

UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Tambahan
Sidang 1993/94

Jun 1994

MSG 362 Statistik Gunaan I

Masa : [3 jam]

Jawab semua **LIMA** soalan. Soalan-soalan mesti dijawab di dalam Bahasa Malaysia. Sifir New Cambridge Elementary Statistical Table disediakan.

Satu set sifir dilampirkan (Lampiran 1-11). Alat penghitung boleh digunakan. Ia disediakan oleh calon sendiri.

1. (a) Huraikan setiap dari tujuh alat utama yang digunakan di dalam bidang kawalan kualiti statistik.

(50%)

- (b) Sebuah kilang mempunyai 5 barisan pemprosesan untuk menghasilkan barangan-A. Pada satu pemeriksaan, sampel yang tak bersandar diambil dari setiap barisan dan datanya seperti yang berikut:

	Ukuran				
Barisan I	3.80	3.52	3.78	3.90	
Barisan II	3.15	3.13	3.26	3.25	3.20
Barisan III	4.20	4.40	4.36	4.28	
Barisan IV	3.78	3.65	3.74	3.52	
Barisan V	3.80	3.67	3.52	3.47	3.54

Berdasarkan maklumat ini, bolehkah kita menyatakan min ukuran dari kelima-lima barisan itu adalah sama? Gunakan $\alpha = 0.05$.

(30%)

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

(20%)

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2. (a) Sampel yang saiznya 200 diambil dari suatu populasi dan diketahui fungsi taburan longgokan $\tilde{F}(x)$ adalah seperti yang berikut:

$$\tilde{F}(x) = \begin{cases} 0 & ; & x < 0.1 & ; \\ 0.11 & ; & 0.1 \leq x < 0.2 & ; \\ 0.24 & ; & 0.2 \leq x < 0.3 & ; \\ 0.59 & ; & 0.3 \leq x < 0.4 & ; \\ 0.79 & ; & 0.4 \leq x < 0.5 & ; \\ 0.92 & ; & 0.5 \leq x < 0.6 & ; \\ 0.98 & ; & 0.6 \leq x < 0.7 & ; \\ 1.00 & ; & 0.7 \leq x & ; \end{cases}$$

Gunakan ujian Kolmogorov-Smirnov untuk menguji hipotesis bahawa populasi itu ialah normal dengan min $\mu = 0.35$ dan $\sigma = 0.1$.
Gunakan $\alpha = 0.05$.

(50%)

- (b) Huraikan secara ringkas setiap yang berikut:

- (i) Lengkung cirian pengoperasian;
- (ii) AQL paras kualiti boleh diterima;
- (iii) LQL paras kualiti penghad;
- (iv) AOQ kualiti keluar secara purata;
- (v) AOQL had kualiti keluar secara purata.

(20%)

- (c) Tentukan satu rancangan pensampelan tunggal supaya mempunyai kedua-dua sifat yang berikut:

- (i) risiko pengeluar 0.05 untuk menolak barangan yang peratus kecacatannya ialah 1.0%.
- (ii) risiko pengguna 0.10 untuk menerima barangan yang peratus kecacatannya ialah 6.0%.

(30%)

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3. (a) Syarikat Super-XON ingin menggunakan carta kawalan kadaran kecacatan untuk memonitor prosesnya yang menghasilkan bahagian elektronik. Dari data awal 25 subkumpulan setiap saiz 500, didapati

Subkumpulan	Bilangan butir yang cacat	Subkumpulan	Bilangan butir yang cacat
1	9	14	11
2	10	15	7
3	6	16	6
4	0	17	19
5	5	18	11
6	7	19	10
7	10	20	9
8	12	21	7
9	13	22	10
10	10	23	10
11	11	24	2
12	10	25	24
13	9		

- (i) Binakan carta kawalan kadaran kecacatan. Anggapkan data awal yang di atas had kawalan percubaan disebabkan sebab-sebab terumpukkan dan tidak digunakan.
- (ii) Katakan proses telah berubah ke $p = 0.025$, apakah kebarangkalian bahawa perubahan ini dapat dikesan pada sampel yang kedua?
(40%)
- (b) Suatu proses penghasilan diketahui telah stabil. Pihak berkuasa ingin mengguna carta-D (carta Demerit per unit) untuk memonitor proses penghasilannya. Dari 25 subkumpulan setiap saiz 300, maklumatnya seperti yang berikut:

Jenis kecacatan	Genting	Major	Minor
Bilangan kecacatan	12	64	225

- (i) Jika pemberat bagi 3 jenis kecacatan ini ialah di dalam kadaran 9:3:1, dapatkan carta demerit per unitnya.

- (ii) Pada suatu sampel yang saiznya 300, didapati

Jenis kecacatan	Genting	Major	Minor
Bilangan kecacatan	2	6	25

Apakah demerit per unitnya? Adakah proses penghasilan itu di dalam kawalan?

(40%)

- (c) Untuk saiz lot $W = 4000$, $AQC = 1.5\%$, 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 anda berikan.

(20%)

4. Pihak pengurus sebuah kilang ingin menggunakan carta kawalan $\bar{X} - S$ untuk memonitor proses penghasilannya. Data awal 26 subkumpulan setiap saiz 5 telah diambil, dan yang berikut ialah ringkasannya:

Subkumpulan	\bar{X}	S	Subkumpulan	\bar{X}	S
1	3.28	0.06	14	3.24	0.10
2	3.03	0.07	15	3.23	0.07
3	3.40	0.08	16	3.41	0.08
4	3.40	0.05	17	3.02	0.12
5	3.65	0.12	18	3.43	0.19
6	3.66	0.34	19	3.25	0.18
7	3.80	0.10	20	3.37	0.10
8	3.48	0.12	21	3.49	0.07
9	3.42	0.11	22	3.40	0.07
10	3.36	0.07	23	3.41	0.23
11	3.43	0.08	24	3.38	0.00
12	3.24	0.13	25	3.98	0.06
13	3.24	0.10	26	3.40	0.18

- (i) Binakan carta $\bar{X} - S$. Jika mana-mana data awal di luar had-had kawalan percubaan, anggapkan sebabnya terumpukkan.
- (ii) Apakah kebarangkalian bahawa perubahan min proses penghasilan ke 3.60 dapat dikesan oleh carta \bar{X} pada subkumpulan yang pertama selepas perubahan itu berlaku. Anggapkan sisihan piawai itu tidak berubah.

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(iii) Dapatkan carta \bar{X} dengan saiz subkumpulan itu supaya dapat mengesan perubahan min proses ke 3.60 dengan keyakinan 95% pada subkumpulan yang pertama selepas perubahan min berlaku.

(50%)

(b) Dapatkan lengkung kualiti keluar secara purata untuk rancangan pensampelan penerimaan yang berikut:

$$N = 4000, \quad n = 150, \quad c = 2$$

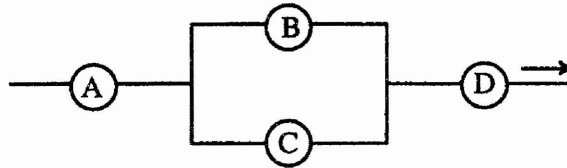
Apakah had kualiti keluar secara puratanya?

(30%)

(c) Merujuk kepada carta $\bar{X} - R$, bincangkan corak-corak utama suatu proses penghasilan di luar kawalan dan sebab-sebab terumpukkan utama yang mungkin.

(20%)

5. (a) Empat komponen A, B, C, D yang tak bersandar, disambung di dalam bentuk yang berikut:



Katakan masahayat (di dalam jam) bagi setiap komponen adalah secaman dan bertaburan X dengan fungsi ketumpatan kebarangkalian f ,

$$f(x) = \begin{cases} 0.02 e^{-0.02x}; & x > 0 \\ 0 & \text{tempat-tempat lain;} \end{cases}$$

Katakan T ialah masahayat sistem ini, cari fungsi ketumpatan kebarangkalian untuk T .

(30%)

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- (b) Jika kadar bahaya untuk suatu pembolehubah rawak X ialah $h(x)$,

$$h(x) = \alpha, \quad \alpha \text{ pemalar}$$

Cari fungsi ketumpatan kebarangkalian bagi X . Apakah kebolehpercayaannya pada $x = 1$?

(30%)

- (c) Katakan populasi X bertaburan normal dengan min μ dan varians $\sigma^2 = 1$. Di dalam ujian berjjukan nisbah (ujian nisbah kebolehjadian) tentang

$$\begin{aligned} H_0: & \quad \mu = 0; \\ H_1: & \quad \mu = 1; \quad \alpha = 0.05; \quad \beta = 0.10; \end{aligned}$$

- (i) tunjukkan rantau penerimaan, rantau penolakkan dan rantau berterusan pengujian di dalam satah mY . m ialah bilangan cerapan yang digunakan, $x_1, x_2, \dots, x_m, \dots$ dan $Y = \sum_{i=1}^m X_i$;

- (ii) Jika cerapan satu sampel ialah

$$\begin{aligned} & 0.7, 0.9, 1.2, 1.5, \\ & 0.2, 0.2, 0.1, 1.6. \end{aligned}$$

Apakah keputusan?

- oooOOooo -

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

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Note.

Small sample inspection levels of MIL-STD-105C

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

Convert to these special inspection levels

B-1
 B-2
 B-3
 B-4

Table 5-5 Single Sampling Plans for Normal Inspection (Table II-A of MIL-STD 105D)*

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.

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	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
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	0 1	↑	↓	1 2	2 3	3 4	5 6	8 9	12 13	18 19	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	
S	3150	↓	↓	1 2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	

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- ↓ = 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)*

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	Ac Re
A	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
B	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
C	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
D	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
E	5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
F	8	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
G	13	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
H	20	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
J	32	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
K	50	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
L	80	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
M	125	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
N	200	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
P	315	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
Q	500	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
i	800	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓

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- ⊕ = 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 10.1.0).

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

Sample size code letter	Sample size	Number of lots inspected	Acceptable Quality Levels (normal 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	
			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	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
C	3 3	3	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
D	5 5	5	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
E	8 8	8	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
F	13 13	13	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
G	20 20	20	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
H	32 32	32	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
J	50 50	50	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
K	80 80	80	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
L	125 125	125	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
M	200 200	200	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
N	315 315	315	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
P	500 500	500	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
Q	800 800	800	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
R	1250 1250	1250	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→

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

TABLE B Factors for Computing Central Lines and 3 σ 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 ₁	A ₃	c ₄	1/c ₄	B ₂	B ₄	B ₅	B ₆	d ₂	1/d ₂	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	0.155	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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TABLE 3-6 Factors for Computing 3σ 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	$1.07/\sqrt{n}$	$1.22/\sqrt{n}$	$1.36/\sqrt{n}$	$1.52/\sqrt{n}$	$1.63/\sqrt{n}$