

UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Kedua  
Sidang Akademik 1994/95

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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. Satu set lampiran dikepilkan. Alat penghitung "non-programmable" boleh digunakan. Ia disediakan oleh pelajar diri sendiri.

1. (a) Apakah tujuh alat utama kawalan kualiti? Apakah fungsi-fungsinya? Huraikan secara lebih teliti yang berikut yang digunakan di dalam bidang kawalan kualiti.

- (i) Histogram
- (ii) Gambarajah sebaran dan korelasi
- (iii) Carta-carta kawalan

(60%)

- (b) Sebuah kilang mempunyai 6 buah baris pemprosesan yang menghasilkan sejenis part yang ukurannya patut sama. Dari semasa ke semasa, pemeriksaan dijalankan. Pada suatu pemeriksaan, sampel yang tak bersandar diambil dari setiap baris, dan maklumat diringkas seperti yang berikut:

baris	saiz sampel	minnya
1	6	4.15
2	7	4.14
3	8	4.07
4	9	4.08
5	10	4.04
6	12	4.05

dan diketahui  $\sum_i \sum_j (x_{ij} - 4.00)^2 = 42.55$ .

$x_{ij}$  ialah cerapan ke- $j$  di dalam sampel ke- $i$ . Bolehkah kita menyatakan min-minnya adalah sama? Gunakan  $\alpha = 0.05$ .

(40%)

2. (a) Kilang A ingin menggunakan carta kawalan kadaran kecacatan untuk menjaga prosesnya yang menghasilkan sejenis bahagian elektronik. Ringkasan maklumat data awal subkumpulan setiap saiz  $n = 500$  adalah seperti yang berikut:

Subsampel	Bilangan butir yang cacat	Subsampel	Bilangan butir yang cacat
1	10	14	12
2	11	15	9
3	8	16	7
4	7	17	26
5	6	18	11
6	7	19	12
7	12	20	8
8	14	21	7
9	32	22	10
10	10	23	8
11	8	24	4
12	8	25	14
13	1	26	10

- (i) Binakan carta kadaran kecacatan untuk kegunaan kelak. Anggapkan data awal yang di atas had kawalan percubaan disebabkan sebab-sebab terumpukkan dan tidak digunakan di dalam penghitungan.
- (ii) Proses penghasilan sedang dijalankan. Suatu sampel  $n = 500$  diambil dan didapati bilangan butir yang cacat ialah 17. Adakah proses di dalam kawalan?
- (iii) Katakan proses penghasilan telah berubah ke atas 20% nilai piawainya. Apakah kebarangkalian carta ini dapat mengesan perubahan di dalam 3 sampel?

(50%)

- (b) Terang setiap sebutan yang berikut:

- (i) LQL, paras kualiti penghad  
(ii) AQL, paras kualiti boleh diterima  
(iii) AOQ, kualiti keluar secara purata  
(iv) AOQL, had kualiti keluar secara purata

(20%)

- (c) Untuk rancangan pensampelan penerimaan berjjukan butir demi butir yang berikut:

$$\alpha = 0.05, p_o = 0.05, \beta = 0.10, p_1 = 0.10$$

Tentukan persamaan garislurus penerimaan dan persamaan garislurus penolakannya. Tunjukkan kawasan penerimaannya, penolakannya dan kawasan berturusannya di atas satu satah, dan di dalam jadual sehingga saiz sampel  $n = 20$ .

(30%)

3. (a) Pihak Pengurusan ingin bermula menggunakan carta  $\bar{x} - R$  untuk menjaga proses penghasilannya. Dari data awal 26 subkumpulan setiap saiz  $n = 4$ , didapati bahawa:

subsampel	min $\bar{x}$	Julat $R$	subsampel	min $\bar{x}$	Julat $R$
1	21.2	3.8	14	32.2	7.4
2	21.4	9.8	15	21.2	9.7
3	19.1	12.3	16	23.2	8.5
4	19.3	13.4	17	18.4	11.2
5	22.3	7.3	18	20.1	10.4
6	36.1	8.1	19	16.5	9.6
7	21.5	10.2	20	24.7	6.7
8	19.2	8.5	21	18.6	8.4
9	17.8	10.7	22	20.4	8.2
10	23.0	6.0	23	21.5	6.2
11	21.2	23.4	24	20.0	13.1
12	19.8	8.2	25	20.4	9.7
13	20.0	9.1	26	21.7	8.8

- (i) Binakan carta  $\bar{x} - R$  untuk kegunaan kelak. Anggapkan titik di luar had-had kawalan percubaan disebabkan sebab-sebab terumpukkan dan tidak digunakan di dalam penghitungan.
- (ii) Jika min proses berubah ke 25.5, apakah kebarangkalian perubahan ini dapat digesan pada sampel ketiga (selepas perubahan berlaku).
- (iii) Jika indeks keupayaan merujuk kepada suatu spesifikasi suatu permintaan, ialah 1.20, cari kebarangkalian satu butir yang dihasilkan proses ini akan memenuhi spesifikasi ini. Anggapkan spesifikasi ini bersimetri terhadap nilai piawai  $\bar{x}_o$ .

(60%)

- (b) Yang berikut ialah rancangan pensampelan penerimaan berganda tiga:

$$N = 5000$$

$$\begin{array}{lll} n_1 = 50, & c_1 = 0, & r_1 = 3; \\ n_2 = 50, & c_2 = 3, & r_2 = 6; \\ n_3 = 50, & c_3 = 7, & r_3 = 8; \end{array}$$

Katakan  $x_1, x_2, x_3$  ialah bilangan butir yang cacat di dalam sampel yang pertama, yang kedua, dan yang ketiga masing-masing. Dapatkan kebarangkalian penerimaan lot berdasarkan sampel yang pertama, yang kedua, dan yang ketiga masing-masing.

(20%)

- (c) Untuk saiz lot  $N = 5000$ ,  $AQL = 1.00\%$ , gunakan MIL-STD-105E pada paras inspeksi II, tentukan rancangan pensampelan penerimaan berganda dua untuk inspeksi normal, inspeksi ketak dan inspeksi longgar. Terangkan nombor-nombor yang diberikan.

(20%)

4. (a) Dari suatu populasi, sampel rawak 200 cerapan diambil dan fungsi taburan sampel adalah seperti yang berikut:

$$\tilde{F}(x) = \begin{array}{ll} 0 & ; \quad x < 1 ; \\ 0.01 & ; \quad 1 \leq x < 2 ; \\ 0.03 & ; \quad 2 \leq x < 3 ; \\ 0.07 & ; \quad 3 \leq x < 4 ; \\ 0.21 & ; \quad 4 \leq x < 5 ; \\ 0.53 & ; \quad 5 \leq x < 6 ; \\ 0.79 & ; \quad 6 \leq x < 7 ; \\ 0.96 & ; \quad 7 \leq x < 8 ; \\ 0.99 & ; \quad 8 \leq x < 9 ; \\ 1.00 & ; \quad 9 \leq x \quad ; \end{array}$$

- (i) Jika data dari populasi normal. Gunakan kertas normal kebarangkalian, dapatkan anggaran min dan variansnya.
- (ii) Gunakan ujian Kolmogorov-Smirnov untuk menguji hipotesis bahawa data ini dari populasi normal.

(40%)

- (b) (i) Takrifkan index keupayaan  $C_p$  bagi suatu proses penghasilan merujuk kepada suatu spesifikasi dari suatu permintaan.
- (ii) Huraikan perhubungan had-had kawalan dan spesifikasi merujuk kepada  $C_p$  apabila  $C_p < 1$ ,  $C_p = 1$ , dan  $C_p > 1$ .

(20%)

- (c) Bagi rancangan pensampelan penerimaan tunggal

$$(A) \quad N = 5000, \quad n = 89, \quad C = 2 \quad \text{dan}$$

$$(B) \quad N = 5000, \quad n = 100, \quad C = 3$$

Jika pengguna ingin menggunakan rancangan pensampelan penerimaan yang AOQL-nya (had kualiti keluar secara purata) kecil sekali, rancangan (A) atau rancangan (B) patut digunakan? Tentukan.

(40%)

5. (a) Katakan kecacatan dikelaskan sebagai kecacatan genting, kecacatan major dan kecacatan minor. Pemberat yang digunakan ialah  $k : l : m$  untuk kecacatan genting, kecacatan major, kecacatan minor.  $U_c, U_{ma}, U_{mi}$  ialah kecacatan per unit untuk subsampel yang saiznya  $n$  dan  $U_{0c}, U_{0ma}, U_{0mi}$  ialah nilai piawainya masing-masing.

- (i) Takrifkan demerit per unit.
- (ii) Dapatkan carta demerit per unit.  
(Perhatikan bahawa bilangan kecacatan atas sebuah barangan bertaburan Poisson)

(30%)

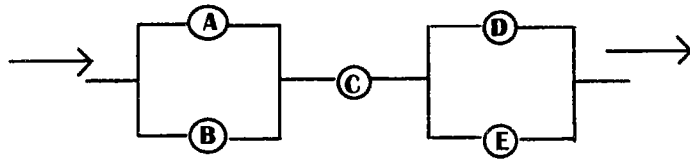
- (b) Jika  $X$  ialah pembolehubah masa hayat suatu komponen elektronik, dan kadar bahayanya ialah  $h(x)$ ,

$$h(x) = \alpha\beta^x, \quad x > 0, \\ \alpha, \beta \text{ pemalar positive.}$$

Cari fungsi ketumpatan kebarangkalian bagi pembolehubah rawak  $X$ .

(30%)

- (c) Satu sistem adalah seperti yang ditunjukkan:



Katakan komponen-komponan saling tak bersandar dan mempunyai taburan seperti  $X$  yang f.k.k.nya  $f(x)$ .

$$f(x) = \frac{1}{25\sqrt{2\pi}} \exp \left\{ -\frac{1}{2} \left( \frac{x-200}{25} \right)^2 \right\}$$

Cari kebolehpercayaan sistem ini pada masa  $t = 120$ .

(40%)

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

17428

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 6-2 Single Sampling Plans for Normal Inspection (Table II-A of MIL-STD 105D)<sup>a</sup>

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	
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	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	

 = 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.

11/8/16



Table 6-8 Single Sampling Plans for Reduced Inspection (Table II-C of MIL-STD 105D)<sup>a</sup>

Sample size code letter	Sample size	Acceptable Quality Levels (reduced inspection) <sup>†</sup>																					
		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
J	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
ii	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.  
 = Acceptance number.  
 = 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 10.1.4).

Table 6-9 Double Sampling Plans for Normal Inspection (Table III-A of MIL-STD 105D)<sup>a</sup>

Sample size code letter	Sample size	Cumulative sample size	Acceptable Quality Levels (normal inspection)																																									
			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		
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	→																																									

- Use first sampling plan below arrow. If sample size equals or exceeds lot or batch size do 100 percent inspection.  
 - Use last sampling plan above arrow.  
 Ac - Acceptance number.  
 Re - Rejection number.  
 \* - Use corresponding single sample plan for alternative, use double sampling plan below, where available.

Table 6-10 Double Sampling Plans for Tightened Inspection (Table III-B of MIL-STD 105D)<sup>a</sup>

Sample size code letter	Sample size	Cumulative sample size	Acceptable Quality Levels (lightened 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			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 First Second	2 4	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	3 First Second	3 6	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	5 First Second	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	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
E	8 First Second	8 16	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	13 First Second	13 26	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	20 First Second	20 40	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	32 First Second	32 64	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
J	50 First Second	50 100	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	80 First Second	80 160	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	125 First Second	125 250	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	200 First Second	200 400	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	315 First Second	315 630	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	500 First Second	500 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
Q	800 First Second	800 1600	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	1250 First Second	1250 2500	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
S	2000 First Second	2000 4000	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. Re - Rejection number.  
 \* Use first sampling plan above arrow. e - Use corresponding single sampling plan (for alternately, use double sampling plan below, where available).  
 Ac - Acceptance number.

Table 6-11 Double Sampling Plans for Reduced Inspection (Table III-C of MIL-STD 105D)<sup>a</sup>

Sample size code letter	Sample size	Cumulative 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			→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
B			→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
C			→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
D	2 First Second	2 2	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
E	3 First Second	3 3	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
F	5 First Second	5 5	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
G	8 First Second	8 8	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
H	13 First Second	13 13	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
J	20 First Second	20 20	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
K	32 First Second	32 32	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
L	50 First Second	50 50	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
M	80 First Second	80 80	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
N	125 First Second	125 125	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
P	200 First Second	200 200	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
Q	315 First Second	315 315	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
R	500 First Second	500 500	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→

<sup>a</sup> - Use first sampling plan before arrow. If sample size equals or exceeds lot or batch size, do 100 percent inspection.  
<sup>†</sup> - If, after the second sample, the acceptance number has been exceeded, but the rejection number has not been reached, accept the lot, but reinitiate normal inspection (see 10.14).  
 \* - Use corresponding single sampling plan for alternately, use double sampling plan below, when available.

→ - Use first sampling plan before arrow.  
 \* - Use first sampling plan above arrow.  
 Ac - Acceptance number.  
 Re - Rejection number.

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 Averages			Chart for Standard Deviations						Chart for Ranges						
	Factors for Control Limits			Factors for Central Line		Factors for Control Limits				Factors for Central Line		Factors for Control Limits				
	A	A <sub>2</sub>	A <sub>3</sub>	c <sub>4</sub>	1/c <sub>4</sub>	B <sub>3</sub>	B <sub>4</sub>	B <sub>5</sub>	B <sub>6</sub>	d <sub>2</sub>	1/d <sub>2</sub>	d <sub>1</sub>	D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	D <sub>4</sub>
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

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135

343

LAMPIRAN 9 (MSG32)

**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

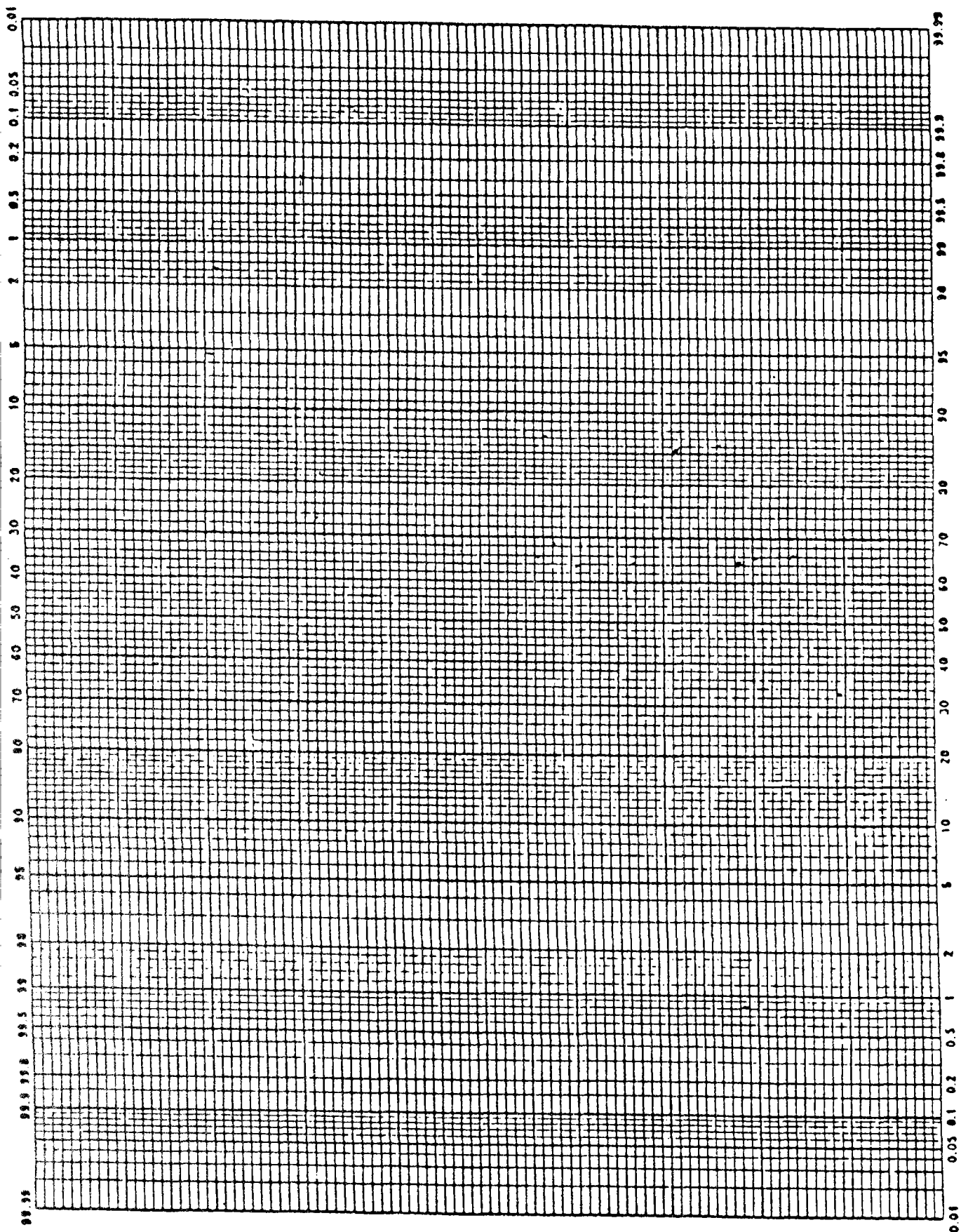
*Source:* Extracted by permission from P. C. Clifford, "Control Charts Without Calculations," *Industrial Quality Control*, 15, No. 6 (May 1959), 44.

## 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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