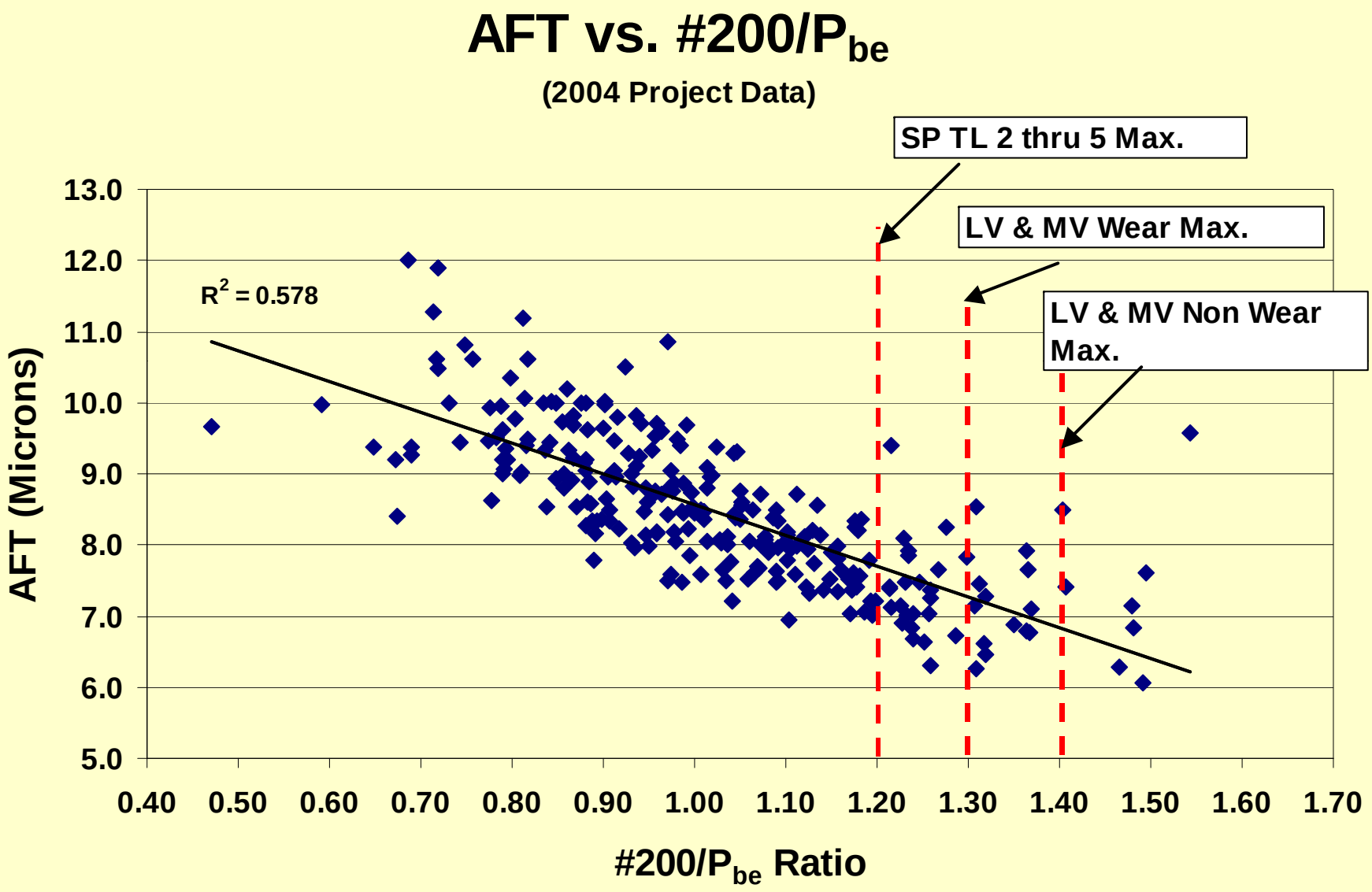
MINIMUM VMA VS. AGGREGATE SURFACE AREA
(Mixtures with 8 Microns AC Film Thickness and 4% Air Voids)

SA (SF/Lb.)	Aggregate SA (SF)	Min. Req. AC_{eff} Volume (gal/CF)	Min. Req. AC_{eff} Volume (CF/CF)	Min. VMA for AC_{eff}	Minimum Total VMA (for 4% Voids and AC_{eff})	% of VMA Which is AC_{eff} (VFA)
15	2234	0.439	0.059	5.9	9.9	59
20	2916	0.572	0.077	7.7	11.7	66
25	3574	0.702	0.094	9.4	13.4	70
30	4210	0.827	0.111	11.1	15.1	73
35	4819	0.946	0.127	12.7	16.7	76
40	5402	1.061	0.142	14.2	18.2	78

Fines to Effective Asphalt
(P_{200}/P_{be})

- The P_{200}/P_{be} ratio may limit the P_{200}, but it has little if any affect on the remaining sieves.

- In the SA calculation, the P_{200} generally accounts for only 20% to 30% of the Total calculated SA. 70% to 80% comes from the other sieves.

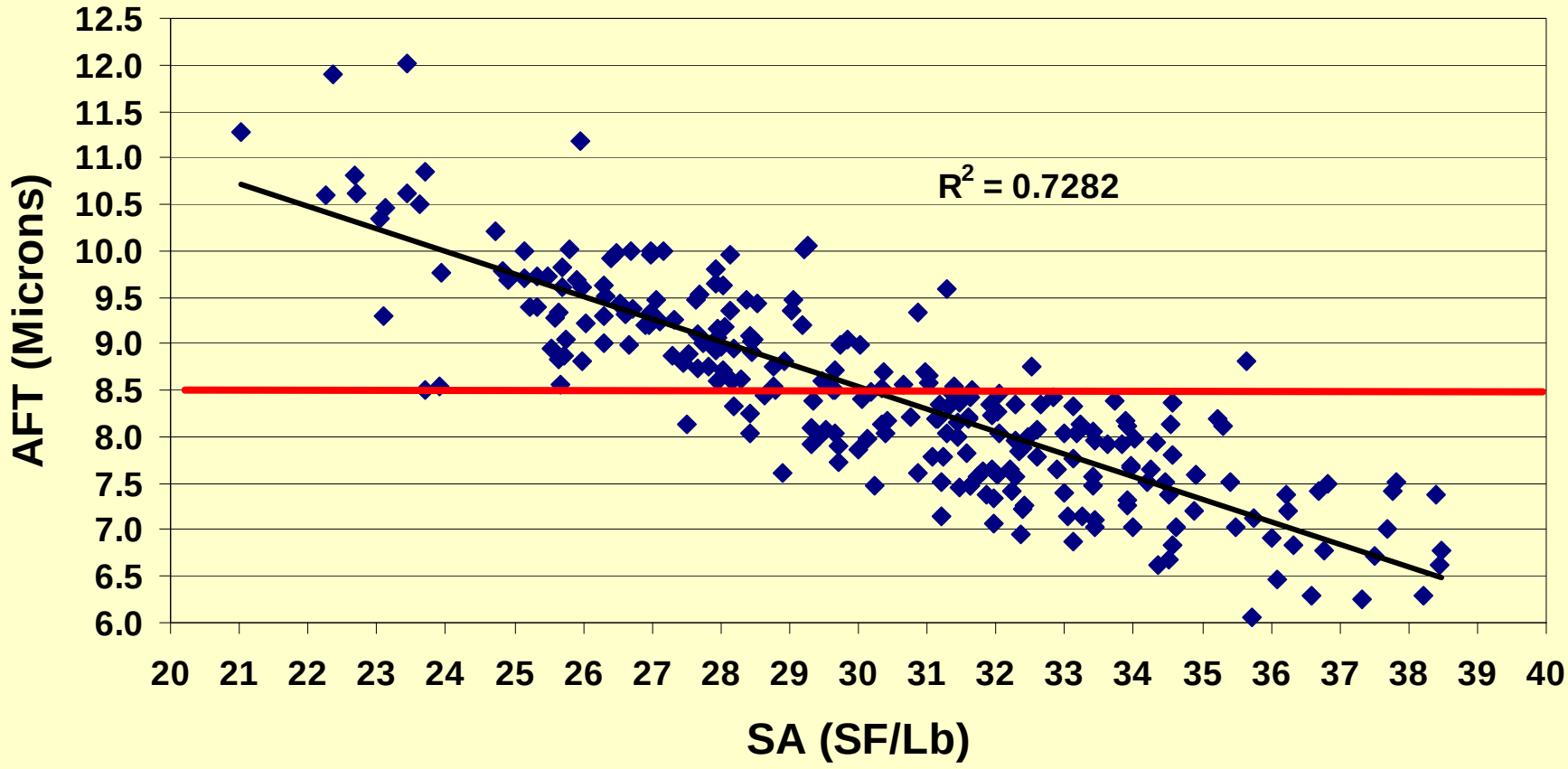

AFT vs. #200/Pbe
(2004 Project Data)
SP TL 2 thru 5 Max.
LV & MV Wear Max.
LV & MV Non Wear Max.
R2 = 0.578
AFT (Microns)
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
0.40
0.50
0.60
0.70
0.80
0.90
1.00
1.10
1.20
1.30
1.40
1.50
1.60
1.70
#200/Pbe Ratio

Summary
of
2004 Project Data

AFT Vs. SA

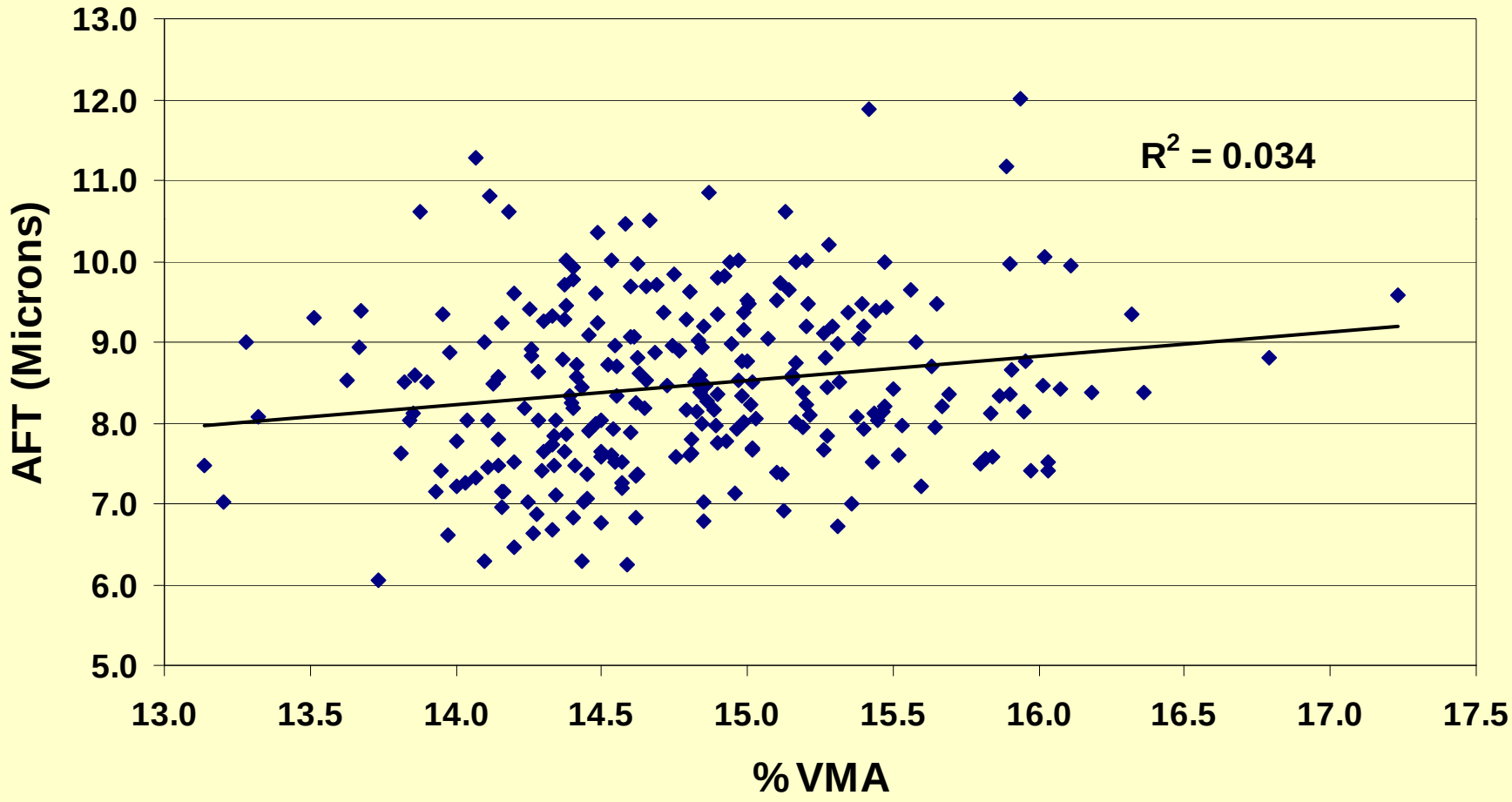
Contractor Results, Except when OT

(2004 Project Data)



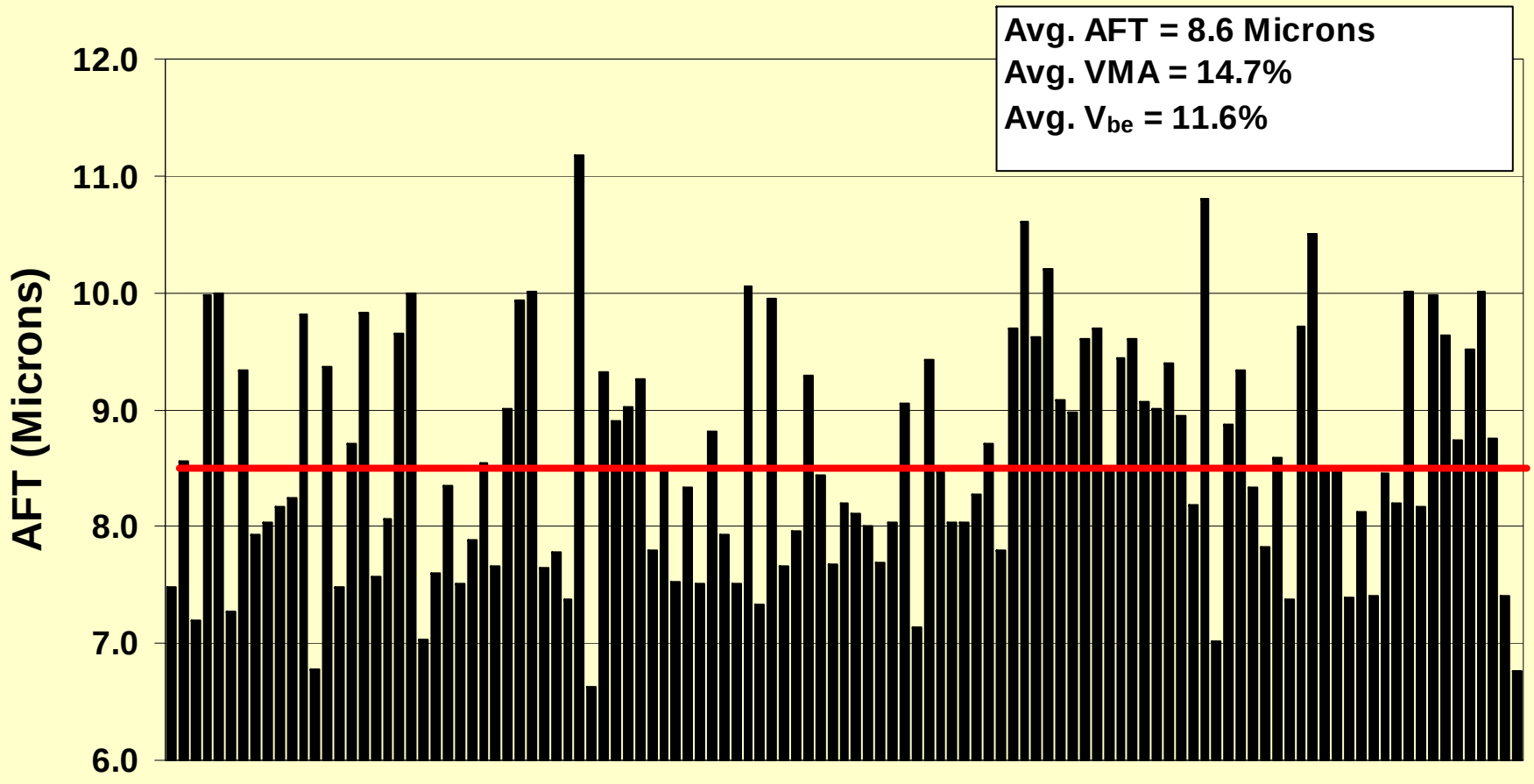
AFT vs. VMA

(2004 Project Data)



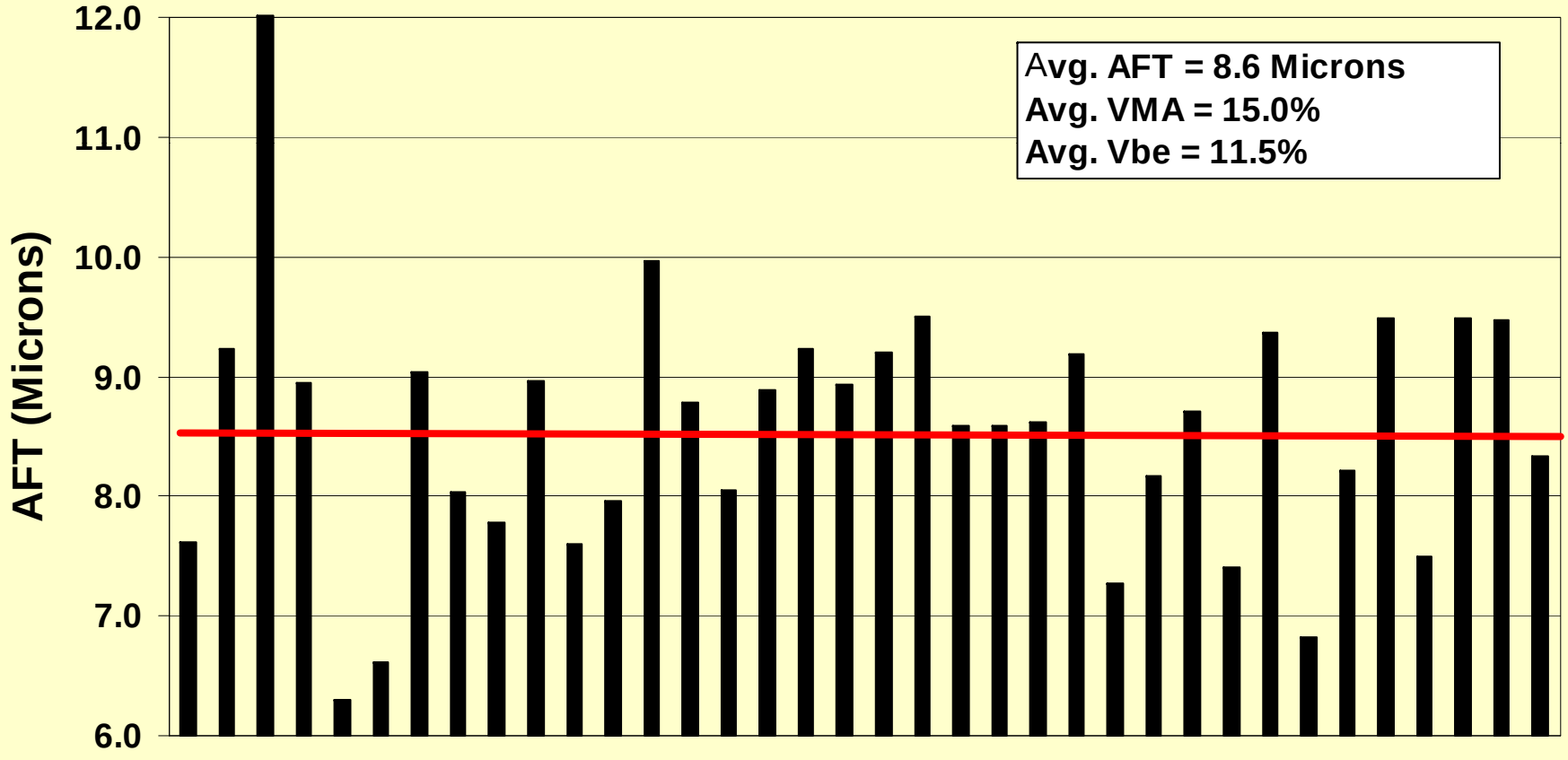
Project Average AFT
Mixtures with 3.0% Air Void Design

(2004 Project Data)



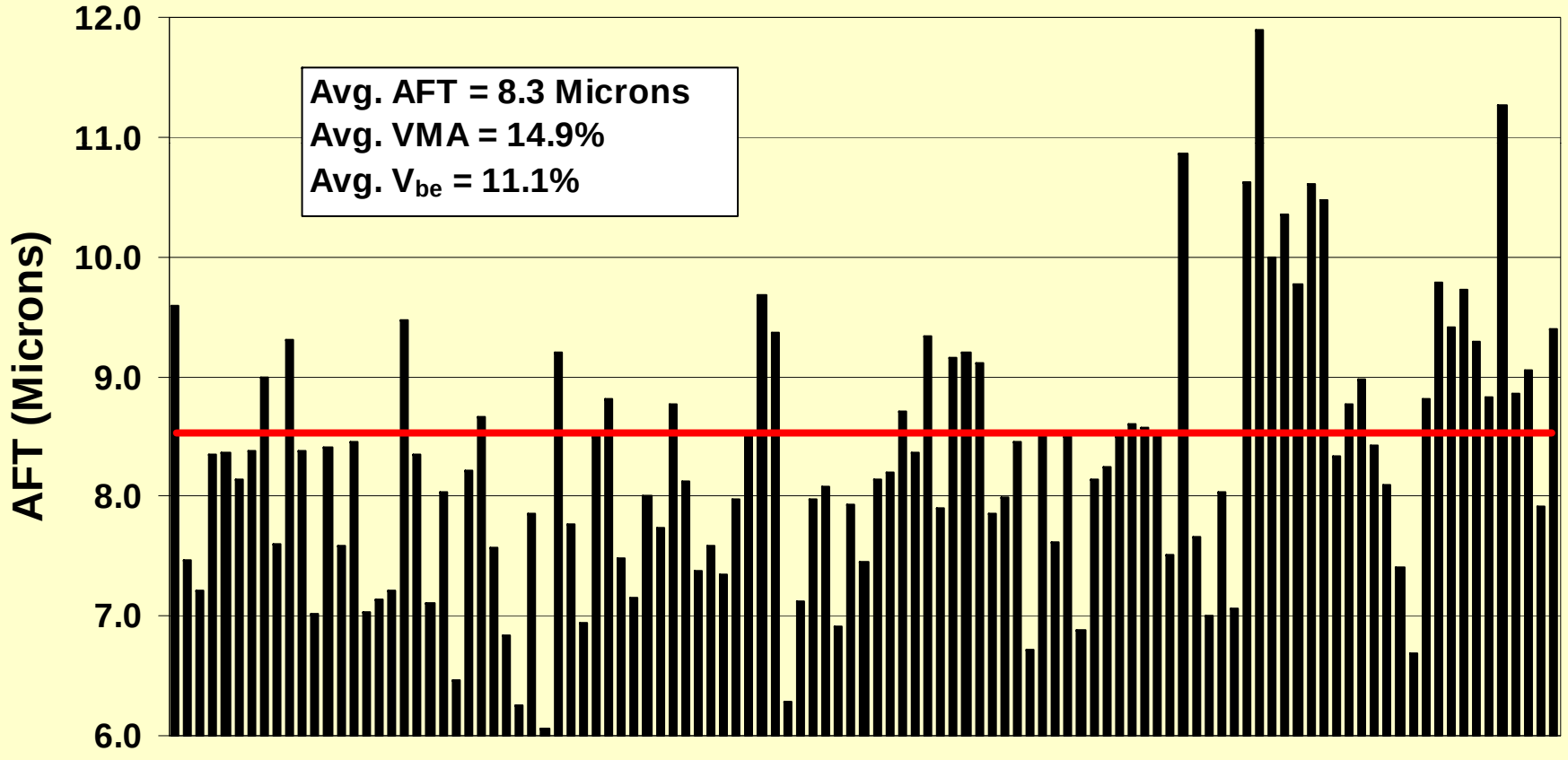
Project Average AFT
Mixtures with 3.5% Air Void Design

(2004 Project Data)



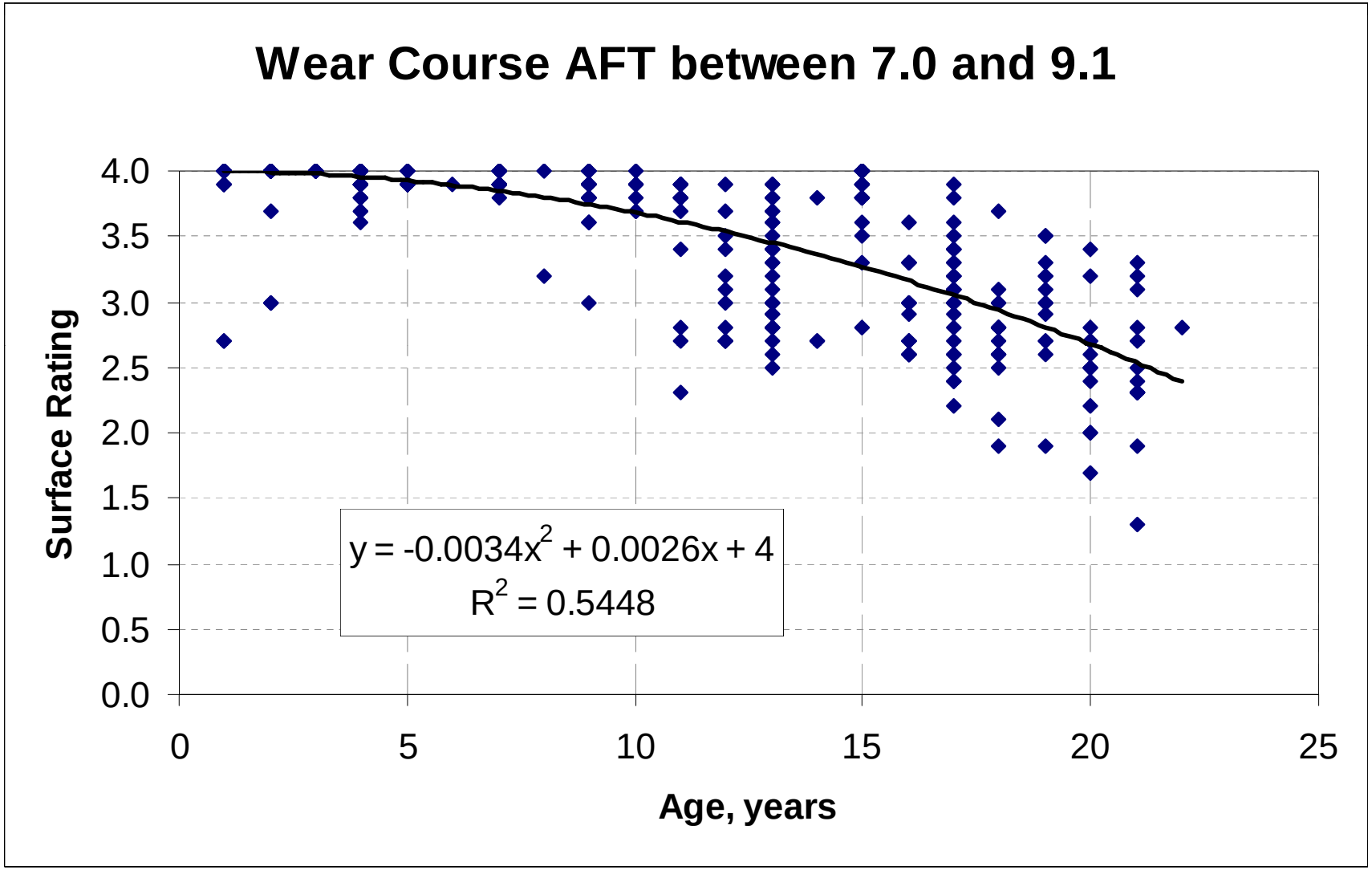
Project Average AFT
Mixtures with 4.0 Air Void Design

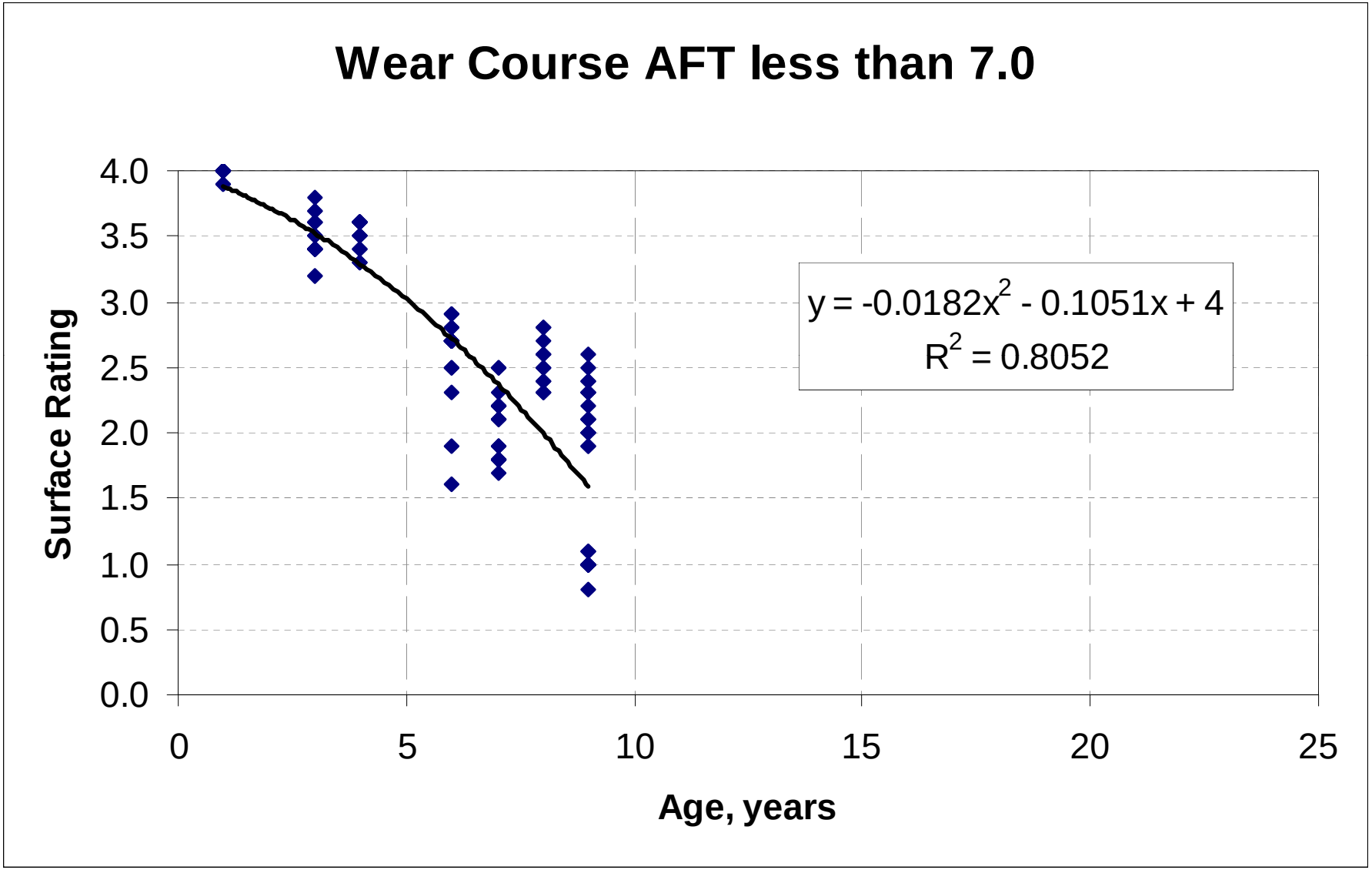
(2004 Project Data)

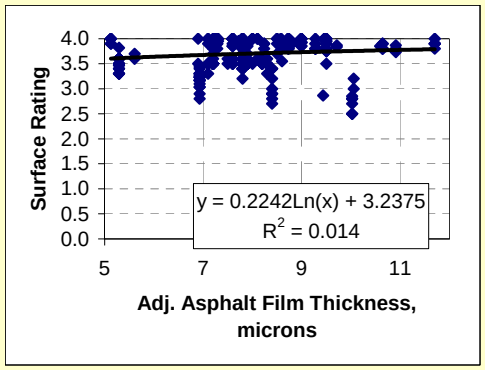


“Adjusted” AFT Specification

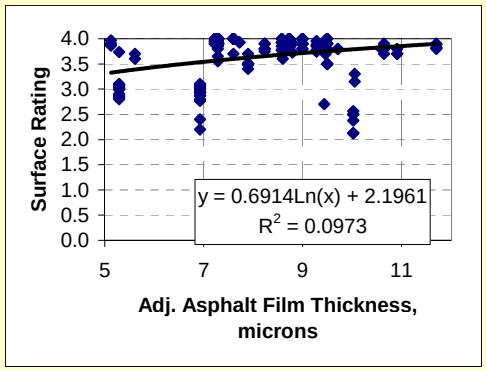
- V_{be} does not have to be directly proportional to the Aggregate SA (V_{be} range less than 6.5%)
- Allows “constant” minimum specification requirements (MA=4 of 8.0 & Indiv of 7.5, etc.) No “steps” required.
- No need for VMA, VFA, or upper limit on $P_{200}/P_{be.}$ **Must maintain V_a requirements**.


Wear Course AFT between 7.0 and 9.1
Surface Rating
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
Age, years
y = -0.0034x2 + 0.0026x + 4
R2 = 0.5448

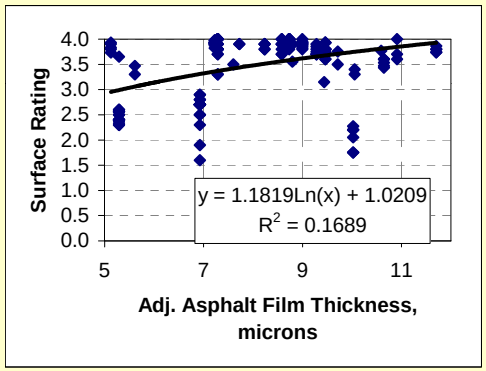

Wear Course AFT less than 7.0
Surface Rating
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
Age, years
y = -0.0182x2 - 0.1051x + 4
R2 = 0.8052



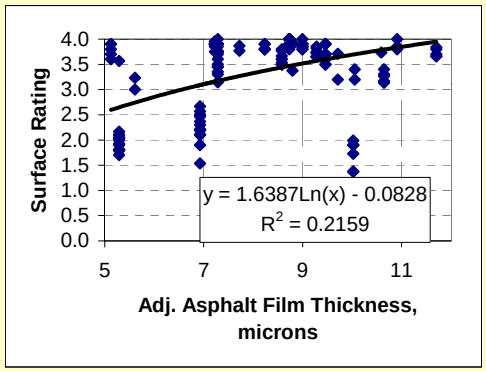
a) 4 years old



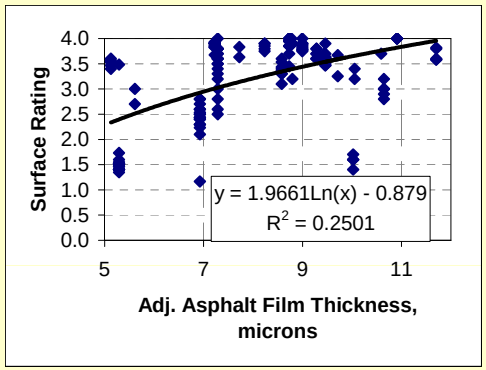
b) 5 years old



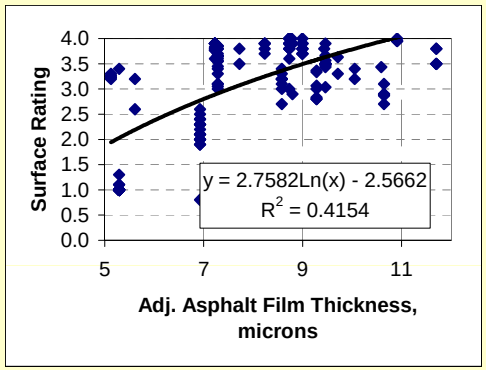
c) 6 years old



d) 7 years old



e) 8 years old



f) 9 years old

Summary

of the current

Adjusted AFT Spec.

Mn/DOT's Adjusted AFT specification is basically a compromise of "straight" AFT and VMA specifications.

Whereas the minimum required V_{be} in a VMA spec is based on the Nominal Maximum aggregate size, **the minimum required V_{be} in our Adj. AFT spec is based on the calculated Aggregate SA "Index"**

- The Contractor's **Trial Mix** shall have a minimum Adjusted AFT of **8.5** microns.
- The minimum **production Individual** Adjusted AFT requirement is **7.5** microns.
- The minimum **production Moving Average** (n=4) Adjusted AFT requirement is **8.0** microns.

A gradation and Adjusted AFT calculation **<u>are required</u>** for each **1000** tons, or portion thereof,

or

at the same rate as the QC Mixture Property (G_{mm} and G_{mb}) tests, with a **minimum of one per day.**

Aggregate SA Adjustment

Since aggregates with higher G_{sb}'s will have less SA per pound than those with lower G_{sb}'s, an Adjusted SA will be calculated as follows for aggregates with minus #4 aggregate G_{sb}'s less than 2.580, or greater than 2.700.

Adjusted SA = SA*(2.650/-#4Gsb)

There is currently no SA adjustment for aggregates with -#4 G_{sb}'s between 2.580 and 2.700.

- The **JMF limits** for the gradation sieves are the same as the **“Broad Band”** limits.

- These “Broad Band” limits apply to both Moving Average and Individual results.

- #8 Individual Sieve Tolerances:

#16 = 4%

#30 = 4%

#50 = 3%

#100 = 2%

#200 = **1.2**%*

* Tolerance has been changed from Table 2360.4M

- Accurate Gradation results are very important, especially for the #30 thru #200 sieves, in order to meet the required test tolerances

- Hand Washing (rather than Agra-Wash) will be required if either gradation or calculated Adjusted AFT are Out of Tolerance

- The allowable Adjusted AFT calculation tolerance is **1.2** microns.

- If the Adjusted AFT calculation is confirmed to be out of tolerance, the Agency Adjusted AFT will be **Equalized** and used for both Individual and Moving Average calculations.

- Equalization of the Agency Adjusted AFT consists of increasing the original Agency value by 0.5 microns.

- This increased value will then be used for acceptance of the test result.

- The minimum **Individual** Adjusted AFT requirement is 7.5 microns.

- Material with less than 7.5, but equal to or greater than 7.0 microns, will receive **90%** pay.

- Material with less than 7.0, but greater than 6.0 microns, will receive **75%** pay.

- Material with 6.0 microns, or less, is subject to **removal** and replacement at the Contractor's expense.

- The minimum **Moving Average** (n=4) Adjusted AFT requirement is 8.0 microns.

- Generally, all Material which contributed to a MA less than 8.0 microns will receive 80% pay.(Exception is Ind. Tests of 8.0 or greater)

- The **MA will not be calculated until the 6th test** after the beginning of mix production of a specific mixture. It will include Individual results of Tests 3, 4, 5 and 6.

- The Adjusted AFT Spec has usually led to mixtures with less -#200, and often more +#8, material.

- The Contractor can make an economic decision: Reduce AC content by using less and cleaner “sand”, or use less +#8 material and more AC.

Conclusion

Our Adjusted AFT Spec is basically a compromise between VMA and "straight" AFT criteria.

Instead of an approximate V_{be} range of 4.5% being based on the Maximum Aggregate Size, it is based on the Aggregate SA "Index".

Adjusted AFT is an "Index" that represents the V_{be}. As the SA increases, the V_{be} must also increase in order to maintain a constant Adjusted AFT

Density

Generally, the two most important factors in long term asphalt pavement performance are adequate (but not too much) asphalt cement and density.

Adjusted AFT will not do it alone!