

UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Kedua  
UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Kedua  
Sidang 1993/94

April 1994

MSG 362 - Statistik Gunaan I

[Masa: 3 Jam]

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Jawab semua LIMA soalan. Soalan-soalan mesti dijawab di dalam Bahasa Malaysia. Sifir New Cambridge Elementary Statistical Tables disediakan. Sifir-sifir lain yang diperlukan dilampirkan (Lampiran 1 - 11). Alat penghitung "non-programmable" boleh digunakan. Ia disediakan oleh calon sendiri.

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1. (a) Senaraikan tujuh alat utama kawalan kualiti. Apakah penggunaannya di dalam bidang kawalan kualiti?

(50/100)

- (b) Sebuah kilang mempunyai 5 barisan pemprosesan yang menghasilkan produk-A. Pada suatu pemeriksaan, sampel yang tak bersandar diambil dari setiap barisan pemprosesan dan ringkasannya adalah seperti yang berikut:

barisan pemprosesan	saiz sampel	minnya
1	$n_1 = 8;$	2.52
2	$n_2 = 8;$	2.32
3	$n_3 = 6;$	2.54
4	$n_4 = 8;$	2.44
5	$n_5 = 5;$	2.28

dan juga diketahui bahawa  $\sum \sum (x_{ij} - 2.00)^2 = 210.12$ ;  $x_{ij}$  ialah cerapan ke-j dari barisan pemprosesan ke-i.

Berdasarkan maklumat ini, bolehkah pihak pengurus menyatakan bahawa hasil 5 barisan pemprosesan itu adalah seragam?

Gunakan  $\alpha = 0.05$ .

(30/100)

- 2 -

- (c) Huraikan keadaan suatu proses penghasilan merujuk kepada kawalan statistik; dan huraikan jenis keadaan utama suatu proses penghasilan di luar kawalan statistik (merujuk kepada carta  $\bar{X}-R$ ) dan sebab-sebab utamanya yang mungkin.

(20/100)

2. (a) Pihak pengurus sebuah kilang ingin menggunakan carta kawalan  $\bar{X}-R$  untuk mengawal proses penghasilannya. Maklumat data awal telah dikutip di dalam subkumpulan yang saiznya  $n = 6$  dan ringkasan datanya seperti yang berikut:

Subsampel	$\bar{X}$	R	Subsampel	$\bar{X}$	R
1	6.36	0.38	14	6.47	0.39
2	6.35	0.34	15	6.41	0.36
3	6.37	0.36	16	6.45	0.34
4	6.65	0.32	17	6.34	0.37
5	6.22	0.37	18	6.36	0.38
6	6.40	0.37	19	6.42	0.35
7	6.43	0.35	20	6.72	0.73
8	6.37	0.31	21	6.50	0.32
9	6.48	0.34	22	6.31	0.34
10	6.42	0.37	23	6.39	0.30
11	6.39	0.29	24	6.40	0.38
12	6.38	0.30	25	6.41	0.68
13	6.42	0.67	26	6.80	0.35

- (i) Binakan carta  $\bar{X}-R$ . Jika mana-mana data di luar had-had kawalan percubaan, anggapkan sebabnya terumpukkan, dapatkan carta  $\bar{X}-R$  akhir untuk kegunaan kelak.
- (ii) Apakah kebarangkalian bahawa perubahan min proses penghasilan ke 6.58 dapat dikesan oleh carta  $\bar{X}$  pada sampel yang pertama selepas perubahan berlaku. Anggapkan sisihan piawainya tidak berubah.
- (iii) Dapatkan carta  $\bar{X}$  dengan saiz subsampel itu supaya dapat mengesan perubahan min proses ke 6.58 dengan keyakinan 90% pada subsampel yang pertama selepas perubahan min berlaku.

(50/100)

- (b) Rancangan pensampelan tunggal diinginkan dengan risiko pengguna 0.10 untuk penerimaan hasil yang 3.00% cacat dan risiko pengeluar 0.05 penolakan hasil yang 0.50% cacat. Pilih rancangan yang memenuhi syarat pengeluar dan paling dekat syarat pengguna.

(30/100)

- (c) Huraikan indeks keupayaan  $C_p$  bagi suatu proses penghasilan merujuk kepada suatu spesifikasi dari suatu permintaan.

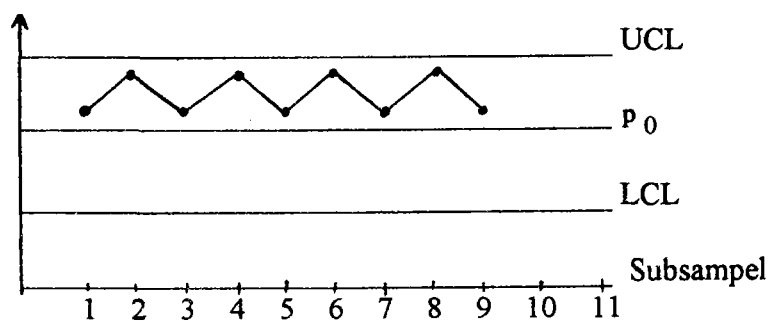
(20/100)

- 3 -

3. (a) Keputusan pemeriksaan subsampel-subsampel (saiz 500) awal hasil pisau elektrik dari sebuah kilang yang menghasilkan alat dapur adalah seperti yang berikut:-

Subsampel	Bilangan yang cacat	Subsampel	Bilangan yang cacat
1	6	13	10
2	5	14	3
3	7	15	8
4	8	16	27
5	9	17	2
6	16	18	3
7	6	19	19
8	9	20	8
9	7	21	7
10	8	22	10
11	7	23	6
12	3	24	1

- (i) Binakan carta-p, kadaran kecacatan untuk kegunaan kelak. Anggapkan titik-titik di luar had kawalan percubaan disebabkan sebab-sebab terumpukkan dan tidak diambil kira.
- (ii) Jika proses berubah ke  $p_0 = 0.25$ , apakah kebarangkalian carta ini dapat mengesan perubahan ini pada sampel yang ketiga?
- (iii) Apakah kebarangkalian untuk kejadian yang bercorak seperti berikut:



(50/100)

- 4 -

- (b) Syarikat T.V. Warna Berhad mengeluarkan sejenis T.V. untuk pasaran. Pihak pengurus ingin menggunakan carta Demerit per unit untuk menjaga barisan pemrosesannya. Dari data awal 24 subsampel setiap saiz 100 didapati data yang berikut:-

Subsampel	Jenis Kecacatan		
	Genting	Major	Minor
1	1	2	10
2	2	2	8
3	0	4	12
4	0	6	18
5	2	5	10
6	1	6	8
7	0	4	15
8	2	2	6
9	7	4	12
10	1	4	7
11	0	4	8
12	0	6	12
13	1	5	20
14	2	4	15
15	1	7	12
16	0	7	14
17	1	2	6
18	1	6	7
19	2	4	12
20	0	8	6
21	1	7	12
22	1	6	14
23	1	4	13
24	1	6	13

- (ii) Dapatkan carta Demerit per unit jika pemberat 3 jenis kecacatan ialah 9 : 3 : 1. Anggapkan ada sebab terumpukkan jika titik di luar had kawalan percubaan.
- (iii) Di dalam satu sampel yang saiznya 100, didapati:-

Jenis Kecacatan	:	Genting	Major	Minor
Bilangan Kecacatan	:	3	12	15

Apakah Demerit per unit bagi subsampel ini? Adakah proses di luar kawalan?

(50/100)

- 5 -

4. (a) Yang berikut ialah sampel dari suatu populasi yang telah dikumpul di dalam jadual taburan frekuensi:

Kelas	Frekuensi
1.80 - 1.84	1
1.84 - 1.88	4
1.88 - 1.92	10
1.92 - 1.96	18
1.96 - 2.00	28
2.00 - 2.04	20
2.04 - 2.08	11
2.08 - 2.12	6
2.12 - 2.16	2

- (i) Jika populasi ialah normal, gunakan kertas normal untuk menganggar min dan variansnya.
- (ii) Gunakan ujian Kolmogorov-Smirnov untuk menguji hipotesis bahawa data ini dari populasi normal.  $\alpha = 0.05$ .

(40/100)

- (b) Untuk saiz lot  $N = 26000$ ,  $AQL = 1.5\%$ , dan menggunakan M.C-STD-105E pada paras inspeksi II, tentukan satu rancangan pensampelan penerimaan berganda dua untuk inspeksi normal, inspeksi ketak dan inspeksi longgar. Terangkan nombor-nombor yang anda berikan itu.

(30/100)

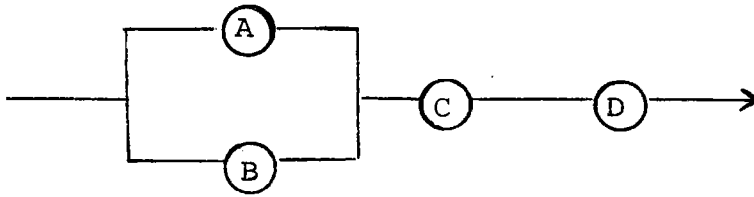
- (c) Bagi rancangan pensampelan penerimaan yang berikut:  
 $N = 5000$ ,  $n = 100$ ,  $c = 2$

- (i) Dapatkan lengkung kualiti keluar secara puratanya.
- (ii) Apakah had kualiti keluar secara purata?
- (iii) Terangkan konsep kualiti keluar secara purata di dalam rancangan pensampelan penerimaan.

(30/100)

- 6 -

5. (a) Satu sistem terdiri daripada 4 komponen yang disambungkan seperti yang berikut:-



Jika masahayat komponen-komponen tak bersandar dan setiap bertaburan seperti  $X$  dengan f.k.k.

$$f(x) = 0.005e^{-0.005x} ; \quad x > 0 ;$$

Cari fungsi ketumpatan kebarangkalian bagi  $T$ . masahayat sistem ini.

(30/100)

- (b) Jika kadar kegagalan untuk suatu pembolehubah rawak  $X$  ialah  $h(x)$ .

$$h(x) = \alpha\beta x^{\beta-1} , \quad x > 0 ;$$

$\alpha, \beta$  pemalar ( $\alpha, \beta > 0$ ) ;

Cari fungsi ketumpatan kebarangkalian bagi  $X$ . Apakah kepercayaannya pada masa  $x = 1$ .

(30/100)

- (c) Di dalam kaedah ujian berjujukan tetang  $p$ , kadaran kecacatan:

$$H_0 : p = 0.05 ;$$

$$\text{berlawan } H_1 : p = 0.20 ; \quad \alpha = 0.05; \beta = 0.10;$$

tunjukkan rantau penolakan  $H_0$ , rantau penerimaan  $H_0$ , dan rantau berterusan pensampelan di atas satah  $-XW$ .  $X$  ialah bilangan butir yang cacat dan  $W = m - X$ ,  $m$  ialah bilangan cerapan yang digunakan.

Jika yang berikut ialah data yang diberi

BBBCBBBBBCC ( B baik, C cacat),

sudahkah keputusan dicapai?

(40/100)

**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
		A	A	A	A	A	A	A
2 to 8	A	A	A	A	A	A	B	
9 to 15	A	A	A	A	A	A	B	
16 to 25	A	A	A	A	A	A	B	
26 to 50	A	B	B	B	C	C	D	
51 to 90	B	B	C	C	C	C	E	
91 to 150	B	B	C	C	C	C	F	
151 to 280	B	C	D	D	E	E	G	
281 to 500	B	C	D	D	E	E	H	
501 to 1200	C	C	E	E	F	F	I	
1201 to 3200	C	D	E	E	F	F	J	
3201 to 10000	C	D	E	E	F	F	K	
10001 to 35000	C	D	E	E	F	F	L	
35001 to 150000	D	E	G	G	H	H	M	
150001 to 500000	D	E	G	G	H	H	N	
500001 and over	D	E	H	H	I	I	O	

Convert to other special inspection levels

Small sample inspection levels of MIL-STD-883C

- L-1 and L-2 ..... B-1
- L-3 and L-4 ..... B-2
- L-5 and L-6 ..... B-3
- L-7 and L-8 ..... B-4

Note.



Table 6-6 Single Sampling Plans for Normal Inspection (Table II-A of MIL-STD 105D)\*

Sample size code letter	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	
A	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
B	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
C	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
D	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
E	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
F	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
G	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
H	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
J	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
K	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
L	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
M	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
N	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Q	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
R	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1



 - 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 8-8 Single Sampling Plans for Reduced Inspection (Table II-C of MIL-STD 105D)\*

Sample size code letter	Sample size	Acceptable Quality Levels (reduced inspection)†																					
		0.010	0.015	0.025	0.040	0.065	1.0	1.5	2.5	4.0	6.5	10	15	25	40	65	100	150	250	400	650	1000	
A	2	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
B	2	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
C	2	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
D	3	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
E	5	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
F	8	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
G	13	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
H	20	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
I	32	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
K	50	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
L	80	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
M	125	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
N	200	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
P	315	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
Q	500	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
R	800	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

\* 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 reinspect normal inspection (see 10.1.6).

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

Sample size code letter	Sample size	Cumulative lot size	Acceptable Quality Levels (normal inspection)																																			
			0.10		0.075		0.040		0.025		0.15		0.40		0.65		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		
A			→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→			
B	2 2	2 4	→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→	
C	3 3	3 6	→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→	
D	5 5	5 10	→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→	
E	8 8	8 16	→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→	
F	13 13	13 26	→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→	
G	20 20	20 40	→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→	
H	32 32	32 64	→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→	
J	50 50	50 100	→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→	
K	80 80	80 160	→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→	
L	125 125	125 250	→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→	
M	200 200	200 400	→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→	
N	315 315	315 630	→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→	
P	500 500	500 1000	→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→	
Q	800 800	800 1600	→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→	
R	1250 1250	1250 2500	→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→		→	

= 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 sample plan for alternatively, use double sampling plan below, where available.

Table 6-10 Double Sampling Plans for Tightened Inspection (Table III-B of MIL-STD 105D)\*

Sample size code letter	Sample size	Cumulative sample size	Acceptable Quality Levels (lightened 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
A			↓																						
B	2 First Second	2 4	↓																						
C	3 First Second	3 6	↓																						
D	5 First Second	5 10	↓																						
E	8 First Second	8 16	↓																						
F	13 First Second	13 26	↓																						
G	20 First Second	20 40	↓																						
H	32 First Second	32 64	↓																						
J	50 First Second	50 100	↓																						
K	80 First Second	80 160	↓																						
L	125 First Second	125 250	↓																						
M	200 First Second	200 400	↓																						
N	315 First Second	315 630	↓																						
P	500 First Second	500 1000	↓																						
Q	800 First Second	800 1600	↓																						
R	1250 First Second	1250 2500	↓																						
S	2000 First Second	2000 4000	↓																						

↓ - 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 for alternately, use double sampling plan below, where available.



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

Observations in Sample, $n$	Chart for Standard Deviations										Chart for Ranges									
	Chart for Averages					Factors for Control Limits					Factors for Central Line					Factors for Control Limits				
	$A$	$A_1$	$A_2$	$A_3$	$A_4$	$c_4$	$1/c_4$	$B_3$	$B_4$	$B_5$	$B_6$	$d_2$	$1/d_2$	$d_1$	$D_1$	$D_2$	$D_3$	$D_4$		
2	1.121	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	0	3.267		
3	1.732	1.023	1.954	0.8862	1.1284	0	2.568	0	2.276	1.693	0.5907	0.868	0	4.358	0	2.574	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	0.415	1.585		
21	0.655	0.173	0.653	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	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	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	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	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	0.459	1.541		

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**TABLE 3-6 Factors for Computing  $3\sigma$  Control Limits for Median and Range Charts from the Median Range**

<i>Subgroup Size</i>	$A_5$	$D_5$	$D_6$	$d_3$
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.

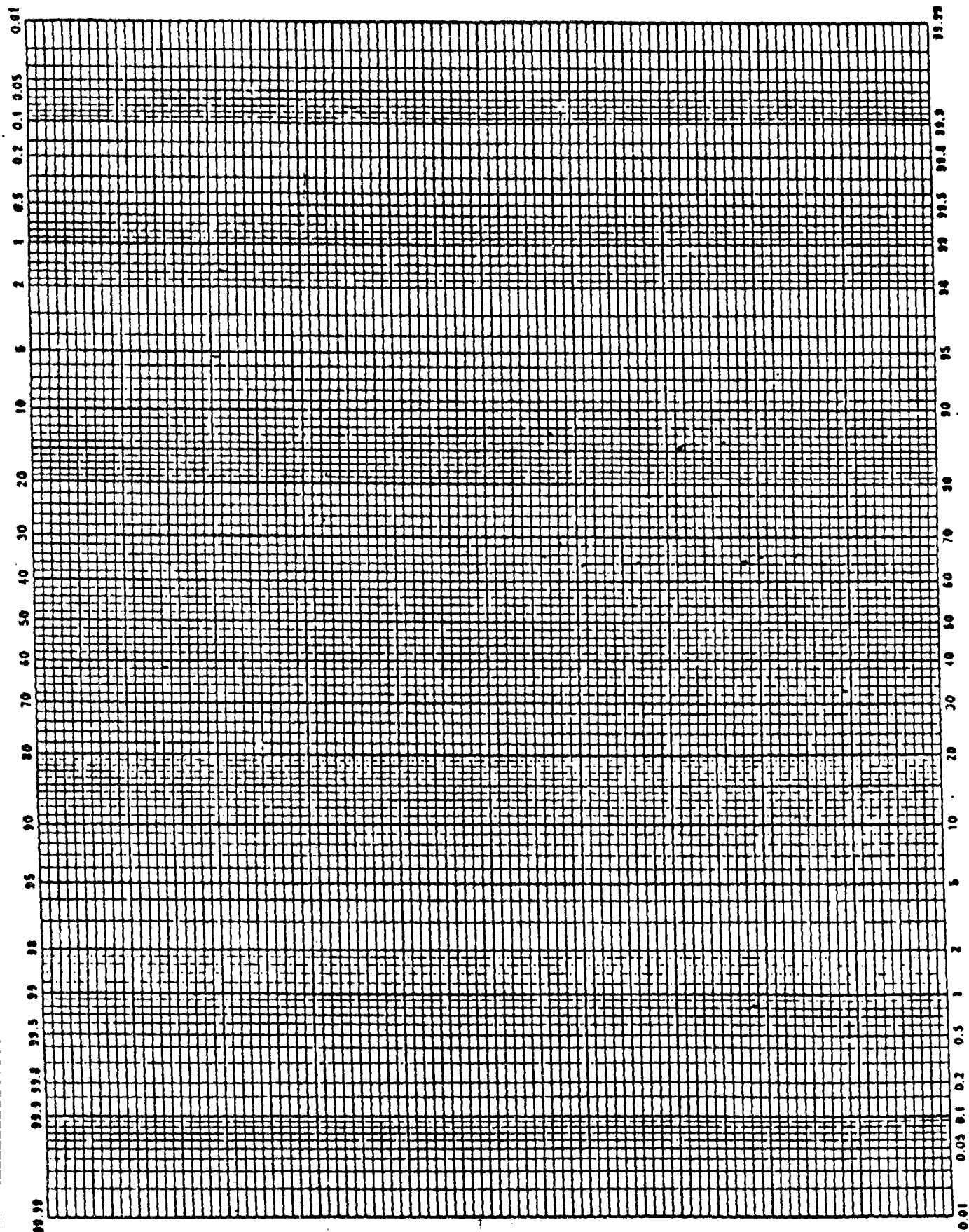


## 7 Kolmogorov-Smirnov Test

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 $n$	$1.07/\sqrt{n}$	$1.22/\sqrt{n}$	$1.36/\sqrt{n}$	$1.52/\sqrt{n}$	$1.63/\sqrt{n}$



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