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Construction of Modified Quick Switching Variable Sampling System Indexed By Crossover Point

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Abstract: This article gives the construction procedure of Modified Quick Switching Variables System indexed by crossover point. The modified Quick Switching System are designated as QSVSS-2 (n; k_N, k_T). The construction of the plan based on normal distribution for given p_c and h_c are provided. The QSVSS-2 has constructed through known and unknown sigma method.

Keyword: Modified Quick Switching System, Variable Sampling Plan, OC function, Crossover point(p_c) and Relative slope(h_c).

I. Introduction

In the situation of huge product manufacturing industries, follow the QSS procedure for reducing product and get the defect at the manufacturing time. The concept of Quick Switching System (QSS-1) was introduced by Dodge (1967). Later QSS was investigated by Romboski (1969), Govintharaju (1991), Devaraj Arumainayagam (1991) and Taylor (1992). Romboski (1969) had studied the QSS-1 by taking Single Sampling Plan as a reference plan. Based on the study he made some modifications in the switching rules of Quick Switching System. The modified systems are designated as QSS- r (r = 2, 3 and 4). Soundharajan and Arumainayagam (1988) studied the properties of this modified System. Senthilkumar at el (2012) studied the designing Quick Switching Variable System indexed by Crossover Point. Senthilkumar and Esha Raffie (2014) studied crossover point for two-plan variables scheme. Senthilkumar and Esha Raffie (2017) also studied six sigma modified quick switching variables sampling system.

This article states the construction procedure of Modified Quick Switching Variables System [QSVSS-2 (n_σ; k_N, k_T)] indexed by crossover point. Tables are constructed for known and unknown sigma method and given p_c and h_c are provided.

II. QSS Variable Sampling System of type QSVSS-2 (n; k_N, k_T)

The condition and assumptions under which the QSVSS-2 can be applied are as follows:

Conditions for Application

- Production is steady so that the results on current, preceding and succeeding lots are broadly indicative of a continuing process.
- Lots are submitted substantially in the order of production.
- Normally lots are expected to be essentially of the same quality.
- Inspection by variables, with quality defined as the fraction non-conforming.

Basic Assumptions

- The quality characteristic is represented by a random variable x measurable on a continuous scale.
- Distribution of x is normal with mean and Standard deviation.
- An upper limit U, has been specified and a item is qualified as defective when x > U. [When the lower limit L is specified, the product is a defective one if x < L].
- The purpose of inspection is to control the fraction defective f in the lot inspected.

When the conditions listed above are satisfied the fraction defective in a lot will be defined by

$$p = 1-F(v) = F(-v)$$

With

$$v = \left(\frac{U-\mu}{\sigma}\right)$$

and
$$F(y) = \int_{-\infty}^{y_1} \frac{1}{\sqrt{2\pi}} e^{-z^2/2} dz \tag{1}$$

Where z ~N (0, 1). It is to be recalled here that the criterion for the σ-method variable plan is to accept the lot if $\bar{x} + k_\sigma \leq U$, where U is the upper specification limit or $\bar{x} + k_\sigma \geq L$ where L is the lower specification limit. The operating procedure of QSVSS (n; k_N, k_T) is given below.

III. Operating Procedure

The steps involved in this procedure is as follows

Step 1: Take a sample of size n_σ from the population. Inspect each unit and record the measurement of the quality characteristic of the sample. Compute the sample mean ($\bar{x}$).

Step 2: If $\bar{x} + k_{N\sigma} \leq U$ or $\bar{x} + k_{N\sigma} \geq L$ accept the lot and repeat step 1 otherwise go to step 3.

Step 3: Take a sample of size n_σ from the next lot and inspect each unit and record the measurement of the quality characteristic of the sample. Calculate the sample mean ($\bar{x}$).

Step 4: If $\bar{x} + k_{T\sigma} \leq U$ or $\bar{x} + k_{T\sigma} \geq L$ accept the lot and go to step 1 otherwise repeat step 3.

Where k_N and k_T are the acceptance criterion. Where ($\bar{x}$) and σ are the average quality characteristic and standard deviation in that order derived from the population.

IV. Operating Characteristic Function

According to Romboski (1969), the OC function of Crossover Point for QSS is given by

$$P_a(p_c) = \frac{1}{2}(P_N + P_T) \tag{2}$$

Romboski (1969) derived the OC function of the QSS-r (n; c_N, c_T), r=2. Based on this, the OC function of QSVSS-2 (n_σ; k_N, k_T) is respectively given as

$$P_a(p) = \frac{\phi(W_N)\phi(W_T)\phi(W_T) + \phi(W_T)(1-\phi(W_N))(1+\phi(W_T))}{\phi(W_T)\phi(W_T) + (1-\phi(W_N))(1+\phi(W_T))} \tag{3}$$

With $W_N = \sqrt{n_\sigma}(U - k_N - \mu)/\sigma = (v - k_N)\sqrt{n_\sigma}$

$W_T = \sqrt{n_\sigma}(U - k_T - \mu)/\sigma = (v - k_T)\sqrt{n_\sigma}$

Under the assumption of normal approximation to the non-central t distribution (Abramowitz and Stegun, 1964), the value of $\phi(W_N)$ and $\phi(W_T)$ are respectively given as

$$\phi(W_N) = \Pr[(U - \bar{X})/\sigma > k_N]$$

$$\phi(W_T) = \Pr[(U - \bar{X})/\sigma > k_T]$$

Where $\phi(W_N)$ and $\phi(W_T)$ are the proportions of lots expected to be accepted using normal (n_σ; k_N) and tightened (n_σ; k_T) variable single sampling plan respectively given by

$$P_N = F(W_N) = \Pr[(U - \bar{x})/\sigma > k_N] \tag{4}$$

$$P_T = F(W_T) = \Pr[(U - \bar{x})/\sigma > k_T] \tag{5}$$

Where, P_N and P_T are the proportions of lots expected to be accepted using normal (n_σ, k_N) and tightened (n_σ, k_T) variable single sampling plans respectively. These two equations are applied in the OC function of QSS (n_σ, c_N, c_T). We obtain the following

$$P_a(p) = \frac{\Pr[(U - \bar{x})/\sigma > k_T}{1 - \Pr[(U - \bar{x})/\sigma > k_N] + \Pr[(U - \bar{x})/\sigma > k_T]} \tag{6}$$

The relative slope at p_c, known as h_c is used to measure the discriminating power of the OC curve. In symbolic terms, the h_c of MQSVSS (n_σ; $k_{N\sigma}$, $k_{T\sigma}$) is such that

$$h_c = -\frac{p}{P_a(p)} \frac{dP_a(p)}{dp} \quad at \quad p = p_c \tag{7}$$

Where, $$\frac{dP_a(p)}{dp} = \frac{(1-P_N+P_T)P_T^{'}+P_T(P_N^{'}-P_T^{'})}{(1-P_N+P_T)^2} \quad at \quad p = p_c$$

In which $$P_T(p) = \int_{-\infty}^{W_T} \frac{1}{\sqrt{2\pi}} e^{-z^2/2} dz \text{ and } P_N(p) = \int_{-\infty}^{W_N} \frac{1}{\sqrt{2\pi}} e^{-z^2/2} dz$$

With $$P_T = (v - k_T)\sqrt{n} \quad and \quad P_N = (v - k_N)\sqrt{n}$$

and $$P_T^{'}(p) = \sqrt{n \exp(v^2 - w_T^2)} \quad \& \quad P_N^{'}(p) = \sqrt{n \exp(v^2 - w_N^2)}$$

V. Designing QSVSS-2 (n□; k_N, k_T) system for given p_c and h_c

From table 1, a method of designing of Modified Quick Switching Variable Sampling System for given values COP is indicated below.

Table 1 fixes the COP (p_c) and relative slope at this point (h_c) from which a Modified Quick Switching Variable Sampling System can be selected under known σ - method. Entering the row given p_c and h_c, one gets the acceptance criteria k_T and k_N the sample size n_σ of QSVSS -2 (n_σ; $k_{N\sigma}$, $k_{T\sigma}$). For example, for given p_c = 0.005, h_c = 2.00, p_c = 0.001, n_σ = 77, $k_{T\sigma}$ = 3.170, $k_{N\sigma}$ = 2.899.

VI. Plotting the OC curve

The OC curve for the Quick switching variable sampling system with n=77; k_T =3.170, k_N = 2.899. Fig 1 shows the OC curve of Modified Quick Switching variable Sampling system indexed by Crossover Point. Figure1 clearly explain about the relationship among the tightened and normal and the probability of acceptance for the crossover point.

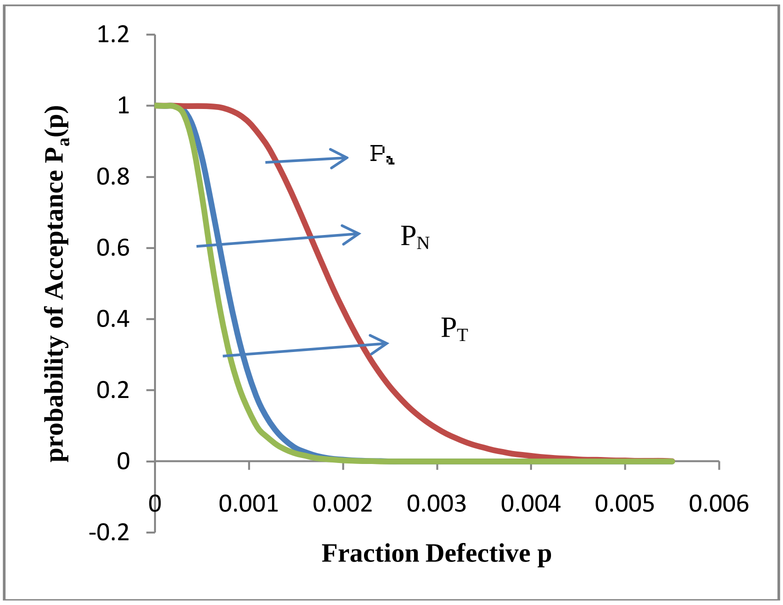

Fig 1: Modified Quick Switching Variable Sampling System with n=77; k_T =3.170, k_N = 2.899.

VII. QSVSS-2 with unknown variable plan as the reference plan

If the population standard deviation σ is unknown, then it is estimated from the sample standard deviation s (n-1 as the divisor). If the sizes of the sample sigma unknown variables system (s method) is n_s and cn_s the acceptance parameter is k_0, then the operating procedure is as follows:

Step 1: Take the sample size n_s from the population. Inspect each unit and record the measurement of the quality characteristic of the sample. Compute the sample mean $\bar{X}$.

Step 2: If $\bar{X} + k_{NS} \leq U$ or $\bar{X} + k_{NS} \geq L$ accept the lot and repeat step 1 otherwise go to step 3.

Step 3: Take a sample of size n_S from the next lot and inspect each unit and record the measurement of the quality characteristic of the sample. Compute the sample mean $\bar{X}$.

Step 4: If $\bar{X} + k_{TS} \le U$ or $\bar{X} + k_{TS} \ge L$ accept the lot and go to step 1 otherwise repeat step 3.

Here $\bar{X}$ and s are the mean and the standard deviation of quality characteristic respectively from the sample. Under the assumptions for Quick Switching System stated, the probability of acceptance $P_a(p)$, of a lot is given in the equation below and P_T and P_N respectively are

$$P_T(p) = \int_{-\infty}^{w_T} \frac{1}{\sqrt{2\pi}} e^{-z^2/2} dz \quad \text{and} \quad P_N(p) = \int_{-\infty}^{w_N} \frac{1}{\sqrt{2\pi}} e^{-z^2/2} dz$$

With $$W_N = \frac{U - k_s - \mu}{s} \cdot \frac{1}{\sqrt{\left(\frac{1}{n_s} + \frac{k_N^2}{2n_s}\right)}} \quad \text{and} \quad W_T = \frac{U - k_s - \mu}{s} \cdot \frac{1}{\sqrt{\left(\frac{1}{n_s} + \frac{k_T^2}{2n_s}\right)}}$$

VIII. Designing QSVSS-2 (n_s ;k_N, k_T) System with unknown σ for given p_c and h_c

Table 1 can be used to determine MQSVSS (ns;k_T,k_N) for specified values of p_c and h_c. For instance, it is desired to have a MQSVSS (ns; k_{TS}, k_{NS}) for given p_c = 0.001, h_c = 2.00, Table 1 gives ns=432, k_Ts=3.172, k_{NS}=2.901 as desired plan parameters.

IX. Construction of Table

The OC function of QSVSS-2 (n; k_T, k_N) is given by above equation. For specified p_c and h_c the equation (7) would result in

$$P_a(p_c) = \frac{P_T}{1 - P_N + P_T} \tag{8}$$

Where $$P_T = \int_{-\infty}^{w_T} \frac{1}{\sqrt{2\pi}} e^{-z^2/2} dz \tag{9}$$

and $$P_N = \int_{-\infty}^{w_N} \frac{1}{\sqrt{2\pi}} e^{-z^2/2} dz \tag{10}$$

By substituting the equation (9) and (10) into (8), one can get the OC function of the QSVSS-2 (n_σ; k_T, k_N). For given various values of pc and hc, the values of n, k_T, k_N are obtained by using computer search routine. The values of n, k_T, k_N for the QSVSS-2 that satisfying equation (2) are obtained using (8). By definition, the relative slope Pa (p_c) at p = p_c is determined as

$$h_C = \frac{-p_C}{P_a(p_c)} \frac{dP_a(p_c)}{dp}$$

A procedure for finding parameters of s - method scheme from σ – method scheme with parameters (ns; k_T, k_N) were derived using Hamaker (1979) approximation as follows:

$$n_s = n_\sigma(1 + k_\sigma^2/2), \ \ where \ \bar{k}_\sigma = (k_{T\sigma} + k_{N\sigma})/2$$

$$k_{Ts} = k_{T\sigma}(4n_s - 4)/(4n_s - 5) \ \ and \ \bar{k}_{Ns} = k_{N\sigma}(4n_s - 4)/(4n_s - 5)$$

Table 1 provides the values of n_σ, $h_{T\sigma}$, $h_{N\sigma}$, n_s, k_{Ts} and k_{Ns} which satisfy equation (8), (9) and (10).

X. CONCLUSION

This article presents, a quality index called the crossover point has introduced to the common quality indices for the design of the Quick Switching variables sampling system. By specifying values of COP, it is possible to control the application of normal and tightened plans in the Quick Switching (n; k_T, k_N) system, to get enhanced system with regard to smaller sample size and the OC curve has been derived.

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Table 1: MQSVSS (n; k_T, k_N) indexed by Crossover Point

p_c	Method	h_c =0.50			h_c =0.75			h_c =1.00		
		n	k_T	k_N	n	k_T	k_N	n	k_T	k_N
0.001	σ	8	3.031	2.806	19	3.040	2.910	30	3.073	2.928
	s	42	3.050	2.823	103	3.047	2.917	165	3.078	2.932
0.002	σ	7	2.822	2.560	19	2.801	2.719	28	2.850	2.719
	s	32	2.845	2.581	91	2.809	2.727	137	2.855	2.724
0.003	σ	7	2.664	2.451	16	2.686	2.556	27	2.710	2.592
	s	30	2.687	2.472	71	2.696	2.565	122	2.716	2.597
0.004	σ	6	2.597	2.304	15	2.590	2.454	27	2.605	2.505
	s	24	2.626	2.329	63	2.600	2.464	115	2.611	2.511
0.005	σ	6	2.503	2.241	14	2.517	2.365	27	2.539	2.301
	s	23	2.532	2.267	56	2.528	2.376	106	2.545	2.306
0.006	σ	6	2.424	2.191	14	2.444	2.310	27	2.448	2.378
	s	22	2.453	2.217	54	2.456	2.321	106	2.454	2.384
0.007	σ	5	2.426	2.051	14	2.380	2.262	26	2.395	2.318
	s	18	2.462	2.082	52	2.392	2.273	98	2.401	2.324
0.008	σ	5	2.363	2.014	14	2.323	2.219	26	2.338	2.275
	s	17	2.401	2.046	50	2.335	2.230	95	2.344	2.281
0.009	σ	5	2.308	1.981	14	2.272	2.182	25	2.298	2.226
	s	16	2.347	2.015	49	2.284	2.193	89	2.305	2.232
0.010	σ	5	2.252	1.956	12	2.260	2.102	24	2.258	2.184
	s	16	2.290	1.989	41	2.274	2.115	83	2.265	2.191
0.020	σ	5	1.900	1.745	10	1.980	1.808	23	1.954	1.929

	s	13	1.940	1.782	28	1.999	1.825	66	1.962	1.936
0.030	σ	4	1.753	1.502	10	1.768	1.665	21	1.769	1.755
	s	9	1.810	1.550	25	1.787	1.683	54	1.777	1.763
0.040	σ	4	1.572	1.411	9	1.631	1.524	19	1.633	1.618
	s	8	1.630	1.463	20	1.653	1.544	44	1.643	1.627
0.050	σ	4	1.462	1.334	9	1.499	1.437	18	1.520	1.510
	s	8	1.516	1.383	19	1.520	1.457	39	1.530	1.520
0.060	σ	4	1.301	1.268	8	1.413	1.325	16	1.428	1.410
	s	7	1.358	1.323	15	1.439	1.349	32	1.440	1.421
0.070	σ	4	1.201	1.191	8	1.312	1.262	15	1.344	1.327
	s	7	1.253	1.243	15	1.336	1.285	28	1.357	1.339
0.080	σ	4	1.131	1.121	8	1.221	1.206	14	1.270	1.251
	s	7	1.180	1.170	14	1.245	1.230	25	1.283	1.264
0.090	σ	4	1.066	1.056	7	1.169	1.110	13	1.204	1.178
	s	6	1.122	1.112	12	1.196	1.136	22	1.219	1.192
0.100	σ	4	1.016	1.007	6	1.133	1.006	12	1.146	1.108
	s	6	1.069	1.060	9	1.170	1.038	20	1.161	1.123

Table 1 (Continues…)

p_c	Method	h_c =1.25			h_c =1.50			h_c =1.75		
		n	k_T	k_N	n	k_T	k_N	n	k_T	k_N
0.001	σ	57	3.051	2.994	65	3.083	2.976	99	3.072	3.008
	s	317	3.053	2.996	363	3.085	2.978	556	3.073	3.009
0.002	σ	55	2.825	2.788	64	2.858	2.774	94	2.853	2.799
	s	272	2.828	2.791	318	2.860	2.776	469	2.855	2.800
0.003	σ	53	2.691	2.659	59	2.727	2.638	90	2.718	2.669
	s	243	2.694	2.662	271	2.730	2.640	416	2.720	2.671
0.004	σ	52	2.590	2.567	58	2.627	2.546	83	2.624	2.529
	s	225	2.593	2.570	252	2.630	2.549	358	2.626	2.531
0.005	σ	52	2.508	2.493	58	2.545	2.473	74	2.553	2.481
	s	215	2.511	2.496	241	2.548	2.476	308	2.555	2.483
0.006	σ	50	2.443	2.429	57	2.478	2.412	63	2.505	2.396
	s	198	2.446	2.432	227	2.481	2.415	252	2.507	2.398
0.007	σ	49	2.385	2.375	56	2.419	2.359	60	2.450	2.338
	s	188	2.388	2.378	216	2.422	2.362	232	2.453	2.341
0.008	σ	47	2.337	2.322	56	2.366	2.313	58	2.402	2.286
	s	175	2.340	2.325	209	2.369	2.316	217	2.405	2.289
0.009	σ	46	2.292	2.279	56	2.319	2.273	56	2.361	2.239
	s	166	2.295	2.282	204	2.322	2.276	204	2.364	2.242
0.010	σ	45	2.251	2.240	54	2.281	2.231	52	2.329	2.189
	s	158	2.255	2.244	191	2.284	2.234	185	2.332	2.192
0.020	σ	37	1.971	1.958	53	1.985	1.973	49	2.035	1.930
	s	108	1.976	1.963	157	1.988	1.976	145	2.039	1.933
0.030	σ	33	1.791	1.780	48	1.807	1.797	47	1.850	1.764
	s	86	1.796	1.785	126	1.811	1.801	124	1.854	1.768
0.040	σ	29	1.659	1.641	44	1.674	1.663	45	1.711	1.638
	s	68	1.665	1.647	105	1.678	1.667	108	1.715	1.642
0.050	σ	27	1.547	1.533	42	1.884	1.226	42	1.600	1.529

	s	59	1.554	1.540	93	1.889	1.229	93	1.604	1.533
0.060	σ	25	1.453	1.439	37	1.470	1.460	42	1.498	1.450
	s	51	1.460	1.446	77	1.475	1.465	88	1.502	1.454
0.070	σ	23	1.373	1.353	35	1.388	1.378	38	1.421	1.362
	s	44	1.381	1.361	68	1.393	1.383	75	1.426	1.367
0.080	σ	22	1.297	1.282	33	1.316	1.305	32	1.363	1.269
	s	40	1.305	1.290	61	1.322	1.310	60	1.369	1.274
0.090	σ	21	1.227	1.216	31	1.248	1.237	32	1.289	1.211
	s	37	1.236	1.225	55	1.254	1.243	57	1.295	1.216
0.100	σ	20	1.164	1.154	29	1.185	1.175	30	1.232	1.145
	s	33	1.173	1.163	49	1.191	1.181	51	1.238	1.151

Table 1 (Continues…)

p_c	Method	h_c =2.00			h_c =2.25			h_c =2.50		
		n	k_T	k_N	n	k_T	k_N	n	k_T	k_N
0.001	σ	77	3.170	2.899	117	3.191	2.892	120	3.145	2.947
	s	432	3.172	2.901	658	3.192	2.893	677	3.146	2.948
0.002	σ	77	2.985	2.656	108	2.892	2.772	117	2.913	2.755
	s	383	2.987	2.658	541	2.893	2.773	587	2.914	2.756
0.003	σ	75	2.858	2.519	101	2.764	2.635	113	2.841	2.557
	s	346	2.860	2.521	469	2.765	2.636	525	2.842	2.558
0.004	σ	75	2.678	2.516	91	2.672	2.532	112	2.674	2.540
	s	328	2.680	2.518	399	2.674	2.534	493	2.675	2.541
0.005	σ	74	2.595	2.444	84	2.598	2.448	105	2.597	2.460
	s	309	2.597	2.446	351	2.600	2.450	441	2.598	2.461
0.006	σ	72	2.648	2.252	73	2.535	2.292	103	2.531	2.399
	s	288	2.650	2.254	286	2.537	2.294	416	2.533	2.400
0.007	σ	67	2.472	2.325	70	2.509	2.291	101	2.475	2.344
	s	260	2.474	2.327	272	2.511	2.293	394	2.477	2.345
0.008	σ	64	2.440	2.257	70	2.522	2.173	99	2.425	2.295
	s	240	2.443	2.259	263	2.524	2.175	375	2.427	2.297
0.009	σ	63	2.503	2.096	63	2.455	2.152	97	2.382	2.251
	s	230	2.506	2.098	230	2.458	2.154	357	2.384	2.253
0.010	σ	60	2.355	2.174	61	2.397	2.132	95	2.344	2.210
	s	214	2.358	2.177	217	2.400	2.134	341	2.346	2.212
0.020	σ	59	2.212	1.755	58	2.088	2.893	88	2.056	1.947
	s	175	2.215	1.758	238	2.090	2.896	264	2.058	1.949
0.030	σ	58	1.861	1.769	53	1.908	1.721	72	1.893	1.754
	s	154	1.864	1.772	140	1.911	1.724	192	1.895	1.756
0.040	σ	55	1.722	1.643	53	1.761	1.607	59	1.781	1.595
	s	133	1.725	1.646	128	1.764	1.610	143	1.784	1.598
0.050	σ	50	1.618	1.529	46	1.665	1.482	52	1.785	1.361
	s	112	1.622	1.532	103	1.669	1.486	116	1.789	1.364
0.060	σ	48	1.532	1.433	43	1.728	1.220	49	1.589	1.383
	s	101	1.536	1.437	90	1.733	1.223	103	1.593	1.386
0.070	σ	45	1.440	1.360	39	1.500	1.297	47	1.506	1.305

	s	89	1.444	1.364	77	1.505	1.301	93	1.510	1.309
0.080	σ	42	1.370	1.285	35	1.442	1.207	38	1.483	1.172
	s	79	1.374	1.289	66	1.448	1.212	71	1.488	1.176
0.090	σ	38	1.308	1.210	30	1.418	1.088	37	1.489	1.026
	s	68	1.313	1.215	54	1.425	1.093	66	1.495	1.030
0.100	σ	35	1.252	1.142	28	1.359	1.023	35	1.351	1.050
	s	60	1.257	1.147	48	1.366	1.028	60	1.357	1.054

Table 1 (Continues…)

p_c	Method	h_c =2.75			h_c =3.00			h_c =3.25		
		n	k_T	k_N	n	k_T	k_N	n	k_T	k_N
0.001	σ	147	3.160	2.938	178	3.132	2.976	202	3.143	2.968
	s	830	3.161	2.939	1008	3.133	2.977	1145	3.144	2.969
0.002	σ	145	2.903	2.774	175	2.908	2.776	179	2.922	2.762
	s	729	2.904	2.775	882	2.909	2.777	902	2.923	2.763
0.003	σ	120	2.819	2.585	175	2.765	2.657	168	2.788	2.632
	s	558	2.820	2.586	818	2.766	2.658	785	2.789	2.633
0.004	σ	115	2.694	2.521	172	2.662	2.569	157	2.700	2.527
	s	506	2.695	2.522	760	2.663	2.570	693	2.701	2.528
0.005	σ	111	2.625	2.434	168	2.663	2.406	156	2.645	2.425
	s	466	2.626	2.435	708	2.664	2.407	657	2.646	2.426
0.006	σ	106	2.561	2.370	167	2.524	2.426	148	2.583	2.359
	s	428	2.563	2.371	678	2.525	2.427	600	2.584	2.360
0.007	σ	105	2.496	2.325	167	2.469	2.371	137	2.514	2.317
	s	410	2.498	2.326	656	2.470	2.372	537	2.515	2.318
0.008	σ	100	2.496	2.220	161	2.412	2.328	135	2.459	2.274
	s	378	2.498	2.221	613	2.413	2.329	513	2.460	2.275
0.009	σ	97	2.412	2.221	154	2.379	2.274	130	2.409	2.237
	s	357	2.414	2.223	571	2.380	2.275	481	2.410	2.238
0.010	σ	95	2.373	2.181	141	2.420	2.144	130	2.370	2.198
	s	341	2.375	2.183	508	2.421	2.145	469	2.371	2.199
0.020	σ	91	2.075	1.931	94	2.108	1.899	128	2.331	2.159
	s	274	2.077	1.933	283	2.110	1.901	451	2.332	2.160
0.030	σ	68	1.985	1.654	81	2.069	1.769	128	2.281	2.122
	s	181	1.988	1.656	230	2.071	1.771	438	2.282	2.123
0.040	σ	63	1.867	1.506	72	2.032	1.619	120	2.226	2.079
	s	153	1.870	1.508	192	2.035	1.621	398	2.227	2.080
0.050	σ	54	1.723	1.434	60	1.995	1.519	115	2.157	2.037
	s	121	1.727	1.437	153	1.998	1.522	368	2.158	2.038
0.060	σ	51	1.671	1.298	50	1.953	1.399	115	2.118	1.998
	s	107	1.675	1.301	120	1.957	1.402	359	2.119	1.999
0.070	σ	47	1.576	1.232	37	1.912	1.269	113	2.068	1.961
	s	93	1.580	1.235	84	1.918	1.273	342	2.070	1.962
0.080	σ	45	1.523	1.140	28	1.873	1.119	105	2.013	1.918
	s	85	1.528	1.143	59	1.881	1.124	308	2.015	1.920
0.090	σ	43	1.418	1.116	27	1.836	1.019	100	1.944	1.876
	s	78	1.423	1.120	55	1.845	1.024	282	1.946	1.878
0.100	σ	39	1.384	1.023	23	1.794	0.899	98	1.905	1.837
	s	67	1.389	1.027	44	1.804	0.904	270	1.907	1.839

Table 1 (Continues…)

p_c	Method	h_c =3.50			h_c =3.75			h_c=4.00		
		n	k_T	k_N	n	k_T	k_N	n	k_T	k_N
0.001	σ	269	3.107	3.015	276	3.135	2.986	312	3.136	2.988
	s	1529	3.108	3.015	1569	3.135	2.986	1775	3.136	2.988
0.002	σ	214	2.936	2.752	251	2.926	2.768	308	2.934	2.764
	s	1079	2.937	2.753	1268	2.927	2.769	1558	2.934	2.764
0.003	σ	196	2.800	2.624	244	2.772	2.661	300	2.762	2.677
	s	917	2.801	2.625	1144	2.773	2.662	1409	2.762	2.677
0.004	σ	196	2.677	2.559	244	2.668	2.575	295	2.560	2.453
	s	868	2.678	2.560	1082	2.669	2.576	1222	2.561	2.454
0.005	σ	181	2.609	2.470	230	2.639	2.444	291	2.388	2.451
	s	765	2.610	2.471	973	2.640	2.445	1143	2.389	2.452
0.006	σ	169	2.580	2.367	194	2.562	2.392	283	2.202	2.364
	s	686	2.581	2.368	789	2.563	2.393	1021	2.203	2.365
0.007	σ	163	2.496	2.343	186	2.353	2.340	277	1.989	2.355
	s	640	2.497	2.344	698	2.354	2.341	930	1.990	2.356
0.008	σ	158	2.444	2.296	172	2.199	2.209	270	1.799	2.327
	s	602	2.445	2.297	590	2.200	2.210	845	1.800	2.328
0.009	σ	151	2.427	2.223	172	2.095	2.123	265	1.597	2.103
	s	559	2.428	2.224	555	2.096	2.124	718	1.598	2.104
0.010	σ	144	2.390	2.180	172	2.066	2.016	261	1.425	2.101
	s	520	2.391	2.181	530	2.067	2.017	667	1.426	2.102
0.020	σ	141	2.353	2.137	165	1.989	1.798	253	1.239	2.014
	s	496	2.354	2.138	461	1.990	1.799	588	1.240	2.015
0.030	σ	135	2.301	2.064	161	1.960	1.146	247	1.026	2.005
	s	457	2.302	2.065	355	1.961	1.147	531	1.026	2.006
0.040	σ	123	2.217	2.017	136	1.883	1.615	240	0.836	1.977
	s	399	2.218	2.018	344	1.884	1.616	477	0.836	1.978
0.050	σ	108	2.188	1.993	111	1.779	1.529	235	0.634	1.753
	s	344	2.190	1.994	263	1.781	1.530	402	0.634	1.754
0.060	σ	103	2.171	1.873	107	1.625	1.422	231	0.462	1.751
	s	314	2.173	1.874	231	1.627	1.424	372	0.462	1.752
0.070	σ	91	2.119	1.830	99	1.416	1.204	223	0.249	1.664
	s	268	2.121	1.832	184	1.418	1.206	325	0.249	1.665
0.080	σ	88	2.035	1.783	99	1.387	1.073	217	0.679	1.655
	s	248	2.037	1.785	174	1.389	1.075	365	0.679	1.656
0.090	σ	73	2.018	1.736	95	1.283	1.021	210	0.677	1.627
	s	202	2.021	1.738	158	1.285	1.023	349	0.677	1.628
0.100	σ	67	1.989	1.712	87	1.129	0.969	205	0.557	1.403
	s	182	1.992	1.714	135	1.131	0.971	303	0.557	1.404