ARTIFICIAL GRADING OF MINERAL AGGREGATE

(An Arizona Method)

Scope

1. This method may be utilized to adjust composites of mineral aggregate by artificially grading the material to meet desired target values for specified screens.

Preparation of Pass No. 4 Sieve Size Samples

2. After samples of each stockpile or bin have been separated into individual sizes of Plus No. 4 and larger, and Pass No. 4 material by coarse sieving as described in ARIZ 201 the Pass No. 4 material is processed by the following procedures. Figure 1 gives an illustration of the steps necessary which may prove helpful in understanding the procedure.

(a) For each stockpile or bin of mineral aggregate the Pass No. 4 material is separated into No. 8 and Pass No. 8 fractions and weights recorded for each.

(b) The Pass No. 8 fractions for each stockpile or bin are proportionately combined and thoroughly blended together.

NOTE: It is important that the material be completely and accurately sieved into the three separate size fractions.

(c) The combined Pass No. 8 material is screened over a series of sieves which includes a No. 8, No. 40, No. 200 sieve, and other intermediate sizes as necessary to prevent overloading individual sieves.

(d) Material which passes the No. 8 sieve and is retained on the No. 40 sieve and any intermediate sieves is combined and saved.

(e) Material which passes the No. 40 sieve and is retained on the No. 200 sieve and any intermediate sieves is combined and saved.

(f) The material passing the No. 200 sieve is also saved.

(g) An approximate 500 gram sample is obtained from the fraction of material which is Pass No. 8 to Retained No. 40, and another approximate 500 gram sample is obtained from the fraction of material which is Pass No. 40 to Retained No. 200.

(h) Each of the samples are subjected to elutriation and fine screening as specified in ARIZ 201, Section 6 or 7, and 8. The sieve analysis of each is determined in accordance with Section 11 of ARIZ 201, except the % passing each sieve is determined and recorded to the nearest 0.01%.

(i) From the elutriation and fine screening of the Pass No. 8 to Retained No. 40 fraction, the % passing the No. 40 sieve and larger than the No. 200 sieve is determined (% Pass No. 200 subtracted from % Pass No. 40), and recorded as "a". The % passing the No. 200 sieve is recorded as "b".

Example:

Sieve size	% Passing
# 8	100
# 40	0.34
# 200	0.25

"a" = (0.34 - 0.25) = 0.09%
"b" = 0.25%

(j) From the elutriation and fine screening of the Pass No. 40 to Retained No. 200 fraction, the % passing No. 200 sieve is recorded as "c".

Example:

Sieve Size	% Passing
# 40	100
# 200	1.32

"c" = 1.32%

NOTE: The size fractions used above for artificial grading and throughout this method are based on meeting desired values for % passing the No. 8, No. 40 and No. 200 sieves. If other or additional sieves are used in artificial grading or adjusting the composite, the procedures of this test method will apply, with appropriate modifications.

Procedure for Adjusting Composite for Pass No. 8 Material

3. The composite of mineral aggregate for Pass No. 8 material is then adjusted to meet desired values. The Pass No. 8 to Retained No. 40 fraction from screening has material clinging to it which will contribute to Pass No. 40 to Retained No. 200 and Pass No. 200 material in the adjusted composite, and the Pass No. 40 to Retained No. 200 fraction from screening has material clinging to it which will contribute to the Pass No. 200 material in the adjusted composite. The procedure below uses results from the elutriation and the fine screening of material from each fraction of material to account for the total contribution to each desired size. Figure 2 provides an illustration which may be useful in understanding the

method. The calculations outlined below are utilized to determine the % of each size fraction from screening that is necessary to be used to obtain desired values. An example is provided with the method for each calculation. The illustration in paragraph (h) is a tabulation of the results for the example provided and should be referred to as the procedure is followed to understand the contributions to each desired value from the individual fractions of material.

(a) The amount of Pass No. 8 to Retained No. 40 material for the desired gradation is determined, (% Pass No. 40 subtracted from % Pass No. 8) and recorded as "d". The amount of Pass No. 40 to Retained No. 200 material for the desired gradation is determined, (% Pass No. 200 subtracted from % Pass No. 40), and recorded as "e". The amount of Pass No. 200 for the desired gradation is recorded as "f".

Example:

Sieve Size	Composite Gradation % Pass Values	Desired Gradation % Pass Values
# 8	45	48
# 40	21	18
# 200	6.5	5.7

"d" = (48 - 18) = 30 %
"e" = (18 - 5.7) = 12.3%
"f" = 5.7%

(b) The percent of the Pass No. 8 to Retained No. 40 fraction of material necessary to be utilized to obtain the desired adjusted % Pass No. 8 is determined and recorded as "g".

$$\text{"g"} = (d) \times \left[1 + \frac{a + b}{100} \right]$$

Example:

$$\text{"g"} = (30) \times \left[1 + \frac{0.09 + 0.25}{100} \right] = 30.10\%$$

(c) The proportional amounts of Pass No. 40 to Retained No. 200, and Pass No. 200 material which are in the Pass No. 8 to Retained No. 40 fraction, and which need to be accounted for in the adjusted composite are determined and recorded as "h" and "i" respectively:

$$\text{"h"} = (g - d) \times \left[\frac{a}{a + b} \right]$$

$$\text{"i"} = (g - d) \times \left[\frac{b}{a + b} \right]$$

Example:

$$\text{"h"} = (30.10 - 30) \times \left[\frac{0.09}{0.09 + 0.25}\right] = 0.03\%$$

$$\text{"i"} = (30.10 - 30) \times \left[\frac{0.25}{0.09 + 0.25}\right] = 0.07\%$$

(d) The amount of Pass No. 40 to Retained No. 200 material from the Pass No. 40 to Retained No. 200 fraction that is required to give the desired value for Pass No. 40 to Retained No. 200 in the adjusted composite is determined and recorded as "j":

$$\text{"j"} = (e - h)$$

Example:

$$\text{"j"} = (12.3 - 0.03) = 12.27\%$$

NOTE: The sum of the contributions to the Pass No. 8 to Retained No. 40, "h" + "j", will equal the total amount desired in the adjusted composite, "e".

(e) The percent of the Pass No. 40 to Retained No. 200 fraction of material, necessary to be utilized to obtain the desired value for Pass No. 40 to Retained No. 200 is determined and recorded as "k":

$$\text{"k"} = (j) \times \left[1 + \frac{c}{100}\right]$$

Example:

$$\text{"k"} = (12.27) \times \left[1 + \frac{1.32}{100}\right] = 12.43\%$$

(f) The amount of Pass No. 200 material which is in the Pass No. 40 to Retained No. 200 fraction, and which needs to be accounted for in the adjusted composite is determined and recorded as "l":

$$\text{"l"} = (k - j)$$

Example:

$$\text{"l"} = (12.43 - 12.27) = 0.16\%$$

(g) The percent of Pass No. 200 material necessary to be utilized to obtain the desired % Pass No. 200 is determined and recorded as "m":

"m" = (f - i - l)

Example:

"m" = (5.7 - 0.07 - 0.16) = 5.47%

NOTE: The sum of the contributions to the % Pass No. 200 material, "i" + "l" + "m", will equal the total amount desired in the adjusted composite, "f".

(h) The following illustration shows the contributions to the adjusted composite from each of the size fractions:

	Pass #8 to Ret. #40 Fraction	Pass #40 to Ret. #200 Fraction	Pass #200 Fraction	Desired Values
% Pass #8 to Ret. #40	30 (d)			30 (d)
% Pass #40 to Ret. #200	0.03(h)	12.27(j)		12.3 (e)
% Pass #200	0.07(i)	0.16(l)	5.47(m)	5.7 (f)
% of each size fraction to be used to obtain desired values	30.10(g)	12.43(k)	5.47(m)	

(i) The percentages of each size fraction which are to be used in the adjusted composite to meet desired values are recorded:

Example:

Pass No. 8 to Retained No. 40 = 30.10%
Pass No. 40 to Retained No. 200 = 12.43%
Pass No. 200 = 5.47%

Procedure for Adjusting Composite for Plus No. 8 Material

4. The composite is adjusted for the Plus No. 8 material to obtain desired % pass values for each size.

(a) The % retained for each sieve size for the desired adjusted composite is divided by the corresponding % retained value for each sieve size in the stockpile or bin composite. This value is multiplied by the individual fractions of that size for each stockpile or bin. This will give an adjusted amount of each size fraction in the stockpile or bin composite which will be the gradation of the desired composite. An example of this for a composite for an asphaltic concrete mix design is shown in Figure 3.

Checking Adjusted Composite

5. A sample of appropriate size as specified in ARIZ 201, for the maximum aggregate size, is prepared for the adjusted composite using material from the individual size fractions for Plus No. 8 material, the Pass No. 8 to Retained No. 40 fraction, the Pass No. 40 to Retained No. 200 fraction, and the Pass No. 200 fraction. This sample is subjected to ARIZ 201 and the resultant gradation compared to the desired gradation.

Preparing Samples Using Material from Artificial Grading

6. The samples necessary are prepared and weighed up for testing utilizing the adjusted composite.

(a) For the Plus No. 8 material, the individual size fractions from the adjusted composite for each stockpile or bin are utilized to prepare samples.

(b) For Pass No. 8 material the amount of each fraction for Pass No. 8 to Retained No. 40, Pass No. 40 to Retained No. 200, and Pass No. 200 from the adjusted composite is utilized to prepare samples.

(c) A weigh up sheet which is used for asphaltic concrete mix designs, which illustrates the use of the adjusted composite fractions is shown in Figure 4.

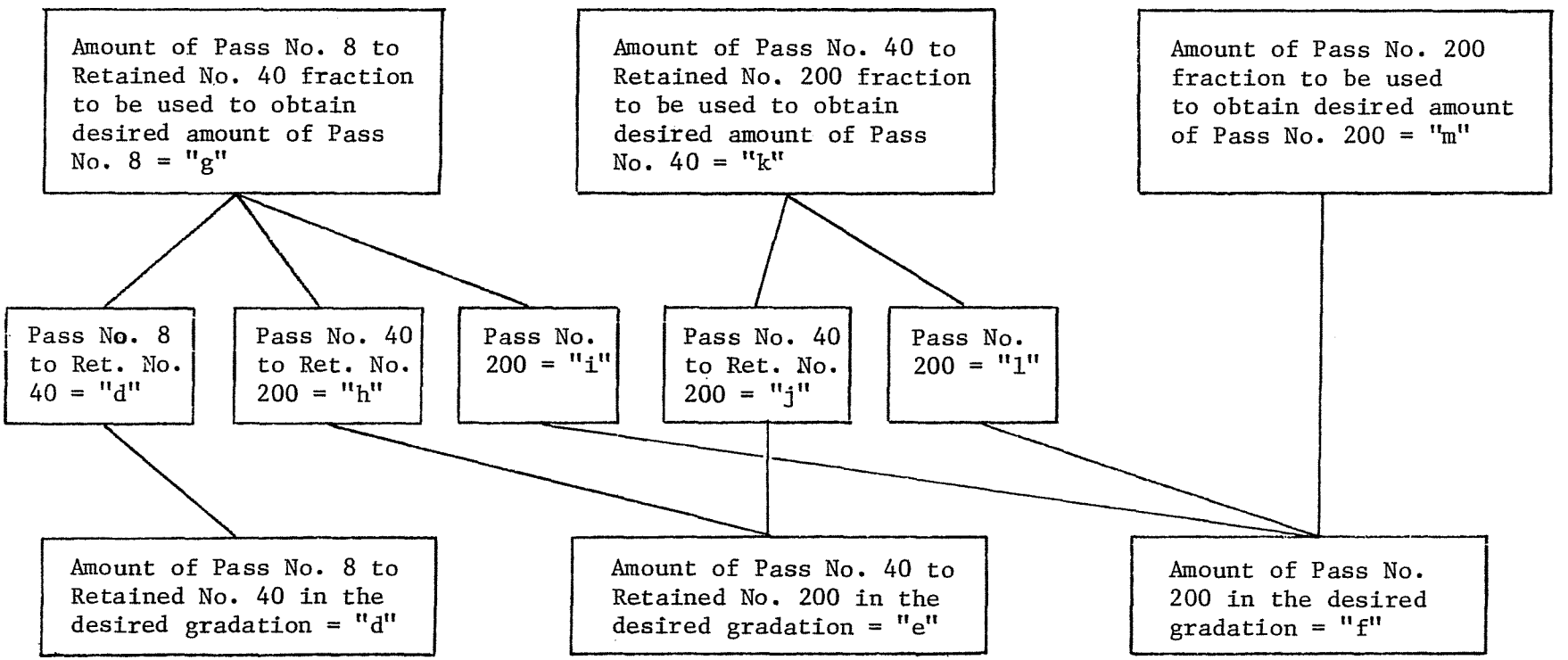
Amount of Pass No. 8 to Retained No. 40 fraction to be used to obtain desired amount of Pass No. 8 = "g"
Amount of Pass No. 40 to Retained No. 200 fraction to be used to obtain desired amount of Pass No. 40 = "k"
Amount of Pass No. 200 fraction to be used to obtain desired amount of Pass No. 200 = "m"
Pass No. 8 to Ret. No. 40 = "d"
Pass No. 40 to Ret. No. 200 = "h"
Pass No. 200 = "i"
Pass No. 40 to Ret. No. 200 = "j"
Pass No. 200 = "l"
Amount of Pass No. 8 to Retained No. 40 in the desired gradation = "d"
Amount of Pass No. 40 to Retained No. 200 in the desired gradation = "e"
Amount of Pass No. 200 in the desired gradation = "f"

FIGURE 1

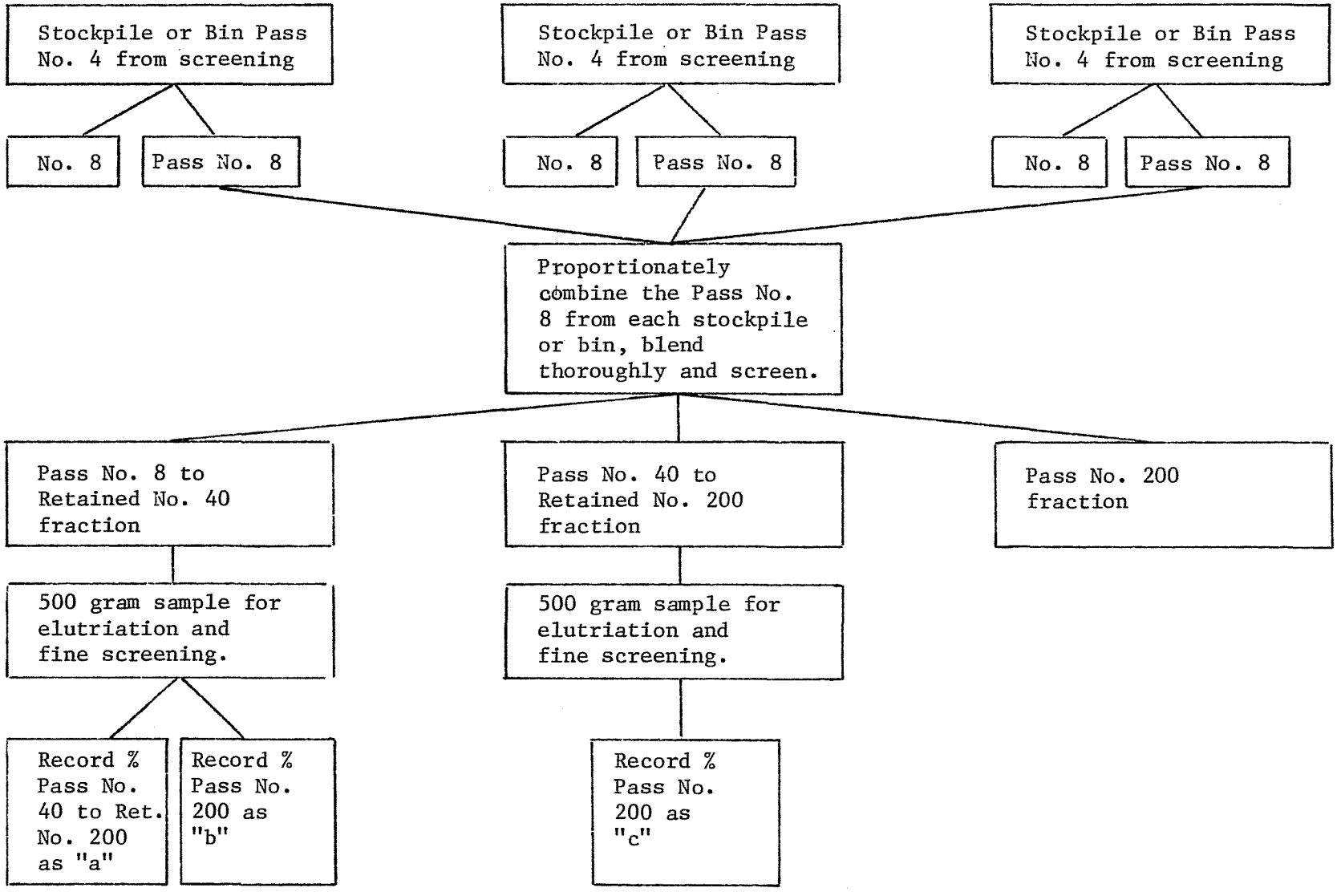
Stockpile or Bin Pass No. 4 from screening
Stockpile or Bin Pass No. 4 from screening
Stockpile or Bin Pass No. 4 from screening
No. 8
Pass No. 8
No. 8
Pass No. 8
No. 8
Pass No. 8
Proportionately combine the Pass No. 8 from each stockpile or bin, blend thoroughly and screen.
Pass No. 8 to Retained No. 40 fraction
Pass No. 40 to Retained No. 200 fraction
Pass No. 200 fraction
500 gram sample for elutriation and fine screening.
500 gram sample for elutriation and fine screening.
Record % Pass No. 40 to Ret. No. 200 as "a"
Record % Pass No. 200 as "b"
Record % Pass No. 200 as "c"

FIGURE 2

COMPOSITE ADJUSTED TO DESIRED COMPOSITE OF PLUS NO. 8 MATERIAL

DATE _____ PROJECT NO. _____ LAB. NO. _____ DESIGN _____

Sieve Size	Aggregate "% of composite" C 30%	I 25%	F 45%			% Ret.	% Ret. Rounded	% Pass	DESIRED ADJUSTED ~~Design Specs.~~ COMPOSITE
1"							0	100	100
3/4"	2.6 ~~3.1~~	0.4 ~~0.5~~				3 ~~3.6~~	4	96	97
1/2"	11.4 ~~11.6~~	3.6 ~~3.6~~				15 ~~15.2~~	15	81	82
3/8"	8.5 ~~7.5~~	2.5 ~~2.2~~				11 ~~9.7~~	10	71	71
1/4"	1.7 ~~2.4~~	2.2 ~~3.1~~	0.1 ~~0.2~~			4 ~~5.7~~	6	65	67
#4	2.5 ~~2.2~~	1.6 ~~1.4~~	1.9 ~~1.7~~			6 ~~5.3~~	5	60	61
#8	2.6 ~~3.0~~	5.4 ~~6.3~~	5.0 ~~5.9~~			13 ~~15.2~~	15	45	48
#10	0	0.3	1.6			1.9	2	43	
#16	0	0.9	4.8			5.7	6	37	
#30	0	1.4	6.8			8.2	8	29	
#40	0	1.7	6.3			8.0	8	21	18
#50	0	0.9	6.2			7.1	7	14	
#100	0	0.8	4.4			5.2	5	9	
#200	0	0.4	2.3			2.7	3	6.5	5.7
Pass #200	0.16	1.53	4.79			6.48	6.5		

MIX DESIGN CRITERIA REQUIREMENTS:

IMC RET.~
MIN. WET STRENGTH~
VOIDS ~
V.M.A. ~
MIN. STABILITY~
FLOW ~

COMPOSITE OF PASS NO. 8 FROM GRADATION OF EACH STOCKPILE OR BIN:

LAB #	-#8
COARSE	0.2
INTER	7.9
FINE	37.2

TOTAL = 45.3

Sieve Size	Adjusted "% of composite" for use of mineral admixture						Calc. % Pass	% Ret.	% Pass	Design Specs.
1"	=	=	=	=	=	=				
3/4"										
1/2"										
3/8"										
1/4"										
#4										
#8										
#10										
#16										
#30										
#40										
#50										
#100										
#200										

Adjusted "% of composite" = Adjusted "% of composite" = Adjusted "% of composite" = Adjusted "% of composite" = Adjusted "% of composite" = Adjusted % Mineral Admix. =

REMARKS

$3/4: \frac{3}{3.6} = 0.8333$

$1/2: \frac{15}{15.2} = 0.9868$

$3/8: \frac{11}{9.7} = 1.1340$

$1/4: \frac{4}{5.7} = 0.7018$

$\#4: \frac{6}{5.3} = 1.1321$

$\#8: \frac{13}{15.2} = 0.8553$

FIGURE 3

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ASPHALTIC CONCRETE MIX DESIGN WEIGH UP CARD

MATERIAL | LAB NO. | DATE

PROJECT NO. | PROJECT NAME

CONTRACTOR | MIX DESIGN REQUEST

LAB NO.	SIZE	ACCUM % RET.	1 RICE	3 STABS	3 IMC	1 COARSE SP. GR	1 COARSE SAND EQUIV.	1 CRUSH. FACES	COARSE C.K.E.	LIME-STONE	FLAKI-NESS INDEX	1 ABRASION "B"	BLEND SP. GR.	1 FINE SAND EQUIV.	1 FINE SP. GR.	1 -#8 MAKE-UP MAT'L	SIZE	LAB NO
COARSE	3/4	2.6	78	86	88	267	26	15				—						
	1/2	14.0	420	462	476	1436	138	81				1900						
	3/8	22.5	675	742	765	2308	221	130				3832						
	1/4	24.2	726	799	823	2482	238	140				—						
	#4	26.7	801	881	908	2738	263	154				—						
INTER	3/4	27.1	813	894	921	2779	267	156				—						
	1/2	30.7	921	1013	1044	3149	302	177				4432						
	3/8	33.2	996	1096	1129	3405	327	192				5000						
	1/4	35.4	1062	1168	1204	3631	348	204										
	#4	37.0	1110	1221	1258	3795	364	213										
FINE	1/4	37.1	1113	1224	1261	3805	365	214										
	#4	39.0	1170	1287	1326	4000	384	225										
COARSE	#8	41.6	1248	1373	1414			240						26	51	—	#8	COARSE
INTER	#8	47.0	1410	1551	1598			271						79	157	—	#8	INTER
FINE	#8	52.0	1560	1716	1768			300						128	256	—	#8	FINE
PASS 8-RET 40		82.10	2463	2709	2791									424	848	376	PASS 8-RET 40	
PASS 40-RET 200		94.53	2836	3119	3214									546	1092	532	PASS 40-RET 200	
PASS 200		100	3000	3300	3400									600	1200	600	PASS	200

REMARKS:

FIGURE 4