UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Tambahan

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MSG 362 - STATISTIK GUNAAN I

Masa : [3 jam]

Jawab mana-mana lima soalan. Semua soalan mesti dijawab di dalam Bahasa Malaysia. Alat penghitung "non programmable" boleh digunakan. Sifir New Cambridge Elementary Statistical Table disediakan satu set. 1 lampiran dikepilkan.

1. (a) Apakah tujuh alat utama kawalan kualiti itu? Apakah fungsi-fungsinya?

(50/100)

(b) Sebuah kilang mempunyai 5 buah mesin untuk menghasilkan sejenis barangan. Pada suatu hari, sampel yang tak bersandar diambil dari setiap mesin, dan yang berikut adalah ringkasannya :-

mesin	saiz sampel	min
I	4	4.6
II	5	2.4
III	6	4.3
IV	4	5.9
V	3	4.2

dan $\sum_{n=1}^{5} \sum_{j=1}^{n_i} (x_{ij} - 4)^2 = 14.35$, x_{ij} ialah cerapan ke - j daripada mesin ke - i. Berdasarkan sampel-sampel ini, bolehkah kita menyatakan bahawa mesin-mesin itu menghasilkan min-min yang sama?

(50/100)

.../2

2. (a) Tentukan satu rancangan persampelan tunggal yang memenuhi syarat-syarat yang berikut :

(i) risiko pengguna 0.10 untuk menerima barangan yang peratus kecacatannya ialah 2.0%.

(ii) risiko pengeluar 0.05 untuk menolak barangan yang peratus kecacatannya ialah 0.6%.

Pilih rancangan itu yang memenuhi syarat pengguna.

(30/100)

(b) Sammpel saiznya 500 diambil daripada suatu populasi dan diketahui fungsi taburan longgokan $\tilde{F}(x)$ seperti yang berikut :

$$\tilde{F}(x) = \begin{cases} 0, & x < 1 \\ 0.10, & 1 \leq x < 2 \\ 0.25, & 2 \leq x < 3 \\ 0.60, & 3 \leq x < 4 \\ 0.80, & 4 \leq x < 5 \\ 0.93, & 5 \leq x < 6 \\ 0.97, & 6 \leq x < 7 \\ 1.00, & 7 \leq x \end{cases}$$

Gunakan ujian Kolmogorov-Smirnov untuk menguji hipotesis bahawa populasinya ialah normal dengan min $\mu = 3.5$ dan Varians $\sigma^2 = 1$. Gunakan $\alpha = 0.05$.

(40/100)

(c) Huraikan setiap yang berikut :

(i) lengkung cirian pengoperasian
(ii) A Q L, paras kualiti boleh diterima, dan
L Q L, paras kualiti penghad
(iii) A O Q, kualiti keluar secara purata, dan
A O Q L, had kualiti keluar secara purata.

(30/100)

3. (a) Huraikan penggunaan index keupayaan bagi suatu proses penghasilan.

(30/100)

.../3

(b) Kilang Antarabangsa menggunakan carta-p untuk menjaga proses penghasilannya. Untuk 25 subsampel yang awal, data seperti yang berikut dikutip :

subsampel	Bilangan butir yang cacat	subsampel	Bilangan butir yang cacat
1	12	14	14
2	13	15	11
3	15	16	34
4	17	17	8
5	10	18	7
6	12	19	15
7	14	20	8
8	19	21	2
9	21	22	7
10	32	23	10
11	14	24	15
12	12	25	20
13	8		

Binakan carta-p jika saiz setiap subsampel ialah 250.

(30/100)

(c) Suatu proses penghasilan telah stabil. Pihak pengurusan ingin menggunakan carta median dan julat untuk menjaga proses penghasilan itu. Daripada 24 subsampel setiap saiz 3 didapati :

subsampel	x_1	x_2	x_3	subsampel	x_1	x_2	x_3
1	2.24	2.12	2.24	13	2.16	2.21	2.03
2	2.14	2.15	2.37	14	2.14	2.24	2.23
3	2.36	2.05	2.27	15	2.32	2.12	2.33
4	2.33	2.26	2.20	16	2.22	2.08	2.13
5	2.02	2.26	2.16	17	2.25	2.22	2.07
6	2.42	2.16	2.04	18	2.23	2.18	2.20
7	2.24	2.24	2.18	19	2.11	2.03	2.29
8	2.18	2.22	2.08	20	2.04	2.42	2.32
9	2.02	2.21	2.20	21	2.17	2.18	2.23
10	2.08	2.38	2.18	22	2.22	2.24	2.34
11	2.24	2.14	2.14	23	2.28	2.27	2.34
12	2.30	2.31	2.07	24	2.14	2.26	2.25

(i) Binakan carta kawalan median julat
(ii) jika spesifikasi permintaan ialah 2.20 ± 0.05, apakah index keupayaan ini?

(40/100)

.../4

4. (a) Carta $\bar{x}$ - S ingin digunakan untuk proses penghasilan. Data awal 24 subkumpulan setiap saiz 5 telah diambil, dan yang berikut adalah ringkasannya :

subsampel	$\bar{X}$	S	subsampel	$\bar{X}$	S
1	5.28	0.06	13	5.24	0.10
2	5.03	0.08	14	5.23	0.07
3	5.40	0.07	15	5.41	0.08
4	5.40	0.05	16	5.02	0.12
5	5.65	0.12	17	5.43	0.19
6	5.66	0.34	18	5.24	0.18
7	5.80	0.10	19	5.37	0.10
8	5.48	0.12	20	5.49	0.07
9	5.42	0.11	21	5.40	0.05
10	5.36	0.07	22	5.40	0.23
11	5.43	0.08	23	5.38	0.06
12	5.24	0.13	24	5.98	0.18

Binakan carta $\bar{x}$ - s untuk kegunaan proses penghasilan.

(30/100)

(b) Carta - D (demerit per unit) digunakan untuk menjaga proses penghasilan. Daripada 25 subsampel setiap saiz 100, maklumat yang berikut diperolehi :

jenis kecacatan	genting	major	minor
Bilangan kecacatan	12	60	325

(i) Dapatkan carta - $\dot{D}$ jika pemberat bagi 3 jenis kecacatan ialah di dalam kadaran 1 : 3 : 9.

(ii) pada suatu sampel yang saiznya 100 diketahui

jenis kecacatan	genting	major	minor
Bilangan kecacatan	2	12	60

Apakah demerit per unit bagi sampel ini? Merujuk kepada carta - D, adakah prosesnya di dalam kawalan?

(30/100)

(c) Ujian hipotesis berjujukan nisbah (ujian nisbah kebolehjadian maksimum) dijalankan untuk menguji hipotesis tentang p, kadaran kecacatan.

$H_0 : p = 0.10$

berlawanan $H_1 : p = 0.40$, $\alpha = 0.05$, $\beta = 0.10$

.../5

(i) Tunjukkan rantau penerimaan H_0, rantau penolak H_0, dan rantau penerusan persampelan di atas satah m Y, di mana m ialah bilangan cerapan dan Y ialah bilangan butir yang cacat yang berpadanan dengan m.

(ii) pada sampel

T T T C C C C T T T C T

sudahkah keputusan dicapai? Yang mana?

Di sini, T bermaksud butir itu tidak cacat. C bermaksud butir itu cacat.

(40/100)

5. (a) Untuk saiz lot N = 3,500, A Q L = 1.5%. Gunakan MTC-STD-105D pada paras inspeksi II, tentukan rancangan persampelan penerimaan tunggal untuk inspeksi normal, longgar dan ketat. Terangkan nombor-nombor yang digunakan.

(30/100)

(b) Untuk saiz lot N = 50,000. A Q L = 0.4%. Gunakan MIL-STD-105D pada paras inspeksi II, tentukan rancangan persampelan penerimaan berganda dua untuk inspeksi normal, longgar dan ketat. Terangkan nombor-nombor yang digunakan.

(30/100)

(c) Yang berikut ialah rancangan persampelan penerimaan berganda tiga. Saiz lot N = 10,000 :

$n_1 = 80$ $c_1 = 1$. $r_1 = 4$

$n_2 = 80$ $c_2 = 4$. $r_2 = 7$

$n_3 = 80$ $c_3 = 7$. $r_3 = 8$

Jika x_1, x_2, x_3 ialah masing-masing bilangan butir yang cacat di dalam sampel yang pertama, sampel yang kedua dan sampel yang ketiga

(i) dapatkan lengkung-lengkung cirian pengoperasian selepas sampel yang pertama dan sampel yang kedua.

(ii) dapatkan persamaan untuk lengkung cirian pengoperasian pada sampel yang ketiga.

(40/100)

.../6

6. (a) Carta kawalan $\bar{x}$ digunakan untuk subsampel yang saiznya ialah 6. Yang berikut ialah maklumatnya :

Carta $\bar{x}$
garis tengah = 3.45
had kawalan atas = 3.63
had kawalan bawah = 3.27

(i) Jika spesifikasinya 3.45 ± 0.05, apakah indeks keupayaan proses ini?

(ii) Jika min proses dipindah ke 3.55, apakah kebarangkalian suatu cerapan akan memenuhi spesifikasi di atas? Anggapkan kebolehan proses tidak berubah.

(30/100)

(b) X ialah pembolehubah rawak masahayat suatu komponen elektronik. Jika kadar bahaya h(x) ialah

$$h(x) = \frac{\beta}{\eta}\left(\frac{x}{\eta}\right)^{\beta-1}, \quad x \geq 0.$$

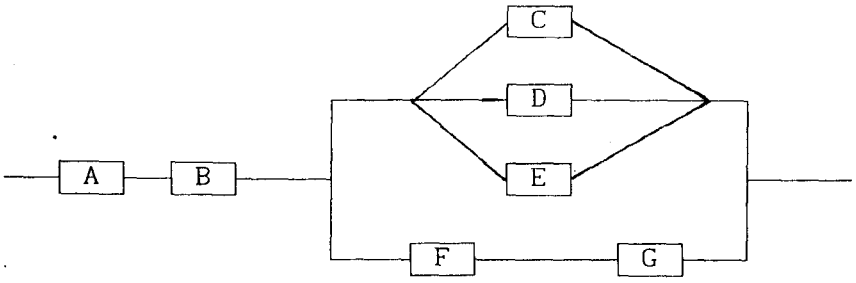
$\beta > 0$, $\eta > 0$, $\beta.\eta$ pemalar.

(i) Dapatkan fungsi ketumputan kebarangkalian bagi x

(ii) Dapatkan kebolehpercayaannya pada x = 1, apabila $\beta = 1$, $\eta = 1$.

(40/100)

(c) Di dalam satu sistem campuran yang berikut :



Setiap komponen mempunyai masahayat yang taburannya mengikut f.k.k. yang berikut :

$$f(x) = \frac{1}{800} e^{-\frac{1}{800}x}, \quad x > 0$$

Cari kebolehpercayaan sistem ini pada min masa bagi f.k.k. ini. Anggapkan komponen-komponen itu saling tak bersandar.

(30/100)

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Table 6-4 ***np'*** **Values for Corresponding *c* Values and Typical Producer's and Consumer's Risks**

c	$P_a = 0.95$ ($\alpha = 0.05$)	$P_a = 0.10$ ($\beta = 0.10$)	*Ratio of* $p'_{0.10}/p'_{0.95}$
0	0.051	2.303	44.890
1	0.355	3.890	10.946
2	0.818	5.322	6.509
3	1.366	6.681	4.890
4	1.970	7.994	4.057
5	2.613	9.275	3.549
6	3.286	10.532	3.206
7	3.981	11.771	2.957
8	4.695	12.995	2.768
9	5.426	14.206	2.618
10	6.169	15.407	2.497
11	6.924	16.598	2.397
12	7.690	17.782	2.312
13	8.464	18.958	2.240
14	9.246	20.128	2.177
15	10.035	21.292	2.122

Source: Extracted by permission from J. M. Cameron, "Tables for Constructing and for Computing the Operating Characteristics of Single-Sampling Plans," *Industrial Quality Control*, 9, No. 1 (July 1952), p. 39.

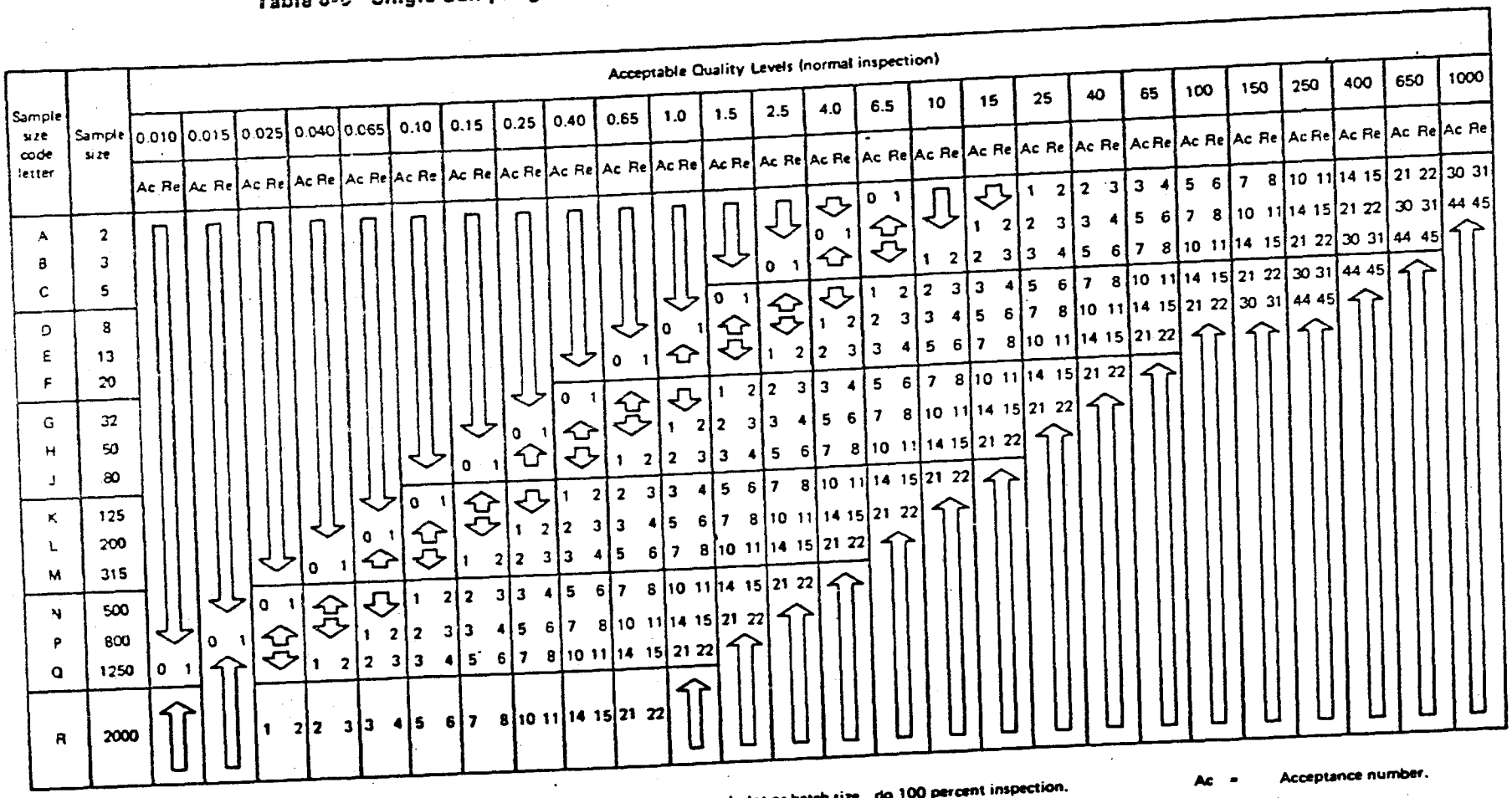
Table 6-5 Sample-Size Code Letters (Table I of MIL-STD 105D)

Lot or batch size	Special inspection levels				General inspection levels		
	S-1	S-2	S-3	S-4	I	II	III
2 to 8	A	A	A	A	A	A	B
9 to 15	A	A	A	A	A	B	C
16 to 25	A	A	B	B	B	C	D
26 to 50	A	B	B	C	C	D	E
51 to 90	B	B	C	C	C	E	F
91 to 150	B	B	C	D	D	F	G
151 to 280	B	C	D	E	E	G	H
281 to 500	B	C	D	E	F	H	J
501 to 1200	C	C	E	F	G	J	K
1201 to 3200	C	D	E	G	H	K	L
3201 to 10000	C	D	F	G	J	L	M
10001 to 35000	C	D	F	H	K	M	N
35001 to 150000	D	E	G	J	L	N	P
150001 to 500000	D	E	G	J	M	P	Q
500001 and over	D	E	H	K	N	Q	R

Note.

Small sample inspection levels of MIL-STD-105C	*Convert to these special inspection levels*
L-1 and L-2	S-1
L-3 and L-4	S-2
L-5 and L-6	S-3
L-7 and L-8	S-4

Table 6-8 Single Sampling Plans for Normal Inspection (Table II-A of MIL-STD 105D)[a]



Sample size code letter	Sample size	Acceptable Quality Levels (normal inspection)																												
		0.010	0.015	0.025	0.040	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10	15	25	40	65	100	150	250	400	650	1000
		Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
A	2	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	0 1	⇩	⇩	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31	44 45		
B	3														0 1	⇕	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22	30 31	44 45				
C	5													0 1	⇕	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22							
D	8											0 1	0 1	⇕	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22								
E	13										0 1	⇕	⇕	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22									
F	20									0 1	⇕	⇕	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22										
G	32								0 1	⇕	⇕	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22											
H	50							0 1	⇕	⇕	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22												
J	80						0 1	⇕	⇕	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22													
K	125					0 1	⇕	⇕	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22														
L	200				0 1	⇕	⇕	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22															
M	315			0 1	⇕	⇕	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22																
N	500			⇕	⇕	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22																	
P	800		0 1	⇕	⇕	2 3	3 4	5 6	7 8	10 11	14 15	21 22																		
Q	1250	0 1	⇑	⇕	⇕	3 4	5 6	7 8	10 11	14 15	21 22	⇑	⇑	⇑	⇑	⇑	⇑	⇑	⇑	⇑	⇑	⇑	⇑	⇑	⇑	⇑	⇑	⇑	⇑	⇑
R	2000	⇑	⇑	1 2	2 3	3 4	5 6	7 8	10 11	14 15	21 22																			

⇩ = Use first sampling plan below arrow. If sample size equals, or exceeds, lot or batch size, do 100 percent inspection.

⇧ = Use first sampling plan above arrow.

Ac = Acceptance number.

Re = Rejection number.

Table 6-7 Single Sampling Plans for Tightened Inspection (Table II-B of MIL-STD 105D)[a]

Sample size code letter	Sample size	Acceptable Quality Levels (tightened inspection)																													
		0.010		0.015		0.025		0.040		0.065		0.10		0.15		0.25		0.40		0.65		1.0		1.5		2.5		4.0		6.5		10	
		Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re
A	2																														
B	3																														
C	5																														
D	8																														
E	13																														
F	20																														
G	32																														
H	50																														
J	80																														
K	125																														
L	200																														
M	315																														
N	500																														
P	800																														
Q	1250																														
R	2000																														
S	3150																														

Sample size code letter	Sample size	Acceptable Quality Levels (tightened inspection)																													
		15		25		40		65		100		150		250		400		650		1000											
		Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re										
A	2																														
B	3																														
C	5																														
D	8																														
E	13																														
F	20																														
G	32																														
H	50																														
J	80																														
K	125																														
L	200																														
M	315																														
N	500																														
P	800																														
Q	1250																														
R	2000																														
S	3150																														

⇩ = Use first sampling plan below arrow. If sample size equals or exceeds lot or batch size, do 100 percent inspection.
⇧ = Use first sampling plan above arrow.
Ac = Acceptance number.
Re = Rejection number.

Table 6-8 Single Sampling Plans for Reduced Inspection (Table II-C of MIL-STD 105D)[a]

Sample size code letter	Sample size	Acceptable Quality Levels (reduced inspection)†																																					
		0.010		0.015		0.025		0.040		0.065		0.10		0.15		0.25		0.40		0.65		1.0		1.5		2.5		4.0		6.5		10		15		25		40		65		100		150		250		400		650		1000	
		Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re
A	2	⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		0 1		⇩		⇩		1 2		2 3		3 4		5 6		7 8		10 11		14 15		21 22		30 31	
B	2																									0 1						0 2		1 3		2 4		3 5		5 6		7 8		10 11		14 15		21 22		30 31	
C	2																															1 3		2 4		3 5		5 6		7 8		10 11		14 15		21 22			
D	3																															1 4		2 5		3 6		5 8		7 10		10 13		14 17		21 24			
E	5																															2 5		3 6		5 8		7 10		10 13		14 17		21 24			
F	8																															3 6		5 8		7 10		10 13									
G	13																															5 8		7 10		10 13											
H	20																															7 10		10 13											
J	32																															10 13													
K	50																																													
L	80																																													
M	125																																													
N	200																																													
P	315																																													
Q	500																																													
R	800																																													

⇩ = Use first sampling plan below arrow. If sample size equals or exceeds lot or batch size, do 100 percent inspection.

⇧ = Use first sampling plan above arrow.

Ac = Acceptance number.

Re = Rejection number.

† = If the acceptance number has been exceeded, but the rejection number has not been reached, accept the lot, but reinstate normal inspection (see 10.1.4).

Table 6-9 Double Sampling Plans for Normal Inspection (Table III-A of MIL-STD 105D)[a]

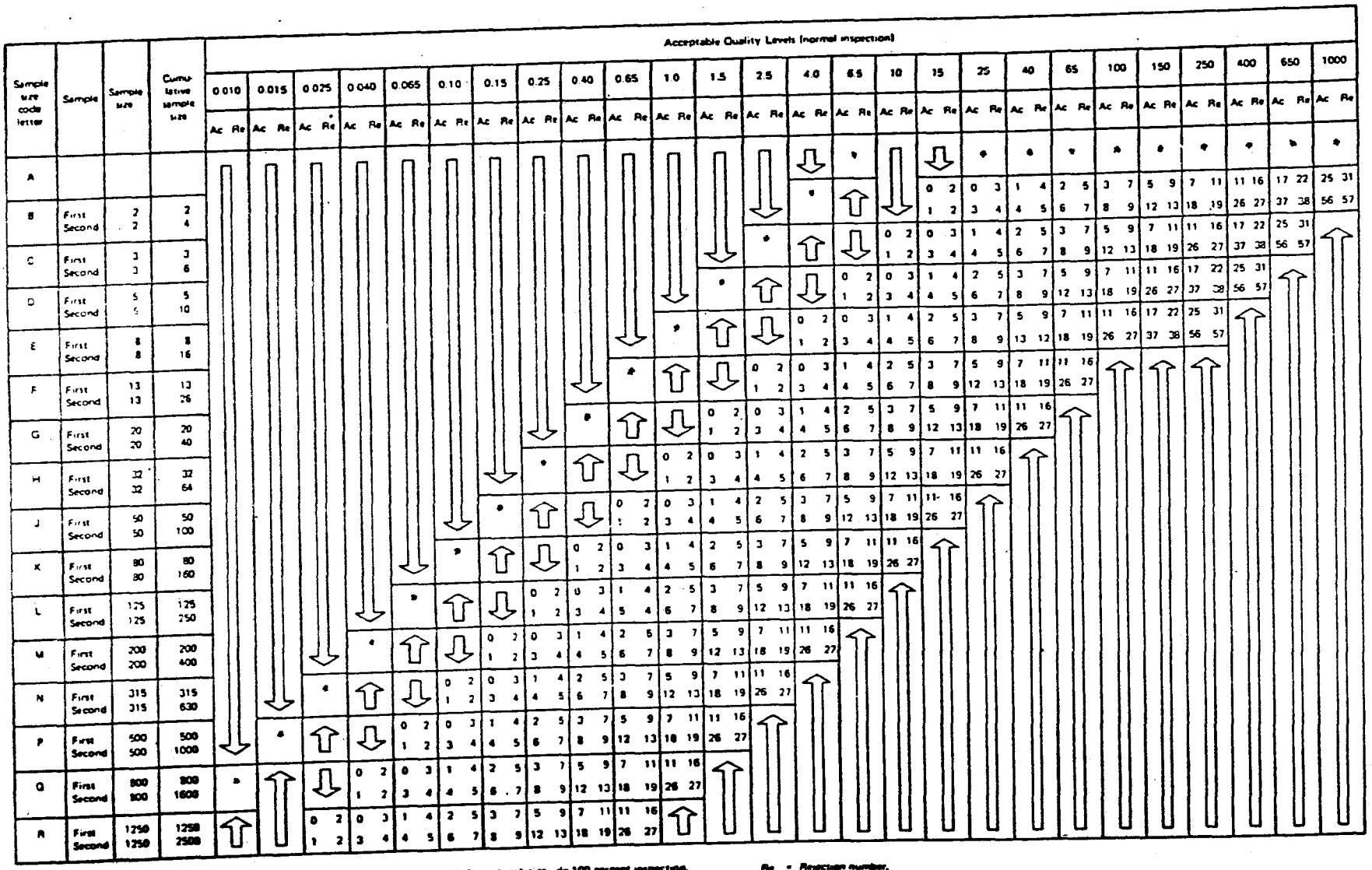


Table 6-10 Double Sampling Plans for Tightened Inspection (Table III-B of MIL-STD 105D)[a]

Sample size code letter	Sample	Sample size	Cumulative sample size	0.010	0.015	0.025	0.040	0.065	0.10	0.15	0.25	0.40	0.65	1.0	1.5	2.5	4.0	6.5	10	15	25	40	65	100	150	250	400	650	1000
				Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
A				↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	*	*	*	*	*	*	*
B	First	2	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	15 20	23 24
	Second	2	4																		1 2	3 4	4 5	6 7	11 12	15 16	23 24	34 35	52 53
C	First	3	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	15 20	23 24	↑
	Second	3	6																	1 2	3 4	4 5	6 7	11 12	15 16	23 24	34 35	52 53	
D	First	5	5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	15 20	23 24	↑	↑
	Second	5	10																1 2	3 4	4 5	6 7	11 12	15 16	23 24	34 35	52 53		
E	First	8	8	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	15 20	23 24	↑	↑	↑
	Second	8	16															1 2	3 4	4 5	6 7	11 12	15 16	23 24	34 35	52 53			
F	First	13	13	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	↑	↑	↑	↑	↑	↑
	Second	13	26														1 2	3 4	4 5	6 7	11 12	15 16	23 24						
G	First	20	20	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	↑	↑	↑	↑	↑	↑	↑
	Second	20	40													1 2	3 4	4 5	6 7	11 12	15 16	23 24							
H	First	32	32	↓	↓	↓	↓	↓	↓	↓	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	↑	↑	↑	↑	↑	↑	↑	↑
	Second	32	64												1 2	3 4	4 5	6 7	11 12	15 16	23 24								
J	First	50	50	↓	↓	↓	↓	↓	↓	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	50	100											1 2	3 4	4 5	6 7	11 12	15 16	23 24									
K	First	80	80	↓	↓	↓	↓	↓	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	80	160										1 2	3 4	4 5	6 7	11 12	15 16	23 24										
L	First	125	125	↓	↓	↓	↓	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	125	250									1 2	3 4	4 5	6 7	11 12	15 16	23 24											
M	First	200	200	↓	↓	↓	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	200	400								1 2	3 4	4 5	6 7	11 12	15 16	23 24												
N	First	315	315	↓	↓	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	315	630							1 2	3 4	4 5	6 7	11 12	15 16	23 24													
P	First	500	500	↓	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	500	1000						1 2	3 4	4 5	6 7	11 12	15 16	23 24														
Q	First	800	800	↓	*	↓	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	800	1600					1 2	3 4	4 5	6 7	11 12	15 16	23 24															
R	First	1250	1250	*	↑	↓	0 2	0 3	1 4	2 5	3 7	6 10	9 14	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	1250	2500				1 2	3 4	4 5	6 7	11 12	15 16	23 24																
S	First	2000	2000			0 2																							
	Second	2000	4000			1 2																							

Acceptable Quality Levels (tightened inspection)

⇩ = Use first sampling plan below arrow. If sample size equals or exceeds lot or batch size, do 100 percent inspection.

⇧ = Use first sampling plan above arrow.

Ac = Acceptance number.

Re = Rejection number.

* = Use corresponding single sampling plan (or alternatively, use double sampling plan below, where available).

Table 8-11 Double Sampling Plans for Reduced Inspection (Table III-C of MIL-STD 105D)[a]

Sample size code letter	Sample	Sample size	Cumulative sample size	Acceptable Quality Levels (reduced inspection) †																																			
				0.010		0.015		0.025		0.040		0.065		0.10		0.15		0.25		0.40		0.65		1.0		1.5		2.5		4.0		6.5		10		15		25		40		65		100		150		250		400		650		1000	
				Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re	Ac	Re
A B C																												⇩	*	⇩		⇩		*		*		*		*		*		*		*		*		*		*	
D	First Second	2 2	2 4																					⇩	*	⇧	⇩	0 2 0 2	⇧ ⇩	0 3 0 4	⇧ ⇩	0 4 1 5	⇧ ⇩	0 4 3 6	⇧ ⇩	1 5 4 7	⇧ ⇩	2 7 6 9	⇧ ⇩	3 8 8 12	⇧ ⇩	5 10 12 16	⇧ ⇩	7 12 18 22	⇧ ⇩	11 17 26 30	⇧ ⇩				
E	First Second	3 3	3 6																					*	⇧	⇩	0 2 0 2	⇧ ⇩	0 3 0 4	⇧ ⇩	0 4 1 5	⇧ ⇩	0 4 3 6	⇧ ⇩	1 5 4 7	⇧ ⇩	2 7 6 9	⇧ ⇩	3 8 8 12	⇧ ⇩	5 10 12 16	⇧ ⇩	7 12 18 22	⇧ ⇩	11 17 26 30	⇧ ⇩				
F	First Second	5 5	5 10																							*	⇧	⇩	0 2 0 2	⇧ ⇩	0 3 0 4	⇧ ⇩	0 4 1 5	⇧ ⇩	0 4 3 6	⇧ ⇩	1 5 4 7	⇧ ⇩	2 7 6 9	⇧ ⇩	3 8 8 12	⇧ ⇩	5 10 12 16	⇧ ⇩						
G	First Second	8 8	8																									*	⇧	⇩	0 2 0 2	⇧ ⇩	0 3 0 4	⇧ ⇩	0 4 1 5	⇧ ⇩	0 4 3 6	⇧ ⇩	1 5 4 7	⇧ ⇩	2 7 6 9	⇧ ⇩	3 8 8 12	⇧ ⇩	5 10 12 16	⇧ ⇩						
H	First Second	13 13	13 26																											*	⇧	⇩	0 2 0 2	⇧ ⇩	0 3 0 4	⇧ ⇩	0 4 1 5	⇧ ⇩	0 4 3 6	⇧ ⇩	1 5 4 7	⇧ ⇩	2 7 6 9	⇧ ⇩	3 8 8 12	⇧ ⇩	5 10 12 16	⇧ ⇩						
J	First Second	20 20	20 40																													*	⇧	⇩	0 2 0 2	⇧ ⇩	0 3 0 4	⇧ ⇩	0 4 1 5	⇧ ⇩	0 4 3 6	⇧ ⇩	1 5 4 7	⇧ ⇩	2 7 6 9	⇧ ⇩	3 8 8 12	⇧ ⇩	5 10 12 16	⇧ ⇩						
K	First Second	32 32	32 64																															*	⇧	⇩	0 2 0 2	⇧ ⇩	0 3 0 4	⇧ ⇩	0 4 1 5	⇧ ⇩	0 4 3 6	⇧ ⇩	1 5 4 7	⇧ ⇩	2 7 6 9	⇧ ⇩	3 8 8 12	⇧ ⇩	5 10 12 16	⇧ ⇩						
L	First Second	50 50	50 100																																	*	⇧	⇩	0 2 0 2	⇧ ⇩	0 3 0 4	⇧ ⇩	0 4 1 5	⇧ ⇩	0 4 3 6	⇧ ⇩	1 5 4 7	⇧ ⇩	2 7 6 9	⇧ ⇩	3 8 8 12	⇧ ⇩	5 10 12 16	⇧ ⇩						
M	First Second	80 80	80 160																																			*	⇧	⇩	0 2 0 2	⇧ ⇩	0 3 0 4	⇧ ⇩	0 4 1 5	⇧ ⇩	0 4 3 6	⇧ ⇩	1 5 4 7	⇧ ⇩	2 7 6 9	⇧ ⇩	3 8 8 12	⇧ ⇩	5 10 12 16	⇧ ⇩						
N	First Second	125 125	125 250																																					*	⇧	⇩	0 2 0 2	⇧ ⇩	0 3 0 4	⇧ ⇩	0 4 1 5	⇧ ⇩	0 4 3 6	⇧ ⇩	1 5 4 7	⇧ ⇩	2 7 6 9	⇧ ⇩	3 8 8 12	⇧ ⇩	5 10 12 16	⇧ ⇩						
P	First Second	200 200	200 400																																							*	⇧	⇩	0 2 0 2	⇧ ⇩	0 3 0 4	⇧ ⇩	0 4 1 5	⇧ ⇩	0 4 3 6	⇧ ⇩	1 5 4 7	⇧ ⇩	2 7 6 9	⇧ ⇩	3 8 8 12	⇧ ⇩	5 10 12 16	⇧ ⇩						
Q	First Second	315 315	315 630																																										*	⇧	⇩	0 2 0 2	⇧ ⇩	0 3 0 4	⇧ ⇩	0 4 1 5	⇧ ⇩	0 4 3 6	⇧ ⇩	1 5 4 7	⇧ ⇩	2 7 6 9	⇧ ⇩	3 8 8 12	⇧ ⇩	5 10 12 16	⇧ ⇩						
R	First Second	500 500	500 1000																																														*	⇧	⇩	0 2 0 2	⇧ ⇩	0 3 0 4	⇧ ⇩	0 4 1 5	⇧ ⇩	0 4 3 6	⇧ ⇩	1 5 4 7	⇧ ⇩	2 7 6 9	⇧ ⇩	3 8 8 12	⇧ ⇩	5 10 12 16	⇧ ⇩						

⇩ = Use first sampling plan below arrow. If sample size equals or exceeds lot or batch size, do 100 percent inspection.

⇧ = Use first sampling plan above arrow.

Ac = Acceptance number.

Re = Rejection number.

* = Use corresponding single sampling plan (or alternatively, use double sampling plan below, when available).

† = If, after the second sample, the acceptance number has been exceeded, but the rejection number has not been reached, accept the lot, but reinstate normal inspection (see 10.14).

TABLE B Factors for Computing Central Lines and 3σ Control Limits for $\bar{X}$, s, and R, Charts

Observations in Sample, n	Chart for Averages: Factors for Control Limits A	A_2	A_3	Chart for Standard Deviations: Factors for Central Line c_4	$1/c_4$	Factors for Control Limits B_3	B_4	B_5	B_6	Chart for Ranges: Factors for Central Line d_2	$1/d_2$	Factors for Control Limits d_1	D_1	D_2	D_3	D_4
2	2.121	1.880	2.659	0.7979	1.2533	0	3.267	0	2.606	1.128	0.8865	0.853	0	3.686	0	3.267
3	1.732	1.023	1.954	0.8862	1.1284	0	2.568	0	2.276	1.693	0.5907	0.888	0	4.358	0	2.574
4	1.500	0.729	1.628	0.9213	1.0854	0	2.266	0	2.088	2.059	0.4857	0.880	0	4.698	0	2.282
5	1.342	0.577	1.427	0.9400	1.0638	0	2.089	0	1.964	2.326	0.4299	0.864	0	4.918	0	2.114
6	1.225	0.483	1.287	0.9515	1.0510	0.030	1.970	0.029	1.874	2.534	0.3946	0.848	0	5.078	0	2.004
7	1.134	0.419	1.182	0.9594	1.0423	0.118	1.882	0.113	1.806	2.704	0.3698	0.833	0.204	5.204	0.076	1.924
8	1.061	0.373	1.099	0.9650	1.0363	0.185	1.815	0.179	1.751	2.847	0.3512	0.820	0.388	5.306	0.136	1.864
9	1.000	0.337	1.032	0.9693	1.0317	0.239	1.761	0.232	1.707	2.970	0.3367	0.808	0.547	5.393	0.184	1.816
10	0.949	0.308	0.975	0.9727	1.0281	0.284	1.716	0.276	1.669	3.078	0.3249	0.797	0.687	5.469	0.223	1.777
11	0.905	0.285	0.927	0.9754	1.0252	0.321	1.679	0.313	1.637	3.173	0.3152	0.787	0.811	5.535	0.256	1.744
12	0.866	0.266	0.886	0.9776	1.0229	0.354	1.646	0.346	1.610	3.258	0.3069	0.778	0.922	5.594	0.283	1.717
13	0.832	0.249	0.850	0.9794	1.0210	0.382	1.618	0.374	1.585	3.336	0.2998	0.770	1.025	5.647	0.307	1.693
14	0.802	0.235	0.817	0.9810	1.0194	0.406	1.594	0.399	1.563	3.407	0.2935	0.763	1.118	5.696	0.328	1.672
15	0.775	0.223	0.789	0.9823	1.0180	0.428	1.572	0.421	1.544	3.472	0.2880	0.756	1.203	5.741	0.347	1.653
16	0.750	0.212	0.763	0.9835	1.0168	0.448	1.552	0.440	1.526	3.532	0.2831	0.750	1.282	5.782	0.363	1.637
17	0.728	0.203	0.739	0.9845	1.0157	0.466	1.534	0.458	1.511	3.588	0.2787	0.744	1.356	5.820	0.378	1.622
18	0.707	0.194	0.718	0.9854	1.0148	0.482	1.518	0.475	1.496	3.640	0.2747	0.739	1.424	5.856	0.391	1.608
19	0.688	0.187	0.698	0.9862	1.0140	0.497	1.503	0.490	1.483	3.689	0.2711	0.734	1.487	5.891	0.403	1.597
20	0.671	0.180	0.680	0.9869	1.0133	0.510	1.490	0.504	1.470	3.735	0.2677	0.729	1.549	5.921	0.415	1.585
21	0.655	0.173	0.663	0.9876	1.0126	0.523	1.477	0.516	1.459	3.778	0.2647	0.724	1.605	5.951	0.425	1.575
22	0.640	0.167	0.647	0.9882	1.0119	0.534	1.466	0.528	1.448	3.819	0.2618	0.720	1.659	5.979	0.434	1.566
23	0.626	0.162	0.633	0.9887	1.0114	0.545	1.455	0.539	1.438	3.858	0.2592	0.716	1.710	6.006	0.443	1.557
24	0.612	0.157	0.619	0.9892	1.0109	0.555	1.445	0.549	1.429	3.895	0.2567	0.712	1.759	6.031	0.451	1.548
25	0.600	0.135	0.606	0.9896	1.0105	0.565	1.435	0.559	1.420	3.931	0.2544	0.708	1.806	6.056	0.459	1.541

TABLE 3-6 Factors for Computing 3σ Control Limits for Median and Range Charts from the Median Range

Subgroup Size	A_5	D_5	D_6	d_3
2	2.224	0	3.865	0.954
3	1.265	0	2.745	1.588
4	0.829	0	2.375	1.978
5	0.712	0	2.179	2.257
6	0.562	0	2.055	2.472
7	0.520	0.078	1.967	2.645
8	0.441	0.139	1.901	2.791
9	0.419	0.187	1.850	2.916
10	0.369	0.227	1.809	3.024

Source: Extracted by permission from P. C. Clifford, "Control Charts Without Calculations," *Industrial Quality Control*, 15, No. 6 (May 1959), 44.

7 Kolmogorov-Smirnov Test

Table 7. Solutions c of Equation (1) in Sec. 15.3
n = Size of sample

n	$\alpha = 20\%$	$\alpha = 10\%$	$\alpha = 5\%$	$\alpha = 2\%$	$\alpha = 1\%$
	0.	0.	0.	0.	0.
1	900	950	975	990	995
2	684	776	842	900	929
3	565	636	708	785	829
4	493	565	624	689	734
5	447	509	563	627	669
6	410	468	519	577	617
7	381	436	483	538	576
8	359	410	454	507	542
9	339	387	430	480	513
10	323	369	409	457	486
11	308	352	391	437	468
12	296	338	375	419	449
13	285	325	361	404	432
14	275	314	349	390	418
15	266	304	338	377	404
16	258	295	327	366	392
17	250	286	318	355	381
18	244	279	309	346	371
19	237	271	301	337	361
20	232	265	294	329	352
21	226	259	287	321	344
22	221	253	281	314	337
23	216	247	275	307	330
24	212	242	269	301	323
25	208	238	264	295	317
26	204	233	259	290	311
27	200	229	254	284	305
28	197	225	250	279	300
29	193	221	246	275	295
30	190	218	242	270	290
35	177	202	224	251	269
40	165	189	210	235	252
45	156	179	198	222	238
50	148	170	188	211	226
55	142	162	180	201	216
60	136	155	172	193	207
65	131	149	166	185	199
70	126	144	160	179	192
75	122	139	154	173	185
80	118	135	150	167	179
85	114	131	145	162	174
90	111	127	141	158	169
95	108	124	137	154	165
100	106	121	134	150	161
Approximation for large n	$1.07/\sqrt{n}$	$1.22/\sqrt{n}$	$1.36/\sqrt{n}$	$1.52/\sqrt{n}$	$1.63/\sqrt{n}$