Recommend Approval: Assistant Division Chief — Date 7/29/14; Division Chief — Date 7/30/14	Maryland Department of Transportation State Highway Administration Office of Materials Technology MARYLAND STANDARD METHOD OF TESTS	
Approved: Director — Date 7/30/14	**STATISTICAL ANALYSIS OF MATERIAL USING QUALITY LEVEL ANALYSIS FOR DETERMINATION OF PAY FACTORS**	**MSMT 735**

SCOPE:

This procedure is used to determine the percent of test results that are within Specification limits. Some of the results calculated in this procedure are used in section 504 of the Maryland State Highway Administration's Standard Specification book for Construction and Materials to determine pay factors for HMA material. It is affected by shifts in the arithmetic mean and by the sample standard deviation

MATERIALS AND EQUIPMENT:

Not applicable.

TEST PROCEDURE:

Sampling and testing shall be performed as specified in the appropriate AASHTO, ASTM, and MSMT procedures.

Note 1: If there are less than three QA test samples, the test data may be combined with the previous mixture acceptance lot to compute CMPWSL.

Note 2: If there are less than three QA test samples and there is no previous mixture acceptance lot, compute CMPWSL as follows:

1. If the combined number of QA and QC test results is equal to or greater than three, the t and f test determination (MSMT 733) will not be performed. The QC and QA test results will both be used for the analysis process to determine CMPWSL.

2. If the combined number of QA and QC test results is less than three, the t and f test determination (MSMT 733) will not be performed and the analysis process to determine CMPWSL will not be performed. The Mixture Pay Factor will be 100.

CALCULATIONS:

Compute the quality level analysis as follows:

1. Determine the arithmetic mean $(\overline{X})$ of the test results:

$$\overline{X} = \frac{\Sigma x}{n}$$

Round mean to one decimal

where:

$\overline{X}$ = arithmetic mean of test results

Σx = sum of test results

x =individual test value, and

n = total number of test values.

2. Compute the sample standard deviation (s):

$$s = \sqrt{\frac{n \Sigma (x^2) - (\Sigma x)^2}{n (n-1)}}$$

Round std. dev. to two decimals

$$s = \{(n \Sigma (x^2) - (\Sigma x)^2) / (n (n-1))\}^{1/2}$$

where:

s = sample standard deviation.

3. Compute the upper quality index (Q_u):

$$Q_u = \frac{USL - \overline{X}}{s}$$

Round Q_u to two decimals

where:

Q_u = upper quality index, and

USL = upper specification limit = target value* plus allowable deviation on a high side.

4. Compute the lower quality index (Q_L):

$$Q_L = \frac{\overline{X} - LSL}{s}$$

Round Q_L to two decimals

where:

Q_L = lower quality index, and

LSL = lower specification limit = target value * minus allowable deviation on a low side.

* target value: established during the field verification of mix design, 904.04.03

5. Compute the quality level:

$$PWSL = (P_u + P_L) - 100$$

Round PWSL to whole number

where:

PWSL = Percent Within Specification Limit.

P_U = percent within the upper specification limit which corresponds to a given Q_U from Table 1.

P_L = percent within the lower specification limit which corresponds to a given Q_L from Table 1.

Note:

When a USL is not specified, P_U shall be 100, and

when a LSL is not specified, P_L shall be 100.

6. Determine the Composite Mixture PWSL (CMPWSL) for each lot:

$$CMPWSL = \frac{f1\ PWSL1+f2\ PWSL2+f3\ PWSL3+f4\ PWSL4}{\Sigma f}$$

Round CMPWSL to whole number

where:

f1 .....f4 = price adjustment factors listed in the table below for the applicable property,

PWSL1 = asphalt content,

PWSL2 = aggregate passing 4.75mm / # 4 sieve

PWSL3 = aggregate passing 2.36 mm / # 8 sieve,

PWSL4 = aggregate passing 0.075 mm / # 200 sieve.

The PWSL for each property is determined from Table 1.

Σf = sum of price adjustment factors.

7. Use the following price adjustment factors (f) to compute CMPWSL:

PROPERTIES	**FACTOR (f)**
Asphalt Content (f1)	62
Aggregate passing 4.75 mm /No. 4 sieve (f2)	7
Aggregate passing 2.36 mm / No. 8 sieve (f3)	7
Aggregate passing 0.075 mm / No. 200 sieve (f4)	24

8. The CMPWSL determined in step 7 above shall be used for the Mixture Pay Factor in conformance with 504.04.02.

REPORT:

Report the PWSL and CMPWSL to the nearest whole number.

TABLE 1
QUALITY LEVEL ANALYSIS BY THE STANDARD DEVIATION METHOD

PU or PL % *	Upper Quality Index (QU) or lower Quality Index (QL)														
	N=3	n=4	n=5	n=6	n=7	n=8	N=9	n=10 To n=11	n=12 to n=14	n=15 To n=18	n=19 to n=25	n=26 To n=37	n=38 to n=69	N=70 To N=200	n=201 to n=x
100	1.16	1.50	1.79	2.03	2.23	2.39	2.53	2.65	2.83	3.03	3.20	3.38	3.54	3.70	3.83
99		1.47	1.67	1.80	1.89	1.95	2.00	2.04	2.09	2.14	2.18	2.22	2.26	2.29	2.31
98	1.15	1.44	1.60	1.70	1.76	1.81	1.84	1.86	1.91	1.93	1.96	1.99	2.01	2.03	2.05
97		1.41	1.54	1.62	1.67	1.70	1.72	1.74	1.77	1.79	1.81	1.83	1.85	1.86	1.87
96	1.14	1.38	1.49	1.55	1.59	1.61	1.63	1.65	1.67	1.68	1.70	1.71	1.73	1.74	1.75
95		1.35	1.44	1.49	1.52	1.54	1.55	1.56	1.58	1.59	1.61	1.62	1.63	1.63	1.64
94	1.13	1.32	1.39	1.43	1.46	1.47	1.48	1.49	1.50	1.51	1.52	1.53	1.54	1.55	1.55
93		1.29	1.35	1.38	1.40	1.41	1.42	1.43	1.44	1.44	1.45	1.46	1.46	1.47	1.47
92	1.12	1.26	1.31	1.33	1.35	1.36	1.36	1.37	1.37	1.38	1.39	1.39	1.40	1.40	1.40
91	1.11	1.23	1.27	1.29	1.30	1.30	1.31	1.31	1.32	1.32	1.33	1.33	1.33	1.34	1.34
90	1.10	1.20	1.23	1.24	1.25	1.25	1.26	1.26	1.26	1.27	1.27	1.27	1.28	1.28	1.28
89	1.09	1.17	1.19	1.20	1.20	1.21	1.21	1.21	1.21	1.22	1.22	1.22	1.22	1.22	1.23
88	1.07	1.14	1.15	1.16	1.16	1.16	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17	1.17
87	1.06	1.11	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.13	1.13
86	1.04	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08
85	1.03	1.05	1.05	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04
84	1.01	1.02	1.01	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.99
83	1.00	0.99	0.98	0.97	0.97	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.95	0.95	0.95
82	0.97	0.96	0.95	0.94	0.93	0.93	0.93	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
81	0.96	0.93	0.91	0.90	0.90	0.89	0.89	0.89	0.89	0.88	0.88	0.88	0.88	0.88	0.88
80	0.93	0.90	0.88	0.87	0.86	0.86	0.86	0.85	0.85	0.85	0.85	0.84	0.84	0.84	0.84
79	0.91	0.87	0.85	0.84	0.83	0.82	0.82	0.82	0.82	0.81	0.81	0.81	0.81	0.81	0.81
78	0.89	0.84	0.82	0.80	0.80	0.79	0.79	0.79	0.78	0.78	0.78	0.78	0.77	0.77	0.77
77	0.87	0.81	0.78	0.77	0.76	0.76	0.76	0.75	0.75	0.75	0.75	0.74	0.74	0.74	0.74
76	0.84	0.78	0.75	0.74	0.73	0.73	0.72	0.72	0.72	0.71	0.71	0.71	0.71	0.71	0.71
75	0.82	0.75	0.72	0.71	0.70	0.70	0.69	0.69	0.69	0.68	0.68	0.68	0.68	0.68	0.67
74	0.79	0.72	0.69	0.68	0.67	0.66	0.66	0.66	0.66	0.65	0.65	0.65	0.65	0.64	0.64
73	0.76	0.69	0.66	0.65	0.64	0.63	0.63	0.63	0.62	0.62	0.62	0.62	0.62	0.61	0.61
72	0.74	0.66	0.63	0.62	0.61	0.60	0.60	0.60	0.59	0.59	0.59	0.59	0.59	0.58	0.58
71	0.71	0.63	0.60	0.59	0.58	0.57	0.57	0.57	0.57	0.56	0.56	0.56	0.56	0.55	0.55
70	0.68	0.60	0.57	0.56	0.55	0.55	0.54	0.54	0.54	0.53	0.53	0.53	0.53	0.53	0.52
69	0.65	0.57	0.54	0.53	0.52	0.52	0.51	0.51	0.51	0.50	0.50	0.50	0.50	0.50	0.50
68	0.62	0.54	0.51	0.50	0.49	0.49	0.48	0.48	0.48	0.48	0.47	0.47	0.47	0.47	0.47
67	0.59	0.51	0.47	0.47	0.46	0.46	0.46	0.45	0.45	0.45	0.45	0.44	0.44	0.44	0.44
66	0.56	0.48	0.45	0.44	0.44	0.43	0.43	0.43	0.42	0.42	0.42	0.42	0.41	0.41	0.41
65	0.52	0.45	0.43	0.41	0.41	0.40	0.40	0.40	0.40	0.39	0.39	0.39	0.39	0.39	0.39
64	0.49	0.42	0.40	0.39	0.38	0.38	0.37	0.37	0.37	0.37	0.36	0.36	0.36	0.36	0.36
63	0.46	0.39	0.37	0.36	0.35	0.35	0.35	0.34	0.34	0.34	0.34	0.34	0.33	0.33	0.33
62	0.43	0.36	0.34	0.33	0.32	0.32	0.32	0.32	0.31	0.31	0.31	0.31	0.31	0.31	0.31
61	0.39	0.33	0.31	0.30	0.30	0.29	0.29	0.29	0.29	0.29	0.28	0.28	0.28	0.28	0.28
60	0.36	0.30	0.28	0.27	0.27	0.27	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.25	0.25
59	0.32	0.27	0.25	0.25	0.24	0.24	0.24	0.24	0.23	0.23	0.23	0.23	0.23	0.23	0.23
58	0.29	0.24	0.23	0.22	0.21	0.21	0.21	0.21	0.21	0.21	0.20	0.20	0.20	0.20	0.20
57	0.25	0.21	0.20	0.19	0.19	0.19	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
56	0.22	0.18	0.17	0.16	0.16	0.16	0.16	0.16	0.16	0.15	0.15	0.15	0.15	0.15	0.15
55	0.18	0.15	0.14	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
54	0.14	0.12	0.11	0.11	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
53	0.11	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
52	0.07	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
51	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02
50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

NOTE: For negative values of QU or QL, PU or PL is equal to 100 minus the table value for PU or PL. If the value of QU or QL does not correspond exactly to a figure in the table, use the next higher figure.

* Within limits for positive values of QU or QL.