UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Pertama
Sidang 1991/92

Oktober/November 1991

MSG 362 Statistik Gunaan I

Masa : [3 jam]

Jawab SEMUA LIMA soalan. Soalan-soalan mesti dijawab di dalam Bahasa Malaysia. Sifir "New Cambridge Elementary Statistcal Tables" disediakan. Sifir-sifir yang diperlukan dilampirkan (lampiran 1-10). Alat penghitung "Non-programmable" boleh digunakan. Ia disediakan oleh setiap calon diri sendiri.

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

(50/100)

(b) Penstratuman dijalankan mengikut mesin yang menghasilkan butir yang ukurannya patut sama. Sampel yang tak bersandar diambil dari setiap mesin dan yang berikut ialah ringkasannya:

Mesin	Saiz sampel	Min
1	5	3.02
2	5	3.01
3	7	3.04
4	7	3.07
5	9	3.24
6	9	3.37

dan diketahui $\sum\sum (X_{ij} - 3.00)^2 = 16.87$, X_{ij} ialah cerapan ke-j di dalam sampel ke-i. Bolehkah kita menyatakan min-minnya adalah sama? Gunakan paras keertian $\alpha = 0.05$.

(30/100)

(c) Terangkan setiap yang berikut:

(i) Risiko pengeluar; Risiko pengguna;

(ii) L Q L, paras kualiti penghad;

...2/-

(iii) A Q L, paras kualiti yang boleh diterima;

(iv) A O Q, kualiti keluar secara purata;

(v) A O Q L, had kualiti keluar secara purata;

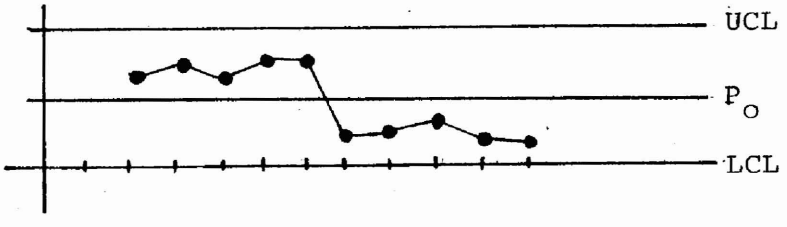
(20/100)

2. (a) Carta kawalan p kadaran kecacatan, ingin digunakan untuk memonitor suatu proses penghasilan part alat elektronik yang mudah. Data awal 24 subsampel setiap saiz 1200 telah diambil dari proses ini dan datanya seperti yang berikut:

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

(i) Binakan carta-p. Anggapkan data awal yang di luar had-had kawalan percubaan disebabkan sebab-sebab terumpukkan dan tidak diambil kira di dalam penghitungan.

(ii) Jika di dalam pemonitoran proses penghasilan ini didapati titik-titik berturut-turut seperti yang berikut:



Apakah kebarangkalian berlakunya kejadian seperti begini.

(40/100)

...3/-

(b) Untuk saiz lot N = 25,000, AQL = 1.0%, gunakan MIL-STD-105D pada paras inspeksi II, tentukan rancangan pensampelan penerimaan berganda dua untuk inspeksi normal, inspeksi ketat dan inspeksi longgar. Jelaskan nombor-nombor yang anda berikan itu.

(30/100)

(c) Yang berikut adalah rancangan pensampelan penerimaan berganda tiga yang dipersetujui di antara pengeluar dan pembeli.

saiz lot N = 7500

$n_1 = 60$; $c_1 = 1$; $r_1 = 5$;

$n_2 = 60$; $c_2 = 5$; $r_2 = 8$;

$n_3 = 60$; $c_3 = 8$; $r_3 = 9$.

Katakan 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 bahagian lengkung cirian pengoperasian selepas sampel yang pertama, dan selepas sampel yang kedua.

(ii) Dapatkan persamaan kebarangkalian penerimaan lot pada sampel yang ketiga.

(30/100)

3. (a) Carta kawalan $\bar{X}$ - S ingin digunakan untuk memonitor ukuran suatu proses penghasilan. Data awal 26 subkumpulan setiap bersaiz 6 telah diambil, dan ringkasannya seperti yang berikut:

...4/-

Subkumpulan	$\bar{X}$	S	Subkumpulan	$\bar{X}$	S
1	6.22	0.12		6.18	0.12
2	6.16	0.22		6.24	0.14
3	6.18	0.12		6.22	0.16
4	6.20	0.12		6.34	0.10
5	6.25	0.08		6.06	0.08
6	6.35	0.09		6.14	0.06
7	6.12	0.07		6.15	0.09
8	6.21	0.11		6.16	0.12
9	6.24	0.12		6.23	0.06
10	6.12	0.08		6.24	0.21
11	6.17	0.07		6.20	0.27
12	6.23	0.13		6.13	0.17
13	6.05	0.31		6.12	0.08

(i) Binakan carta $\bar{X}$ - S untuk kegunaan. Anggapkan data awal yang di luar had-had kawalan percubaan itu disebabkan sebab-sebab terumpukkan dan tidak diambil kira di dalam penghitungan.

(ii) Jika spesifikasi dari permintaan ialah 6.14 ± 0.06 apakah indeks keupayaan proses ini merujuk kepada spesifikasi ini? Apakah kebarangkalian sebuah butir yang dihasilkan proses ini akan memenuhi spesifikasi ini?

(40/100)

(b) Sampel sebanyak 200 cerapan diambil dari suatu populasi dan didapati jadual taburan frekuensinya seperti yang berikut:

Kelas	frekuensi	Kelas	frekuensi
-4	4	1	39
-3	10	2	23
-2	23	3	10
-1	39	4	3
0	48	5	1

Ujikan hipotesis bahawa populasi ini ialah normal. Gunakan ujian khi-kuasa dua pada paras keertian $\alpha = 0.05$.

(30/100)

...5/-

(c) Carta kawalan $\bar{\bar{X}}$ - S telah dibina untuk digunakan memonitor proses penghasilan gelang omboh (piston ring). Ukurannya ialah garispusat dalam gelang. Didapati carta-$\bar{\bar{X}}$ seperti yang berikut untuk subsampel bersaiz 5:

garis tengah: 74.001 (mm)

$UCL_{\bar{\bar{X}}} = 74.014$

$LCL_{\bar{\bar{X}}} = 73.988$

Jika paras proses bergerak ke 74.005, manakala sisihan piawainya tidak berubah, cari kebarangkalian

(i) satu titik luar kawalan didapati pada sampel pertama selepas paras proses bergerak.

(ii) satu titik luar kawalan didapati pada sampel ketiga selepas paras proses bergerak.

(30/100)

4. (a) Syarikat Chip Komputer mengeluarkan sejenis chip untuk kegunaan komputer. Pihak pengurusan ingin menggunakan carta-D (carta demerit per unit) untuk mengawal proses penghasilannya. Dari 25 subsampel awal setiap saiz 1000, didapati data yang berikut:

...6/-

subsampel	Jenis kecacatan genting	major	minor
1	2	15	50
2	1	20	72
3	5	17	63
4	7	23	46
5	6	16	35
6	3	14	27
7	1	18	62
8	4	10	68
9	2	9	64
10	12	40	47
11	3	7	59
12	1	15	67
13	4	17	58
14	6	10	62
15	7	12	75
16	2	4	43
17	1	18	53
18	6	20	85
19	3	4	61
20	7	16	47
21	2	23	58
22	2	35	49
23	4	7	68
24	6	18	72

(i) Dapatkan carta-D jika pemberat 3 jenis kecacatan ini di dalam kadaran 27:3:1.

(ii) Di dalam satu pemeriksaan sampel yang saiznya 100 diambil dari proses penghasilannya dan didapati:

Jenis kecacatan	genting	major	minor
Bilangan kecacatan	2	5	63

Dapatkan demerit per unit bagi sampel ini. Adakah proses di dalam kawalan?

(50/100)

(b) Tentukan satu rancangan pensampelan tunggal supaya:

(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 0.5%.

...7/-

Pilih rancangan pensampelan penerimaan yang memenuhi syarat pengguna dan dekat sekali dengan syarat pengeluar, dan pilih rancangan yang saiz sampelnya kecil sekali.

(30/100)

(c) Bincangkan index keupayaan C_p bagi suatu proses penghasilan merujuk kepada suatu spesifikasi dari suatu permintaan.

Ada apa-apa indeks keupayaan lain? Huraikan.

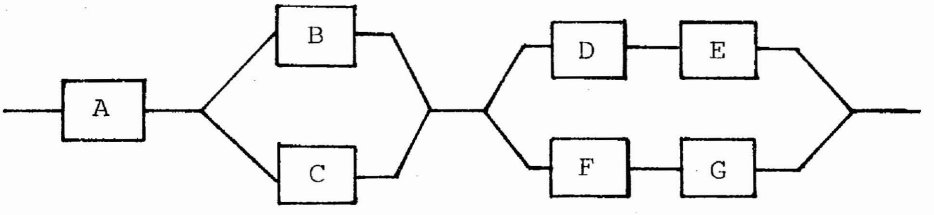
(20/100)

5. (a) Apakah prinsip yang digunakan di dalam pembinaan carta-kawalan? Gunakan prinsip ini untuk membina carta-u, carta bilangan kecacatan per unit.

Anggapkan taburan bilangan kecacatan di dalam mana-mana butir dari suatu proses penghasilan bertaburan Poisson dengan parameter μ.

(30/100)

(b) Di dalam suatu sistem campuran yang berikut:



setiap komponen mempunyai masahayat jam yang taburannya mengikut f.k.k. yang berikut:

$$f(x) = \begin{cases} \dfrac{1}{50\sqrt{2\pi}} \exp\left\{-\frac{1}{2}\left(\dfrac{x-500}{100}\right)^2\right\}; & x > 500; \\ 0; & \text{tempat-tempat lain;} \end{cases}$$

cari kebolehpercayaan sistem ini pada masa jam x = 600.

(30/100)

...8/-

(c) Terangkan perbezaan di antara kadar kegagalan dan kadar bahaya.

X ialah pembolehubah rawak masahayat suatu komponen bagi suatu alat elektronik. Kadar bahayanya ialah h(x).

$$h(x) = \alpha\gamma e^{\gamma x}, \qquad \alpha, \gamma > 0, \quad \text{(parameter)} ;$$
$$x > 0 \quad ,$$

(i) Tentukan f.k.k. untuk pembolehubah rawak masahayat X ini.

(ii) Apakah kebolehpercayaan komponen ini pada masa $x = 2$ apabila $\alpha = 1$, $\gamma = 1$.

(40/100)

- 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," *Industry Quality Control*, 9, No. 1 (July 1952), 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 6-6 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	
		Ac	Re	Ac	Re	Ac	Re	Ac	Re	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	⇩	
B	3																													⇧			
C	5																									0	1			⇧			
D	8																					0	1	⇩		⇩		⇩		1	2	⇩	
E	13																					⇧		⇩		⇩		⇩		2	3		
F	20																							1	2	2	3	3	4	3	4		
G	32																	0	1	⇩		⇩		⇩		⇩		⇩		5	6	⇩	
H	50															0	1	⇧		⇧		⇧		2	3	3	4	5	6	7	8		
J	80													0	1	⇧		⇧		⇧		⇧		3	4	5	6	7	8	10	11		
K	125											0	1	⇩		⇩		1	2	2	3	3	4	5	6	7	8	10	11	14	15	⇩	
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					0	1	⇩		⇩		1	2	2	3	3	4	5	6	7	8	10	11	14	15	21	22						
P	800			0	1	⇧		⇧		1	2	2	3	3	4	5	6	7	8	10	11	14	15	21	22								
Q	1250	0	1	⇧		⇧		1	2	2	3	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	⇧											

Sample size code letter	Sample size	Acceptable Quality Levels (normal inspection)																															
		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														
A	2	1	2	2	3	3	4	5	6	7	8	10	11	14	15	21	22	30	31														
B	3	2	3	3	4	5	6	7	8	10	11	14	15	21	22	30	31	44	45														
C	5	3	4	5	6	7	8	10	11	14	15	21	22	30	31	44	45	⇧															
D	8	⇩		7	8	10	11	14	15	21	22	30	31	44	45	⇧																	
E	13	5	6	⇩		⇩		⇩		⇩		⇩		⇧																			
F	20	7	8	10	11	14	15	21	22	⇧		⇧																					
G	32	⇩		⇩		⇩		⇩		⇩		⇧																					
H	50	10	11	14	15	21	22	⇧		⇧																							
J	80	14	15	21	22	⇧		⇧																									
K	125	⇩		⇩		⇩		⇧																									
L	200	21	22	⇧		⇧																											
M	315	⇧		⇧																													
N	500	⇧																															
P	800																																
Q	1250																																
R	2000																																

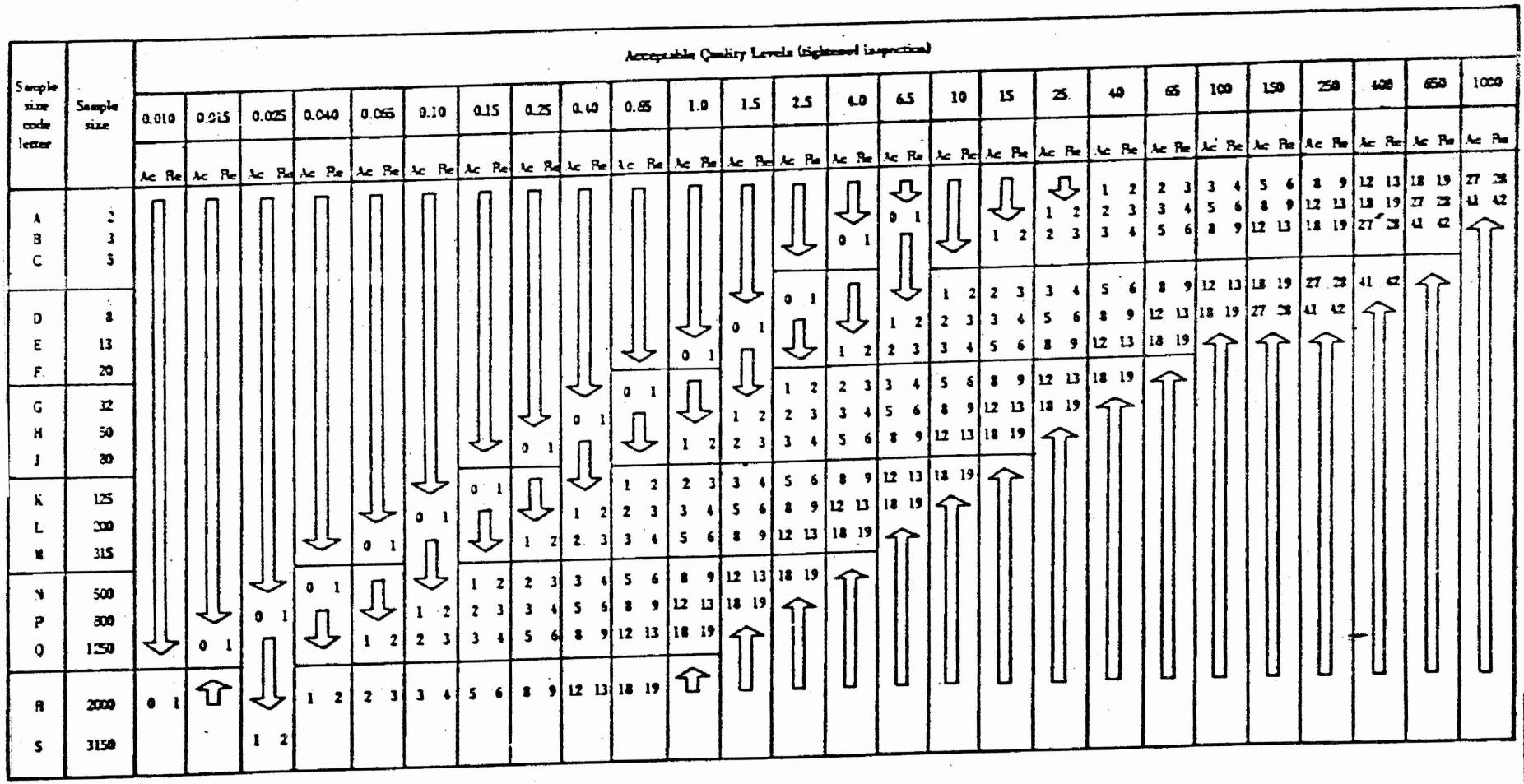
⇩ = Use first sampling plan below arrow. If sample size equals, or exceeds, lot or batch size, do 100 percent inspection.

⇧ = 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
A	2	⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		1	2	2	3	3	4	5	6	8	9	12	13	18	19	27	28
B	3																																			2	3	3	4	5	6	8	9	12	13	18	19	27	28	41	42
C	5																																	1	2	2	3	3	4	5	6	8	9	12	13	18	19	27	28	41	42	⇧	
D	8																																	2	3	3	4	5	6	8	9	12	13	18	19	27	28	41	42		
E	13																																	3	4	5	6	8	9	12	13	18	19	27	28	41	42				
F	20																																	5	6	8	9	12	13	18	19	27	28	41	42				
G	32																																	8	9	12	13	18	19	27	28	41	42						
H	50																																	12	13	18	19	27	28	41	42						
J	80																																	18	19	27	28	41	42						
K	125																																	27	28	41	42						
L	200																																	41	42								
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 8-8 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																																	1	2	2	3	3	4	5	6	7	8	10	11	14	15	21	22	30	31
B	2																																	1	3	2	4	3	5	5	6	7	8	10	11	14	15	21	22	30	31
C	2																																	1	4	2	5	3	6	5	8	7	10	10	13	14	17	21	24		
D	3																																	2	5	3	6	5	8	7	10	10	13	14	17	21	24				
E	5																																	3	6	5	8	7	10	10	13								
F	8																																	5	8	7	10	10	13								
G	13																																	7	10	10	13										
H	20																																	10	13												
J	32																																														
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 8-9 Double Sampling Plans for Normal Inspection (Table III-A of MIL-STD 105D)ª

Sample size code letter	Sample	Sample size	Cumulative 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
A				↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	↓	↓	*	*	*	*	*	*	*	*	*
B	First	2	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	17 22	25 31
	Second	2	4																	1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27	37 38	56 57
C	First	3	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	17 22	25 31	↑
	Second	3	6																1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27	37 38	56 57	
D	First	5	5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	17 22	25 31	↑	↑
	Second	5	10															1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27	37 38	56 57		
E	First	8	8	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	17 22	25 31	↑	↑	↑
	Second	8	16														1 2	3 4	4 5	6 7	8 9	13 12	18 19	26 27	37 38	56 57			
F	First	13	13	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	↑	↑	↑	↑	↑	↑
	Second	13	26													1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27						
G	First	20	20	↓	↓	↓	↓	↓	↓	↓	↓	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	↑	↑	↑	↑	↑	↑	↑
	Second	20	40												1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27							
H	First	32	32	↓	↓	↓	↓	↓	↓	↓	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	↑	↑	↑	↑	↑	↑	↑	↑
	Second	32	64											1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27								
J	First	50	50	↓	↓	↓	↓	↓	↓	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	50	100										1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27									
K	First	80	80	↓	↓	↓	↓	↓	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	80	160									1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27										
L	First	125	125	↓	↓	↓	↓	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	125	250								1 2	3 4	5 4	6 7	8 9	12 13	18 19	26 27											
M	First	200	200	↓	↓	↓	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	200	400							1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27												
N	First	315	315	↓	↓	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	315	630						1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27													
P	First	500	500	↓	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	500	1000					1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27														
Q	First	800	800	*	↑	↓	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	800	1600				1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27															
R	First	1250	1250	↑	↑	0 2	0 3	1 4	2 5	3 7	5 9	7 11	11 16	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	1250	2500			1 2	3 4	4 5	6 7	8 9	12 13	18 19	26 27																

↓ = 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 (or alternatively, use double sampling plan below, where available).

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	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
A				⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩		⇩	
B	First	2	2																																																	
	Second	2	4																																																
C	First	3	3																																																
	Second	3	6																																															
D	First	5	5																																															
	Second	5	10																																															
E	First	8	8																																															
	Second	8	16																																															
F	First	13	13																																															
	Second	13	26																																															
G	First	20	20																																															
	Second	20	40																																															
H	First	32	32																																															
	Second	32	64																																															
J	First	50	50																																															
	Second	50	100																																															
K	First	80	80																																															
	Second	80	160																																															
L	First	125	125																																															
	Second	125	250																																															
M	First	200	200																																															
	Second	200	400																																															
N	First	315	315																																															
	Second	315	630																																															
P	First	500	500																																															
	Second	500	1000																																														
Q	First	800	800																																															
	Second	800	1600																																														
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																																								

⇩ - 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 6-11 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	Ac Re
A B C				↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓ *	↓ * ↑	* ↑ ↓	↓ *	↓ * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * ↑
D	First	2	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	↑	↓	0 2	0 3	0 4	0 4	1 5	2 7	3 8	5 10	7 12	11 17	↑	↑
	Second	2	4															0 2	0 4	1 5	3 6	4 7	6 9	8 12	12 16	18 22	26 30		
E	First	3	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	↑	↓	0 2	0 3	0 4	0 4	1 5	2 7	3 8	5 10	7 12	11 17	↑	↑	↑
	Second	3	6														0 2	0 4	1 5	3 6	4 7	6 9	8 12	12 16	18 22	26 30			
F	First	5	5	↓	↓	↓	↓	↓	↓	↓	↓	↓	*	↑	↓	0 2	0 3	0 4	0 4	1 5	2 7	3 8	5 10	↑	↑	↑	↑	↑	↑
	Second	5	10													0 2	0 4	1 5	3 6	4 7	6 9	8 12	12 16						
G	First	8	8	↓	↓	↓	↓	↓	↓	↓	↓	*	↑	↓	0 2	0 3	0 4	0 4	1 5	2 7	3 8	5 10	↑	↑	↑	↑	↑	↑	↑
	Second	8													0 2	0 4	1 5	3 6	4 7	6 9	8 12	12 16							
H	First	13	13	↓	↓	↓	↓	↓	↓	↓	*	↑	↓	0 2	0 3	0 4	0 4	1 5	2 7	3 8	5 10	↑	↑	↑	↑	↑	↑	↑	↑
	Second	13	26											0 2	0 4	1 5	3 6	4 7	6 9	8 12	12 16								
J	First	20	20	↓	↓	↓	↓	↓	↓	*	↑	↓	0 2	0 3	0 4	0 4	1 5	2 7	3 8	5 10	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	20	40										0 2	0 4	1 5	3 6	4 7	6 9	8 12	12 16									
K	First	32	32	↓	↓	↓	↓	↓	*	↑	↓	0 2	0 3	0 4	0 4	1 5	2 7	3 8	5 10	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	32	64									0 2	0 4	1 5	3 6	4 7	6 9	8 12	12 16										
L	First	50	50	↓	↓	↓	↓	*	↑	↓	0 2	0 3	0 4	0 4	1 5	2 7	3 8	5 10	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	50	100								0 2	0 4	1 5	3 6	4 7	6 9	8 12	12 16											
M	First	80	80	↓	↓	↓	*	↑	↓	0 2	0 3	0 4	0 4	1 5	2 7	3 8	5 10	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	80	160							0 2	0 4	1 5	3 6	4 7	6 9	8 12	12 16												
N	First	125	125	↓	↓	*	↑	↓	0 2	0 3	0 4	0 4	1 5	2 7	3 8	5 10	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	125	250						0 2	0 4	1 5	3 6	4 7	6 9	8 12	12 16													
P	First	200	200	↓	*	↑	↓	0 2	0 3	0 4	0 4	1 5	2 7	3 8	5 10	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	200	400					0 2	0 4	1 5	3 6	4 7	6 9	8 12	12 16														
Q	First	315	315	*	↑	↓	0 2	0 3	0 4	0 4	1 5	2 7	3 8	5 10	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	315	630				0 2	0 4	1 5	3 6	4 7	6 9	8 12	12 16															
R	First	500	500	↑	↑	0 2	0 3	0 4	0 4	1 5	2 7	3 8	5 10	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
	Second	500	1000			0 2	0 4	1 5	3 6	4 7	6 9	8 12	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			Chart for Standard Deviations: Factors for Central Line		Chart for Standard Deviations: Factors for Control Limits				Chart for Ranges: Factors for Central Line		Chart for Ranges: Factors for Control Limits				
	A	A_2	A_3	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	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.