WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

1.0 SCOPE

1.1 This procedure provides a method of estimating the percentage of each lot or sublot of material, product, item of construction, or completed construction which may be expected to be within specified tolerances.

2.0 DEFINITIONS

2.1 Xi = the individual values under consideration.

2.2 n = the number of individual values under consideration.

2.3 X = the arithmetic mean, or average of values under consideration. X may be expressed as Xi/n, or the sum of the individual values divided by the number of individual values.

2.4 R = the range, or the difference between the largest and smallest values under consideration.

2.5 Q = Quality Index, found by subtracting the average, X, from the upper or lower tolerance limit and dividing by the range, R.

2.6 P = Percent within tolerance.

3.0 PROCEDURE

3.1 Locate n sampling positions on the lot, or sublot, in a random manner.

3.2 Make a measurement at each position, or take a test portion and make the measurement on the test portion.

3.3 Average all measurements to find X.

3.4 In cases where n is less than 10, find R by subtracting the smallest value from the largest value in the group of measurements.

3.5 In cases where n is equal to or greater than 10, arrange the measurements in the order in which they were taken and divide into subgroups of 5 each. Find R for each subgroup, add these values, and divide by the number of subgroups to find R.

3.6 Find the Upper Quality Index, QUX by subtracting the-average, X, of the measurements from the upper tolerance limit, U, fnd dividing the result by R or R.

Qu = v (Equation 1)

3.4 Find the Lower Quality Index, QL, by subtracting the lower tolerance limit, L, from the average, X, and dividing by R or R.

QL = R or -R (Equation 2)

3.8 Estimate the percentage, Pus that will fall within the upper tolerance limit by entering the-tables of Attachment l, with Qu, using the column appropriate to the total number, n, . of measurements.

3.9 Estimate the percentage, PL, that will fall within the lower tolerance limit by entering the tables of Attachment 1, with QLS using the column appropriate to the total number, n, of measurements.

3.10 In cases where both Upper, U, and Lower, L, tolerance limits are concerned, the total percentage, P, of the lot or sublot estimated to fall wi-.thin tolerances is the sum of the percentage, Pu, within the upper limit, U, and the percentage, PL, within the lower limit, L, subtracted from 100.

P (Pu + PL) - 100 (Equation 3)

Gary L. Robson, Director
Materials Control, Soils
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Table 106-2

TABLE FOR ESTIMATING PERCENT OF LOT WITHIN TOLERANCE
(RANGE METHOD)
(Revised 2/68)

Percent Within Tolerance	NEGATIVE VALUES OF Q_U or Q_L												
	n=3	n=4	n=5	n=6	n=7	n=10*	n=15*	n=25*	n=30*	n=35*	n=40*	n=50*	n=60*
20	0.49	0.40	0.36	0.33	0.31	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36
19	0.50	0.42	0.37	0.34	0.32	0.37	0.37	0.37	0.37	0.37	0.38	0.38	0.38
18	0.51	0.43	0.38	0.35	0.33	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39
17	0.52	0.44	0.40	0.36	0.34	0.40	0.40	0.41	0.41	0.41	0.41	0.41	0.41
16	0.53	0.46	0.41	0.38	0.36	0.42	0.42	0.42	0.43	0.43	0.43	0.42	0.42
15	0.54	0.47	0.42	0.39	0.37	0.43	0.44	0.44	0.44	0.44	0.44	0.44	0.44
14	0.54	0.48	0.44	0.40	0.38	0.45	0.45	0.46	0.46	0.46	0.46	0.46	0.46
13	0.55	0.50	0.45	0.42	0.40	0.47	0.47	0.47	0.48	0.48	0.48	0.48	0.48
12	0.56	0.51	0.46	0.43	0.41	0.48	0.49	0.50	0.50	0.50	0.50	0.50	0.50
11	0.57	0.52	0.48	0.45	0.43	0.50	0.51	0.52	0.52	0.52	0.52	0.52	0.52
10	0.58	0.54	0.50	0.46	0.44	0.52	0.53	0.54	0.54	0.54	0.54	0.55	0.55
9	0.58	0.55	0.51	0.48	0.46	0.54	0.55	0.56	0.57	0.57	0.57	0.57	0.57
8	0.59	0.56	0.53	0.49	0.47	0.57	0.58	0.59	0.59	0.59	0.59	0.60	0.60
7	0.59	0.58	0.55	0.51	0.49	0.59	0.61	0.61	0.62	0.62	0.62	0.62	0.62
6	0.59	0.59	0.57	0.53	0.51	0.62	0.63	0.64	0.65	0.65	0.66	0.66	0.66
5	0.60	0.60	0.58	0.55	0.53	0.64	0.66	0.68	0.68	0.69	0.69	0.70	0.70
4	0.60	0.62	0.60	0.57	0.55	0.68	0.68	0.72	0.73	0.73	0.73	0.74	0.74
3	0.60	0.63	0.62	0.59	0.58	0.71	0.74	0.77	0.78	0.78	0.78	0.79	0.79
2	0.60	0.64	0.65	0.62	0.61	0.76	0.80	0.83	0.84	0.85	0.85	0.86	0.86
1	0.60	0.66	0.66	0.65	0.65	0.82	0.88	0.93	0.94	0.95	0.95	0.97	0.97

*When n ≧ 10, the samples are arranged consecutively in subgroups of five, the range (R) of each subgroup determined, and then the average range ($\bar{R}$) of all subgroups computed for use in finding Q_U or Q_L.

Table 106-3

TABLE FOR ESTIMATING PERCENT OF LOT WITHIN TOLERANCE
(RANGE METHOD)
(Revised 2/68)

Percent Within Tolerance	NEGATIVE VALUES OF Q_U or Q_L												
	n=3	n=4	n=5	n=6	n=7	n=10*	n=15*	n=25*	n=30*	n=35*	n=40*	n=50*	n=60*
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
45	0.09	0.07	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
40	0.19	0.13	0.11	0.10	0.09	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
39	0.20	0.15	0.13	0.11	0.10	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
38	0.22	0.16	0.14	0.12	0.11	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
37	0.24	0.17	0.15	0.13	0.12	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
36	0.26	0.19	0.16	0.15	0.13	0.15	0.16	0.15	0.15	0.15	0.15	0.15	0.15
35	0.27	0.20	0.17	0.16	0.14	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
34	0.29	0.21	0.18	0.17	0.15	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
33	0.31	0.23	0.19	0.18	0.16	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
32	0.32	0.24	0.21	0.19	0.17	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
31	0.34	0.26	0.22	0.20	0.18	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
30	0.36	0.27	0.23	0.21	0.19	0.22	0.22	0.22	0.23	0.23	0.23	0.23	0.23
29	0.37	0.28	0.24	0.22	0.20	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
28	0.39	0.30	0.25	0.23	0.22	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
27	0.40	0.31	0.27	0.24	0.23	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.27
26	0.41	0.32	0.28	0.25	0.24	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
25	0.43	0.34	0.29	0.27	0.25	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
24	0.44	0.35	0.30	0.28	0.26	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
23	0.46	0.36	0.32	0.29	0.27	0.32	0.32	0.31	0.31	0.32	0.32	0.32	0.32
22	0.47	0.38	0.33	0.30	0.28	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
21	0.48	0.39	0.34	0.31	0.29	0.34	0.34	0.34	0.34	0.34	0.35	0.35	0.35

*When $n \geq 10$, the samples are arranged consecutively in subgroups of five, the range (R) of each subgroup determined, and then the average range ($\bar{R}$) of all subgroups computed for use in finding Q_U or Q_L.

Table 106-4

TABLE FOR ESTIMATING PERCENT OF LOT WITHIN TOLERANCE
(RANGE METHOD)
(Revised 2/68)

Percent Within Tolerance	POSITIVE VALUES OF Q_U or Q_L												
	n=3	n=4	n=5	n=6	n=7	n=10*	n=15*	n=25*	n=30*	n=35*	n=40*	n=50*	n=60*
79	0.48	0.39	0.34	0.31	0.29	0.34	0.34	0.34	0.34	0.34	0.35	0.35	0.35
78	0.47	0.38	0.33	0.30	0.28	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
77	0.46	0.36	0.32	0.29	0.27	0.32	0.32	0.31	0.31	0.32	0.32	0.32	0.32
76	0.44	0.35	0.30	0.28	0.26	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
75	0.43	0.34	0.29	0.27	0.25	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
74	0.41	0.32	0.28	0.25	0.24	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
73	0.40	0.31	0.27	0.24	0.23	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.27
72	0.39	0.30	0.25	0.23	0.22	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
71	0.37	0.28	0.24	0.22	0.20	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
70	0.36	0.27	0.23	0.21	0.19	0.22	0.23	0.23	0.23	0.23	0.23	0.23	0.23
69	0.34	0.26	0.22	0.20	0.18	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
68	0.32	0.24	0.21	0.19	0.17	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
67	0.31	0.23	0.19	0.18	0.16	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19
66	0.29	0.21	0.18	0.17	0.15	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
65	0.27	0.20	0.17	0.16	0.14	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
64	0.26	0.19	0.16	0.15	0.13	0.15	0.16	0.15	0.15	0.15	0.15	0.15	0.15
63	0.24	0.17	0.15	0.13	0.12	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
62	0.22	0.16	0.14	0.12	0.11	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
61	0.20	0.15	0.13	0.11	0.10	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
60	0.19	0.13	0.11	0.10	0.09	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
55	0.09	0.07	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
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

*When $n \geq 10$, the samples are arranged consecutively in subgroups of five, the range (R) of each subgroup determined, and then the average range ($\bar{R}$) of all subgroups computed for use in finding Q_U or Q_L.

Table 106-5

TABLE FOR ESTIMATING PERCENT OF LOT WITHIN TOLERANCE
(RANGE METHOD)
(Revised 2/68)

Percent Within Tolerance	POSITIVE VALUES OF Q_U or Q_L												
	n=3	n=4	n=5	n=6	n=7	n=10*	n=15*	n=25*	n=30*	n=35*	n=40*	n=50*	n=60*
99	0.60	0.66	0.66	0.65	0.65	0.82	0.88	0.93	0.94	0.95	0.95	0.97	0.97
98	0.60	0.64	0.65	0.62	0.61	0.76	0.80	0.83	0.84	0.85	0.85	0.86	0.86
97	0.60	0.63	0.62	0.59	0.58	0.71	0.74	0.77	0.78	0.78	0.78	0.79	0.79
96	0.60	0.62	0.60	0.57	0.55	0.68	0.68	0.72	0.73	0.73	0.73	0.74	0.74
95	0.60	0.60	0.58	0.55	0.53	0.64	0.66	0.68	0.68	0.69	0.69	0.70	0.70
94	0.59	0.59	0.57	0.53	0.51	0.62	0.63	0.64	0.65	0.65	0.65	0.66	0.66
93	0.59	0.58	0.55	0.51	0.49	0.59	0.61	0.61	0.62	0.62	0.62	0.62	0.62
92	0.59	0.56	0.53	0.49	0.47	0.57	0.58	0.59	0.59	0.59	0.59	0.60	0.60
91	0.58	0.55	0.51	0.48	0.46	0.54	0.55	0.56	0.57	0.57	0.57	0.57	0.57
90	0.58	0.54	0.50	0.46	0.44	0.52	0.53	0.54	0.54	0.54	0.54	0.55	0.55
89	0.57	0.52	0.48	0.45	0.43	0.50	0.51	0.52	0.52	0.52	0.52	0.52	0.52
88	0.56	0.51	0.46	0.43	0.41	0.48	0.49	0.50	0.50	0.50	0.50	0.50	0.50
87	0.55	0.50	0.45	0.42	0.40	0.47	0.47	0.47	0.48	0.48	0.48	0.48	0.48
86	0.54	0.48	0.44	0.40	0.38	0.45	0.45	0.46	0.46	0.46	0.46	0.46	0.46
85	0.54	0.47	0.42	0.39	0.37	0.43	0.44	0.44	0.44	0.44	0.44	0.44	0.44
84	0.53	0.46	0.41	0.38	0.36	0.42	0.42	0.42	0.43	0.43	0.43	0.42	0.42
83	0.52	0.44	0.40	0.36	0.34	0.40	0.40	0.41	0.41	0.41	0.41	0.41	0.41
82	0.51	0.43	0.38	0.35	0.33	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39
81	0.50	0.42	0.37	0.34	0.32	0.37	0.37	0.37	0.37	0.37	0.38	0.38	0.38
80	0.49	0.40	0.36	0.33	0.31	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36

*When $n \geq 10$, the samples are arranged consecutively in subgroups of five, the range (R) of each subgroup determined, and then the average range ($\bar{R}$) of all subgroups computed for use in finding Q_U or Q_L.