INFORMATION: Engineering Brief No. 57   May 19, 1999
EXTENDED Q-VALUE TABLE FOR ESTIMATING
PERCENT OF LOT WITHIN LIMITS (PWL)

Manager, Engineering and
  Specifications Division, AAS-200

All Regions
ATTN: Manager, Airports Division and
          AMA-600

Engineering Brief No. 57 provides an extended table of quality
index (Q) values when the number of measurements exceeds eight
when evaluating material using the method of estimating
percentage of material within specification limits (PWL). The
values in the extended table should be used in accordance with
guidance found in General Provision Section 110 of
AC 150/5370-10, STANDARDS FOR SPECIFYING CONSTRUCTION OF
AIRPORTS.

Any comments you have concerning this brief will be appreciated.

ORIGINAL SIGNED BY

John L. Rice

Attachment

ENGINEERING BRIEF NO. 57   EXTENDED Q-VALUE TABLE FOR ESTIMATING
PERCENT OF LOT WITHIN LIMITS (PWL)

1. PURPOSE. The purpose of this engineering brief is to provide an extended table of
quality index (Q) values when the number of measurements exceeds eight when
evaluating material using the method of estimating percentage of material within
specification limits (PWL). The values in the extended table should be used in
accordance with guidance found in General Provision Section 110 of AC 150/5370-10,
STANDARDS FOR SPECIFYING CONSTRUCTION OF AIRPORTS.

2. BACKGROUND. From time to time, the number of measurements used to
determine the PWL of material in a lot exceeds the limits of the table provided in
AC 150/5370-10. When this happens, this office has provided additional statistical
information as published in FP-85 Standard Specifications for Construction of Roads
and Bridges on Federal Highway Projects, 1985, U.S. Department of Transportation,
Federal Highway Administration (FHWA). Revision to the FHWA publication indicate
that the percent within limits table had been replaced with a table based on percent
defective. The possible limited availability of the previous table was a consideration in
issuing this brief.

3. DERIVATION. The table presented herein was derived by using the formula for the
best - uniformly minimum variance unbiased (UMVA) - estimate of the percentage of a
lot of material above (or below) a specification tolerance limit in an Excel™ spreadsheet.
The equations used to develop the table were a key element in the development of
U.S. Department of Defense MIL-STD 414 (1957). They have been reported in books
on statistics as well as research reports on statistical acceptance plans. The equations
used in this brief were obtained from DOT/FAA/RD-90/15 Development of Acceptance
Plans for Airport Pavement Materials, Foster, J.E., and Majidzadeh, K., 1990. The
equations are:

$$PWL = 100 \times \left\{ 1 - \int_{0}^{A} beta(X; n/2 - 1) dX \right\}$$

where,

PWL = percent within limits
A = max [0, 1/2 - 1/2 $\times$ Q $\times$ ($n^{1/2}$/n-1)] where Q = quality index
X = sample (sublot value)
beta =(X; n/2-1) =   beta distribution density with $\alpha = \beta = n/2-1$ where α and β are
                                parameters of the beta distribution

The extended table lists Q-values for n=9 through n=16.

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Jeffrey L Rapol
Civil Engineer

TABLE 1 EXTENDED. TABLE FOR ESTIMATING PERCENT OF LOT WITHIN LIMITS (PWL)

PWL, P_L and P_U	Positive Values of Q, Q_L and Q_U							
	n=9	n=10	n=11	n=12	n=13	n=14	n=15	n=16
99	1.9994	2.0362	2.0656	2.0897	2.1096	2.1265	2.1409	2.1534
98	1.8379	1.8630	1.8828	1.8989	1.9122	1.9234	1.9329	1.9412
97	1.7235	1.7420	1.7566	1.7684	1.7781	1.7863	1.7933	1.7993
96	1.6313	1.6454	1.6566	1.6655	1.6729	1.6791	1.6844	1.6890
95	1.5525	1.5635	1.5721	1.5790	1.5847	1.5895	1.5936	1.5971
94	1.4829	1.4914	1.4981	1.5035	1.5079	1.5116	1.5148	1.5175
93	1.4199	1.4265	1.4316	1.4358	1.4392	1.4421	1.4446	1.4467
92	1.3620	1.3670	1.3709	1.3741	1.3767	1.3789	1.3808	1.3825
91	1.3081	1.3118	1.3148	1.3172	1.3191	1.3208	1.3222	1.3234
90	1.2576	1.2602	1.2623	1.2640	1.2654	1.2666	1.2677	1.2686
89	1.2098	1.2115	1.2129	1.2141	1.2150	1.2158	1.2165	1.2172
88	1.1643	1.1653	1.1661	1.1668	1.1673	1.1678	1.1683	1.1686
87	1.1208	1.1212	1.1215	1.1217	1.1220	1.1222	1.1224	1.1226
86	1.0791	1.0789	1.0788	1.0787	1.0787	1.0787	1.0787	1.0787
85	1.0389	1.0382	1.0377	1.0374	1.0371	1.0369	1.0368	1.0366
84	1.0000	0.9990	0.9982	0.9976	0.9971	0.9968	0.9965	0.9962
83	0.9624	0.9610	0.9599	0.9591	0.9585	0.9580	0.9576	0.9572
82	0.9258	0.9241	0.9228	0.9219	0.9211	0.9205	0.9200	0.9195
81	0.8901	0.8882	0.8868	0.8857	0.8848	0.8841	0.8835	0.8830
80	0.8554	0.8533	0.8517	0.8505	0.8495	0.8487	0.8480	0.8475
79	0.8214	0.8192	0.8175	0.8161	0.8151	0.8142	0.8135	0.8129
78	0.7882	0.7858	0.7840	0.7826	0.7815	0.7806	0.7798	0.7792
77	0.7556	0.7531	0.7513	0.7498	0.7486	0.7477	0.7469	0.7462
76	0.7236	0.7211	0.7192	0.7177	0.7165	0.7155	0.7147	0.7140
75	0.6922	0.6896	0.6876	0.6861	0.6849	0.6839	0.6831	0.6824
74	0.6613	0.6587	0.6567	0.6551	0.6539	0.6529	0.6521	0.6514
73	0.6308	0.6282	0.6262	0.6247	0.6234	0.6224	0.6216	0.6209
72	0.6008	0.5982	0.5962	0.5947	0.5935	0.5925	0.5916	0.5909
71	0.5712	0.5686	0.5667	0.5651	0.5639	0.5629	0.5621	0.5614
70	0.5419	0.5394	0.5375	0.5360	0.5348	0.5338	0.5330	0.5323
69	0.5130	0.5105	0.5086	0.5072	0.5060	0.5051	0.5043	0.5036
68	0.4844	0.4820	0.4802	0.4787	0.4776	0.4767	0.4759	0.4752
67	0.4560	0.4537	0.4520	0.4506	0.4495	0.4486	0.4479	0.4472
66	0.4280	0.4257	0.4241	0.4227	0.4217	0.4208	0.4201	0.4195
65	0.4001	0.3980	0.3964	0.3951	0.3941	0.3933	0.3926	0.3920
64	0.3725	0.3705	0.3690	0.3678	0.3668	0.3661	0.3654	0.3649
63	0.3451	0.3432	0.3418	0.3407	0.3398	0.3390	0.3384	0.3379
62	0.3179	0.3161	0.3148	0.3137	0.3129	0.3122	0.3116	0.3111
61	0.2908	0.2892	0.2880	0.2870	0.2862	0.2856	0.2850	0.2846
60	0.2639	0.2624	0.2613	0.2604	0.2597	0.2591	0.2586	0.2582
59	0.2372	0.2358	0.2348	0.2339	0.2333	0.2328	0.2323	0.2319
58	0.2105	0.2093	0.2084	0.2076	0.2070	0.2066	0.2062	0.2058
57	0.1840	0.1829	0.1821	0.1814	0.1809	0.1805	0.1801	0.1798
56	0.1575	0.1566	0.1559	0.1553	0.1549	0.1545	0.1542	0.1540
55	0.1312	0.1304	0.1298	0.1293	0.1289	0.1286	0.1284	0.1282
54	0.1049	0.1042	0.1037	0.1034	0.1031	0.1028	0.1026	0.1025
53	0.0786	0.0781	0.0778	0.0775	0.0773	0.0771	0.0769	0.0768
52	0.0524	0.0521	0.0518	0.0516	0.0515	0.0514	0.0513	0.0512
51	0.0262	0.0260	0.0259	0.0258	0.0257	0.0257	0.0256	0.0256
50	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

TABLE 1 EXTENDED. TABLE FOR ESTIMATING PERCENT OF LOT WITHIN LIMITS (PWL)

PWL, P_L and P_U	Negative Values of Q, Q_L and Q_U							
	n=9	n=10	n=11	n=12	n=13	n=14	n=15	n=16
49	-0.0262	-0.0260	-0.0259	-0.0258	-0.0257	-0.0257	-0.0256	-0.0256
48	-0.0524	-0.0521	-0.0518	-0.0516	-0.0515	-0.0514	-0.0513	-0.0512
47	-0.0786	-0.0781	-0.0778	-0.0775	-0.0773	-0.0771	-0.0769	-0.0768
46	-0.1049	-0.1042	-0.1037	-0.1034	-0.1031	-0.1028	-0.1026	-0.1025
45	-0.1312	-0.1304	-0.1298	-0.1293	-0.1289	-0.1286	-0.1284	-0.1282
44	-0.1575	-0.1566	-0.1559	-0.1553	-0.1549	-0.1545	-0.1542	-0.1540
43	-0.1840	-0.1829	-0.1821	-0.1814	-0.1809	-0.1805	-0.1801	-0.1798
42	-0.2105	-0.2093	-0.2084	-0.2076	-0.2070	-0.2066	-0.2062	-0.2058
41	-0.2372	-0.2358	-0.2348	-0.2339	-0.2333	-0.2328	-0.2323	-0.2319
40	-0.2639	-0.2624	-0.2613	-0.2604	-0.2597	-0.2591	-0.2586	-0.2582
39	-0.2908	-0.2892	-0.2880	-0.2870	-0.2862	-0.2856	-0.2850	-0.2846
38	-0.3179	-0.3161	-0.3148	-0.3137	-0.3129	-0.3122	-0.3116	-0.3111
37	-0.3451	-0.3432	-0.3418	-0.3407	-0.3398	-0.3390	-0.3384	-0.3379
36	-0.3725	-0.3705	-0.3690	-0.3678	-0.3668	-0.3661	-0.3654	-0.3649
35	-0.4001	-0.3980	-0.3964	-0.3951	-0.3941	-0.3933	-0.3926	-0.3920
34	-0.4280	-0.4257	-0.4241	-0.4227	-0.4217	-0.4208	-0.4201	-0.4195
33	-0.4560	-0.4537	-0.4520	-0.4506	-0.4495	-0.4486	-0.4479	-0.4472
32	-0.4844	-0.4820	-0.4802	-0.4787	-0.4776	-0.4767	-0.4759	-0.4752
31	-0.5130	-0.5105	-0.5086	-0.5072	-0.5060	-0.5051	-0.5043	-0.5036
30	-0.5419	-0.5394	-0.5375	-0.5360	-0.5348	-0.5338	-0.5330	-0.5323
29	-0.5712	-0.5686	-0.5667	-0.5651	-0.5639	-0.5629	-0.5621	-0.5614
28	-0.6008	-0.5982	-0.5962	-0.5947	-0.5935	-0.5925	-0.5916	-0.5909
27	-0.6308	-0.6282	-0.6262	-0.6247	-0.6234	-0.6224	-0.6216	-0.6209
26	-0.6613	-0.6587	-0.6567	-0.6551	-0.6539	-0.6529	-0.6521	-0.6514
25	-0.6922	-0.6896	-0.6876	-0.6861	-0.6849	-0.6839	-0.6831	-0.6824
24	-0.7236	-0.7211	-0.7192	-0.7177	-0.7165	-0.7155	-0.7147	-0.7140
23	-0.7556	-0.7531	-0.7513	-0.7498	-0.7486	-0.7477	-0.7469	-0.7462
22	-0.7882	-0.7858	-0.7840	-0.7826	-0.7815	-0.7806	-0.7798	-0.7792
21	-0.8214	-0.8192	-0.8175	-0.8161	-0.8151	-0.8142	-0.8135	-0.8129
20	-0.8554	-0.8533	-0.8517	-0.8505	-0.8495	-0.8487	-0.8480	-0.8475
19	-0.8901	-0.8882	-0.8868	-0.8857	-0.8848	-0.8841	-0.8835	-0.8830
18	-0.9258	-0.9241	-0.9228	-0.9219	-0.9211	-0.9205	-0.9200	-0.9195
17	-0.9624	-0.9610	-0.9599	-0.9591	-0.9585	-0.9580	-0.9576	-0.9572
16	-1.0000	-0.9990	-0.9982	-0.9976	-0.9971	-0.9968	-0.9965	-0.9962
15	-1.0389	-1.0382	-1.0377	-1.0374	-1.0371	-1.0369	-1.0368	-1.0366
14	-1.0791	-1.0789	-1.0788	-1.0787	-1.0787	-1.0787	-1.0787	-1.0787
13	-1.1208	-1.1212	-1.1215	-1.1217	-1.1220	-1.1222	-1.1224	-1.1226
12	-1.1643	-1.1653	-1.1661	-1.1668	-1.1673	-1.1678	-1.1683	-1.1686
11	-1.2098	-1.2115	-1.2129	-1.2141	-1.2150	-1.2158	-1.2165	-1.2172
10	-1.2576	-1.2602	-1.2623	-1.2640	-1.2654	-1.2666	-1.2677	-1.2686
9	-1.3081	-1.3118	-1.3148	-1.3172	-1.3191	-1.3208	-1.3222	-1.3234
8	-1.3620	-1.3670	-1.3709	-1.3741	-1.3767	-1.3789	-1.3808	-1.3825
7	-1.4199	-1.4265	-1.4316	-1.4358	-1.4392	-1.4421	-1.4446	-1.4467
6	-1.4829	-1.4914	-1.4981	-1.5035	-1.5079	-1.5116	-1.5148	-1.5175
5	-1.5525	-1.5635	-1.5721	-1.5790	-1.5847	-1.5895	-1.5936	-1.5971
4	-1.6313	-1.6454	-1.6566	-1.6655	-1.6729	-1.6791	-1.6844	-1.6890
3	-1.7235	-1.7420	-1.7566	-1.7684	-1.7781	-1.7863	-1.7933	-1.7993
2	-1.8379	-1.8630	-1.8828	-1.8989	-1.9122	-1.9234	-1.9329	-1.9412
1	-1.9994	-2.0362	-2.0656	-2.0897	-2.1096	-2.1265	-2.1409	-2.1534