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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.

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- 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 I, 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.

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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)

L. Robson, Director ials Control, Soils Director Mater and Testing Division

Table 196-2

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

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1.010

Percent Within Toleranco	n=3	n=4	n=5	n=6	NEGA	NEGATIVE VALUES OF QU or QL 7 n=10 th n=15 th n=25 th	n=15%	-0-0-0	or Q _L	=25° n=30°		n=30*	n=30* n=35*
07	0.49	0.40	0.36	0.35	0.31	0.50	0.30	c	.30		0.30	0.30 0.30 0.	0.30 0.30 0.30
19	0.50	0.42	0.37	0.34	0.32	0.37	0.37	0	.37	0.	0.37	0.37 0.37 0.	0.37 0.37 0.38 0.38
18	0.51	0.43	0.38	0.35	0.33	0.39	0.39	0		0	0.39	. 0.39 0.39 0.	" 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	0.41	0.41 0.41 0.
16	0.53	0.46	0.41	0.38	0.36	0.42	0.42	٠	0.42	0	0.43	0.43 0.43 0.	0.43 0.43 0.43
15	0.54	0.47	0.42	0.39	0.37	0.43	0.44		0.44		0.44	0.44 0.44 0.	0.44 0.44 0.44 0.
F	0.54	0.48	0.44	0.40	0.38	0.45	0.45		0.46		0.46	0.46 0.46 0.	0.46 0.46 0.46 0.
13	0.55	0.50	0.45	0.42	0.40	0.47	0.47	~	0.47	0.47 0.48		0.48	0.48 0.48 0.
12	0.56	0.51	0.46	0.43	0.41	0.48	0.49		0.50		0.50	0.50 0.50 0.	0.50 0.50 0.50 0.
Ξ	0.57	0.52	0.48	0.45	0.43	0.50	0.51		0.52		0.52	0.52 0.52 0.	0.52 0.52 0.52 0.
Iq	0.58	0.54	0.50	0.46	0.44	0.52	0.53	~	0.54		0-54	0.54 0.54 0.5	0.54 0.54 0.54 0.
9	0.58	0.55	0.51	0.48	0.46	0.54	0.55	0	.56		0.57	0.57 0.57 0.5	0.57 0.57 0.57 0.
8	0.59	0.56	0.53	0.49	0.47	0.57	0.58	0	. 59	.59 0.59	0.59	0.53 0.59 0.5	0.53 0.59 0.59 0.
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 0.6
6	0.59	0.59	0.57	0.53	0.51	0.62	0.63	. 0	0.64	.64 0.65	0.65	0.65 0.65 0.6	0.65 0.65 0.66 0.
5	0.60	0.60	0.58	0.55	0.53	0.64	0.66	0	0.68	.68 0.68		0.68	0.68 0.69 0.6
4	0.60	0.62	0.60	0.57	0.55	0.68	0.68	0	. 72		0.73	0.73 0.73 0.7	0.73 0.73 0.73 0.
ω	0.60	0.63	0.62	0.59	0.58	0.71	0.74		0.77		0.78	0.78 0.78 0.7	0.78 0.78 0.78 0.
2	0.60	0.64	0.65	0.62	0.61	0.76	0.80		0.83		0.84	0.84 0.85 0.8	0.84 0.85 0.85 0.
-	0.60	0.66	0.66	0.65	0.65	0.82	0.88		0.93		0.94	0.94 0.95 0.9	0.94 0.95 0.95 0.
	≪When n subgro	≧ 10, up dete	When n ≧ 10, the samples subgroup determined, and		are arranged consecutively then the average range (R)	consecut rage rang	(R)	in s	ubgrou 11 sub	ubgroups of f 11 subgroups (subgroups of five, the all subgroups computed		

	25 24 23 21 21 0 0	30 239 28 27 26 0 26 0	32 33 4 0 0	337 0. 0. 0.	Percent Vithin Tolerance	a the
subgroup	0.43 0.44 0.46 0.47 0.47	0.36 0.37 0.40 0.41	0.27 0.29 0.31 0.32 0.32	0.09 0.19 0.20 0.22 0.24 0.24	n=3	
lo,	0.34 0.35 0.38 0.39	0.27 0.28 0.30 0.31 0.31	0.20 0.21 0.23 0.24 0.26	0.07 0.13 0.15 0.16 0.17 0.19	0.00	
the samples rmined, and	0.30	0.23 0.24 0.25 0.27 0.28	0.17 0.18 0.19 0.21 0.22	0.11 0.11 0.13 0.14	0.00	
are ar then t	0.27 0.28 0.29 0.30 0.31	0.21 0.22 0.23 0.24 0.25	0.16 0.17 0.18 0.19 0.20	0.05 0.10 0.11 0.12 0.12 0.13	n-6	(RANGE METHOD (Revised 2/68
ranged o he avera	0.25 0.26 0.27 0.28 0.29	0.19 0.20 0.22 0.23 0.23	0.14 0.15 0.16 0.17 0.18	0.05 0.09 0.11 0.12 0.13	NEGA n=7 0.00	
are arranged consecutively then the average range (R)	0.29 0.30 0.32 0.33 0.34	0.22 0.24 0.25 0.26 0.28	0.117 0.18 0.19 0.20 0.21	0.05 0.11 0.12 0.13 0.14	NEGATIVE VALUES	(RANGE METHOD) (Revised 2/68)
vely in (R) of	0.29 0.30 0.32 0.33 0.34	0.22 0.24 0.25 0.26 0.28	0.17 0.18 0.19 0.20 0.21	0.05 0.11 0.12 0.13 0.14 0.14	.00 PF	
subgroups of five, the all subgroups computed	0.29 0.30 0.31 0.33 0.34	0.22 0.24 0.25 0.25 0.26 0.28	0.17 0.18 0.20 0.21	0.05 0.11 0.12 0.13 0.14	Q _U or Q _L * n=25* 0.00	
s of five roups cor	0.29 0.30 0.31 0.33 0.34	0.23 0.24 0.25 0.26 0.28	0.17 0.18 0.19 0.20 0.21	0.11 0.11 0.12 0.15	n-30*	or contract
	0.29 0.30 0.32 0.33	0.23 0.24 0.25 0.26 0.28	0.17 0.18 0.20 0.21	0.05 0.11 0.12 0.13 0.14 0.14	n=35*	
range (R) for use ir	0.29 0.30 0.32 0.33	0.23 0.24 0.25 0.26 0.28	0.17 0.18 0.19 0.20 0.21	0.05 0.11 0.12 0.13	n=40*	REISSUED: JANUARY ATTACHMENT 1 PAGE 2 of 4
ge (R) of each use in finding	0.29 0.30 0.32 0.33	0.23 0.24 0.25 0.26 0.28	0.117 0.18 0.19 0.20 0.21	0.11 0.12 0.14	n=50☆	10 200
	0.29	0.23 0.24 0.25 0.27 0.28	0.17 0.18 0.20 0.21	0:05 0.11 0.12 0.14 0.15	n=60%	1995

					R (R	(RANGE METHOD) (Revised 2/68)	(68)			PAC	ATTACHMENT I PAGE 3 of 4	-	
Percent					POSI	POSITIVE VALUES	UES OF QU	u or QL					
Tolerance	n=3	n-4	S=u	n=6	n=7	n=10*	n=15*	1	n=30#	n=35\$	n=40:	-	n=50*
79	0.48	0.39	0.34	0.31	0.29	0.34	0.34	0.34	0.34		0.35	- 1	35
78	0.47	0.38	0.33	0.30	0.28	0.33	0.33	0.33	0.33	0.33	0.33	~ .	1
77	0.46	0.36	0.32	0.29	0.27	0.32	0.32	0.31	22		0.32	~	22
76	0.44	0.35	0.30	0.28	0.26	0.30	0.30	0.30	0.30		0.30	~ .	3
75	0.43	0.34	0.29	0.27	0.25	0.29	0.29	0.29 ,	0.29	0.29	0.29	0	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
73	0.40	0.31	0.27	0.24	0.23	0.26	0.26	. 0.26	0.26		0.26	0	0.26
72	0.39	0.30	0.25	0.23	0.22	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
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
69	0.34	0.26	0.22	0.20	0.18	0.21	0.21	0.21	0.21	0.21	0.21	0	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
67	0.31	0.23	0.19	0.18	0.16	0.19	0.19	0.19	0.19	0.19	0.19	•	. 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	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	0.17
64	0.26	0.19	0.16	0.15	0.13	0.15	0.16	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	0.14
62	0.22	0.16	0.14	0.12	0.11	0.13	0.13	0.13		0.13		0	
61	0.20	0.15	0.13	0.11	0.10	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	
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
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
	≪When n ≥		10, the samples determined. and	are a	are arranged consecutively then the average range (R)	onsecut l	°, i	subgroup all subo	subgroups of five, all subgroups compu	the	range (R) of each for use in finding	20	of each findin

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Table 106-5

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

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Percent						TOOLITEL THEORY OF		A A	ŕ				
Vithin Tolerance n=3	e n=3	hen	5=U	n=6	n=7	n= 10%	n= 15*	n= 25#	n= 30*	n=35≏	n=40*	n≈ 50*	n= 604
									a a.	0	000		0 97
99	0.60	0.66	0.55	0.65	0.65	0.02	0.00	0.90		21			
93	0.60	0.64	0.65	0.62	0.61	0.76	0.80	0.83	0.84	0	0.85	0.86.	1.00
97	0.60	0.63	0.62	0.59	0.58	0.71	0.74	0.77	0.78	~	0.78	0.79	0.79
0	0 60	0 63	0 60	0.57	0.55	0.68	0.68	0.72	0.73	~	0.73	0.74	0.74
22	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
oL	0 20	0 20	0.57	0.53	0.51	0.62	0.63	0.64	0.65	0.65	0.65	0.66	0.66
5.	0.00	0 10	0.55	0.51	0.49	0.59	0.61	0.61	0.62	0.62	0.62	0.62	0.62
32	0.00	0.75	0.52	0 49	0.47	0.57	0:58	0.59	0.59	0.59	0.59	0.60	0.60
		0.00	5	0 48	0.46	0.54	0.55	0.56	0.57	0.57	0.57	0.57	0.57
9	0.53	0.54	0.50	0.46	. 0.44	0.52	0.53	0.54	0.54	0.54	0.54	0.55	0.55
})]	2				5		0 53	0.53	0.52	0.52	0.52	0.52
09	0.9/	0.94	0.40			0.10	0 10	5	0 50	0.50	0.50	0.50	0.50
00	0.50	0.51	0.40	0.10			2.2	1.10	0 48	0 1.2	0.48	0.48	0.48
287	0.55	0.50	0.45	0.42	0.40	0.47	0.4	0.1	0.10	0.10		0 16	0 46
36	0.54	0.48	0.44	0.40	0.38	0.45	0.45	0.45	0.40	0.40	0.40	0.40	0.10
53	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
2	0 53	0 46	0.41	0.38	0.36	0.42	0.42	0.42		0.43	0.43	0.42	0.42
	5	0 44	0.40	0.36	0.34	0.40	0.40	0.41		0.41	0.41	0.41	0.41
8.0	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
20	50.50	0 42	0.35	0.34	0.32	0.37	0.37	0.37		0.37	0.38	0.38	0.38
	0.10	0 10	0.36	0.33	0.31	0.36	0.36	0.36		0.36	0.36	0.36	0.36
	#When n ≧	, ≧ 10,	the samples		are arranged consecutively	consecu	tively	in subg	subgroups of five,	five, the		(R) of each	ich.
	subgroup Q _{II} or Q _I .		determined, and		then the average range (\overline{R})	ner age.	ge (R)		all subgroups comp	computed	for us	for use in finding	gnig

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