UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Kedua
Sidang Akademik 2005/2006

April/Mei 2006

EPM 332/3 – Kualiti & Kebolehpercayaan

Masa : 3 jam

ARAHAN KEPADA CALON :

Sila pastikan bahawa kertas soalan ini mengandungi **LAPAN (8)** mukasurat dan **TUJUH (7)** soalan serta **LAPAN (8)** Lampiran yang bercetak sebelum anda memulakan peperiksaan.

Sila jawab **LIMA (5)** soalan sahaja.

Calon dibenarkan menjawab semua soalan dalam **Bahasa Malaysia** kecuali soalan **No 4. hingga soalan No. 7[a]** dalam **Bahasa Inggeris.**

LAMPIRAN :

1. Lampiran 1: Jadual 1 MIL-HDBK-217B [1 mukasurat]
2. Lampiran 2: Jadual Nilai Pemalar K [1 mukasurat]
3. Lampiran 3: Factor for Computing Central Lines and 3σ Control Limits [6 mukasurat]

Setiap soalan mestilah dimulakan pada mukasurat yang baru.

...2/-

S1. [a] **Kebolehpercayaan suatu peranti boleh diukur menerusi beberapa pengukuran. Terangkan secara ringkas DUA ukuran prestasi kebolehpercayaan. Apakah perbezaan di antara kualiti dan kebolehpercayaan.**

Reliability of a device can be measured by a number of measurements. Explain briefly TWO of the reliability performance measurements. What is the distinction between quality and reliability?

(30 Markah)

[b] **Tentukan kadar kegagalan dalam %/1000 jam untuk ujian berikut:**

Jangkamasa ujian: 2000 jam

Bilangan unit yang diuji: 20

Bilangan unit yang gagal: 7

Sejarah kegagalan diberikan dalam Jadual S1[b].

Determine the failure rate in %/1000 hour for the following test:

Test duration: 2000 hour

Number of units tested: 20

Number of failed units: 7

Failure history is given in Table Q1[b].

Jadual S1[b]
Table Q1[b]

No Unit *Unit No.*	**Jam kegagalan** *Hours to Failure*
2	**350**
5	**400**
7	**750**
8	**800**
11	**950**
13	**955**
15	**1100**

(30 Markah)

...3/-

[c] **Satu jenis perintang *fixed-film* RNR 1/8-W 82,000 ohm yang menurut MIL-R-55182 digunakan dalam penggunaan *Naval (sheltered)*. Suhu ambien ialah 65°C dan perintang menghamburkan 0.1 W. Perintang dibeli pada paras kadar kegagalan R. Apakah kadar kegagalannya? Model kadar kegagalan untuk perintang RNR diberi sebagai $\lambda_p = \lambda_b(\pi_E \text{ X } \pi_R \text{ X } \pi_Q)$ dan untuk λ_b, π_E, π_R dan π_Q gunakan Jadual-jadual yang berkaitan di LAMPIRAN 1.**

*A type RNR 1/8-W 82,000 ohm fixed-film resistor per MIL-R-55182 is used in a Naval (sheltered) application. The ambient temperature is 65 °C and the resistor dissipates 0.1W. The resistor was purchased to failure-rate level R. What is the failure rate? The failure rate model for RNR resistor is given as $\lambda_p = \lambda_b(\pi_E X \pi_R X \pi_Q)$ and for λ_b, π_E, π_R and π_Q use related Tables in **APPENDIX 1**.*

(40 Markah)

S2. [a] **Lakarkan serta labelkan lengkungan tub mandi, dan berdasarkan lengkungan tersebut bincangkan fasa-fasa jangka hayat suatu peralatan.**

Draw and label a bath tub curve, and based on the curve, discuss the life phases of an equipment.

(30 Markah)

[b] **Berapa banyak sub sistem, perlu disambung secara lelebih selari untuk memastikan kebarangkalian berjaya keseluruhan sistem tersebut ialah 98% bagi jangkamasa pengoperasian selama 1500 jam? Setiap satu mempunyai kadar kegagalan 17%/1000 jam.**

How many subsystems need to be connected in parallel redundancy to assure a 98% probability of success of the whole system for an operational period of 1500 hour? Each has a failure rate of 17%/1000 hour.

(30 Markah)

[c] **Dua belas unit komponen diuji menggunakan satu pelan ujian hayat (dengan penggantian komponen yang gagal). Pelan ini akan menerima lot yang mempunyai satu purata hayat 2000 jam dengan kebarangkalian 90%. Kegagalan keenam berlaku pada jam ke 250. Tentukan samada lot boleh diterima jika;**

Twelve units of components are placed on test using a life test plan (with replacement of failed items) that will accept a lot having a mean life of 2000 hour with a probability of 90%. The sixth failure occurs at the 250 hour. Determine whether the lot is acceptable if:

...4/-

(i) **Ujian hayat ditamatkan apabila kegagalan keenam berlaku dan komponen yang gagal diganti.**

Life test is terminated upon occurrence of the sixth failure and failed components are replaced.

(ii) **Ujian hayat ditamatkan pada masa yang ditetapkan dan komponen yang gagal tidak diganti.**

Life test is terminated at pre-assigned time and failed components are not replaced.

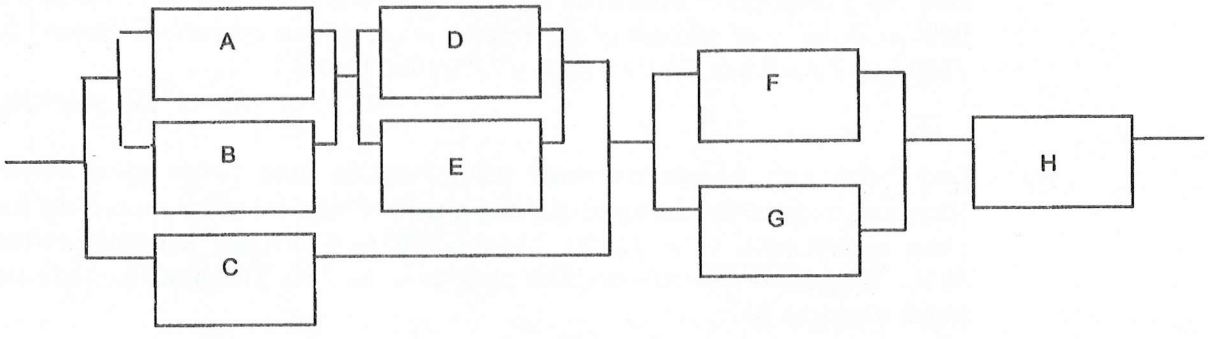
Pemalar k boleh diperolehi daripada jadual-jadual berkaitan di LAMPIRAN 2.

The value of constant k is from the related tables in ***APPENDIX 2.***

(40 Markah)

S3. [a] **Tentukan kebarangkalian kejayaan bagi sistem siri-selari di dalam Rajah S3[a]. Diberi kebarangkalian kejayaan komponen adalah seperti berikut: $P_A = 0.8$, $P_B = 0.85$, $P_C = 0.92$, $P_D = P_E = 0.8$, $P_F = 0.85$, $P_G = 0.75$ and $P_H = 0.7$.**

Determine the probability of survival of the series-parallel system shown in Figure Q3[a]. The probability of success for each component is given as; $P_A = 0.8$, $P_B = 0.85$, $P_C = 0.92$, $P_D = P_E = 0.8$, $P_F = 0.85$, $P_G = 0.75$ and $P_H = 0.7$.



Rajah S3[a]
Figure Q3[a]

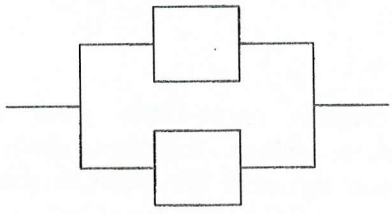
(50 Markah)

...5/-

[b] **Merujuk Rajah S3[b], bincangkan kekurangan litar lelebih selari dan cadangkan bagaimana mengatasi kekurangan tersebut.**

Refer to Figure Q3[b], discuss the limitations of parallel redundant circuits and propose how to solve the mentioned limitations.

(20 Markah)



Rajah S3[b]
Figure Q3[b]

[c] **Satu konfigurasi mengandungi satu modul operasi dan unit siap sedia yang serupa. Unit siap sedia tersebut diaktifkan untuk beroperasi menggunakan suis pengesan kegagalan jika modul biasa gagal. Masa pengoperasian ialah 850 jam. Kebolehpercayaan modul operasi ialah 75% dan kebolehpercayaan suis pengesan kegagalan dianggap 90%. Kira kebarangkalian berjaya untuk konfigurasi tersebut**

A configuration consists of an operating module and an identical standby unit. The standby unit is switched into operation by a failure-sensing switch if the regular module should fail. Operational time is 850 hrs. The reliability of the operating module is 75% and the reliability of the failure sensing switch is assumed 90%. Calculate the probability of survival for the configuration.

(30 Markah)

S4. [a] **Terangkan sistem pengurusan kualiti. Huraikan EMPAT BELAS (14) ciri-ciri penting yang membentuk Pengurusan Kualiti Menyeluruh.**

Explain the quality management system. Deseribe the FOURTEEN (14) points that are foundation for Total Quality Management.

(60 Markah)

...6/-

[b] **Senaraikan SEMBILAN (9) teknik penambahbaikan kualiti. Terangkan kegunaan carta pareto dan langkah-langkah yang perlu dilakukan untuk membina carta pareto dengan memberikan contoh yang sesuai.**

Name NINE (9) quality improvement techniques. Explain the use of Pareto Charts and the steps to be followed for construction of Pareto chart with a suitable example.

(40 Markah)

S5. [a] **Terangkan secara ringkas carta-carta yang diperlukan bagi data pembolehubah dan data atribut. Bagaimanakah mengenalpasti sesuatu proses itu berada diluar kawalan dan apakah tindakan pembaikan yang boleh diambil untuk mengawal proses tersebut?**

Explain briefly the different types of charts required for variable and attribute type of data. How out of control process can be found and what remedial action can be taken to control the process?

(50 Markah)

[b] **Syarikat pembuatan ABC menghasilkan drum brek untuk kenderaan 4 roda yang mana kekerasan permukaannya adalah kritikal dan diukur dalam satu skala. Berikut adalah data bagi kekerasan permukaan drum brek yang dikumpul semasa proses berada dalam kawalan.**

The ABC manufacturing company produces brake drums for 4 wheelers, the surface hardness is critical and measured in one scale. The following data for surface hardness of brake drums were collected when process was in control.

	Reading			
Sample	1	2	3	4
1	604	612	588	600
2	597	601	607	603
3	581	570	585	592
4	620	605	595	588
5	590	614	608	604

(i) **Pihak pengurusan mencadangkan carta-R dan carta-$\bar{x}$. Kirakan had kawalan bagi carta-R dan carta-$\bar{x}$ tersebut.**

Management recommends R-chart and $\bar{x}$-chart. Calculate control limits for R-chart and $\bar{x}$- chart.

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(ii) **Beberapa pekerja baru telah diambil sepanjang proses pengumpulan data dijalankan dan berikut adalah data yang diperolehi daripada pekerja tersebut: 570, 603, 623 dan 583. Tentukan sama ada proses tersebut berada dalam kawalan. Tunjukkan jalan kerja anda dengan jelas.**

Since these data were collected some new employees were hired. A new sample obtained the following readings: 570, 603, 623 and 583. Determine whether the process is in control. Show your working clearly.

(50 Markah)

S6. [a] **Apakah itu pensampelan penerimaan? Terangkan maksud *"AQL", "LTPD", "Type I error", "Type II error"* dan lengkung OC.**

What is acceptance sampling? Explain what is meant by AQL, LTPD, Type I error, Type II error, OC Curve.

(35 Markah)

[b] **Sebuah firma hartanah menilai borang perjanjian jualan masuk dengan menggunakan satu pelan pensampelan N = 1500, n = 110, dan c = 3. Bina suatu lengkung OC dengan menggunakan tujuh titik.**

A real estate firm evaluates incoming selling agreement forms using the single sampling plan N = 1500, n = 110, and c = 3. Construct the OC curve using seven points.

(40 Markah)

[c] **Terangkan fungsi-fungsi ISO. Bagaimanakah ia dapat membantu meningkatkan kualiti produk.**

Explain the functions of ISO. How it has helped in improving the quality of products?

(25 Markah)

S7. [a] **Suatu proses yang sedia ada tidak menepati spesifikasi Rockwel berskala C. Tentukan keupayaan proses berdasarkan nilai julat bagi subkumpulan yang bersaiz 4. Data-datanya ialah 7, 5, 5, 3, 2, 4, 5, 9, 4, 5, 4, 7, 5, 3, 4, 7, 5, 5 dan 7. Anggapkan spesifikasi atas dan spesifikasi bawah adalah bersamaan (30±7) dalam ukuran unit kekerasan.**

Tentukan sama ada proses berupaya atau tidak.

An existing process is not meeting the Rockwell-c specifications. Determine the process capability based on the range values for subgroups of size 4. Data are 7, 5, 5, 3, 2, 4, 5, 9, 4, 5, 4, 7, 5, 3, 4, 7, 5, 5 and 7. Assuming the upper and lower specification as (30 ± 7) in hardness unit.

Determine whether process is capable or not.

(50 Markah)

[b] [i] **Berikan definisi dan persamaan matematik yang mewakili kebolehsediaan operasi dan kebolehsediaan terwujud yang diberkaitan dengan kebolehsenggaraan.**

Give the definition and the mathematical equations that represent operational availability and inherent availability associated with maintainability.

[ii] **Apakah kebolehsediaan operasi bagi satu kumpulan empat *"automatic teller machine"*, di cawangan USM untuk tempoh seminggu? Kesemua mesin beroperasi 24 jam sehari. Dalam tempoh tersebut sejumlah 20 jam mesin-mesin tersebut tidak dapat berfungsi dengan jayanya di lokasi tersebut.**

What is the operational availability of a group of four automatic teller machines at USM branch for a one-week period? The machines are operating 24 hour per day. There were a total number of 20 down hours for the location?

(50 Markah)

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LAMPIRAN 1
APPENDIX 1

Table 8-1 *Failure Rates λ_b (failures/10^6 h) for MIL-R-10509 and MIL-R-55182 Fixed-Film Resistors. (Source: MIL-HDBK-217B, Table 2.5.2-5.)*

T	Ratio of Operating to Rated Wattage									
(°C)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
0	0.0012	0.0013	0.0014	0.0016	0.0018	0.0020	0.0022	0.0024	0.0027	0.0029
10	0.0013	0.0014	0.0016	0.0018	0.0020	0.0022	0.0024	0.0027	0.0030	0.0033
20	0.0014	0.0016	0.0018	0.0020	0.0022	0.0025	0.0027	0.0031	0.0034	0.0038
30	0.0016	0.0017	0.0020	0.0022	0.0025	0.0027	0.0031	0.0034	0.0038	0.0043
40	0.0017	0.0019	0.0022	0.0024	0.0027	0.0031	0.0034	0.0039	0.0044	0.0049
50	0.0019	0.0021	0.0024	0.0027	0.0030	0.0034	0.0039	0.0044	0.0049	0.0055
55	0.0020	0.0022	0.0025	0.0028	0.0032	0.0036	0.0041	0.0046	0.0052	0.0059
60	0.0021	0.0023	0.0026	0.0030	0.0034	0.0038	0.0043	0.0049	0.0056	0.0063
65	0.0022	0.0025	0.0028	0.0032	0.0036	0.0041	0.0046	0.0052	0.0059	0.0067
70	0.0023	0.0026	0.0029	0.0033	0.0038	0.0043	0.0049	0.0055	0.0063	0.0071
75	0.0024	0.0027	0.0031	0.0035	0.0040	0.0045	0.0052	0.0059	0.0067	0.0076
80	0.0025	0.0028	0.0032	0.0037	0.0042	0.0048	0.0055	0.0062	0.0071	0.0081
85	0.0026	0.0030	0.0034	0.0039	0.0044	0.0051	0.0058	0.0066	0.0075	0.0086
90	0.0027	0.0031	0.0036	0.0041	0.0047	0.0054	0.0061	0.0070	0.0080	0.0092
95	0.0029	0.0033	0.0038	0.0043	0.0049	0.0057	0.0065	0.0074	0.0085	0.0097
100	0.0030	0.0034	0.0040	0.0045	0.0052	0.0060	0.0069	0.0079	0.0090	0.010
105	0.0031	0.0036	0.0042	0.0048	0.0055	0.0063	0.0073	0.0084	0.0096	0.011
110	0.0033	0.0038	0.0044	0.0050	0.0058	0.0067	0.0077	0.0089	0.010	0.011
115	0.0034	0.0040	0.0046	0.0053	0.0061	0.0071	0.0082	0.0094	0.010	0.012
120	0.0036	0.0042	0.0048	0.0056	0.0065	0.0075	0.0086	0.010	0.011	0.013
125	0.0038	0.0044	0.0051	0.0059	0.0068	0.0079	0.0091	0.010	0.012	0.013
130	0.0040	0.0046	0.0053	0.0062	0.0072	0.0083	0.0097	0.011	0.013	
135	0.0041	0.0048	0.0056	0.0065	0.0076	0.0088	0.010	0.011	0.013	
140	0.0043	0.0051	0.0059	0.0069	0.0080	0.0093	0.010	0.012		
145	0.0046	0.0053	0.0062	0.0072	0.0084	0.0098	0.011	0.013		
150	0.0048	0.0056	0.0065	0.0076	0.0089	0.010	0.012			
155	0.0050	0.0058	0.0069	0.0080	0.0094	0.011	0.012			
160	0.0052	0.0061	0.0072	0.0084	0.0099	0.011	0.013			
165	0.0055	0.0064	0.0076	0.0089	0.010	0.012				
170	0.0057	0.0068	0.0080	0.0094	0.011	0.013				
175	0.0060	0.0071	0.0084	0.0099	0.011	0.013				

Table 9-3 *Environmental Symbol Identification and Description. (Source: MIL-HDBK-217B.)*

Environment	π_E Symbol	Nominal Environmental Conditions
Ground, benign	G_B	Nearly zero environmental stress with optimum engineering operation and maintenance.
Space, flight	S_F	Earth orbital. Approaches ground, benign conditions without access for maintenance. Vehicle neither under powered flight nor in atmospheric reentry.
Ground, fixed	G_F	Conditions less than ideal to include installation in permanent racks with adequate cooling air, maintenance by military personnel, and possible installation in unheated buildings.
Ground, mobile (and portable)	G_M	Conditions more severe than those for G_F, mostly for vibration and shock. Cooling air supply may also be more limited, and maintenance less uniform.
Naval, sheltered	N_S	Surface-ship conditions similar to G_F but subject to occasional high shock and vibration.
Naval, unsheltered	N_U	Nominal surface shipborne conditions but with repetitive high levels of shock and vibration.
Airborne, inhabited	A_I	Typical cockpit conditions without environmental extremes of pressure, temperature, shock, and vibration.
Airborne, uninhabited	A_U	Bomb bay, tail, or wing installations where extreme pressure, temperature, and vibration cycling may be aggravated by contamination from oil, hydraulic fluid, and engine exhaust. Class I and Ia equipment of MIL-E-5400 should not be used in this environment.
Missile, launch	M_L	Severe conditions of noise, vibration, and other environments related to missile launch, and space vehicle boost into orbit, vehicle reentry, and landing by parachute. Conditions may also apply to installation near main rocket engines during launch operations.

Table 9-5 π_E, *Environmental Factor.*

Environment	π_E
G_B	1.0
S_F	1.0
G_F	2.5
A_I	5.0
N_S	7.5
G_M	10.0
N_U	11.0
A_U	12.0
M_L	18.0

Table 9-6 π_R, *Resistance Factor.*

Resistance Range	π_R
Up to 100,000 Ω	1.0
> 0.1–1 MΩ	1.1
> 1.0–10 MΩ	1.6
> 10 MΩ	2.5

Table 9-7 π_Q, *Quality Factor.*

Failure-Rate Level	π_Q
M (1.0%/1000 h)	1.0
P (0.1%/1000 h)	0.3
R (0.01%/1000 h)	0.1
S (0.001%/1000 h)	0.03

LAMPIRAN 2
APPENDIX 2

Table 11-1 *Tabulation of Constant k Versus Termination Failures r for Two Values of Producer's Risk α. (Based on Table 2B-1 in DoD Handbook H108.)*

r	k ($\alpha = 0.05$)	k ($\alpha = 0.10$)
1	0.052	0.106
2	0.178	0.266
3	0.272	0.367
4	0.342	0.436
5	0.394	0.487
6	0.436	0.525
7	0.469	0.556
8	0.498	0.582
9	0.522	0.604
10	0.543	0.622
15	0.616	0.687
20	0.663	0.726
25	0.695	0.754
30	0.720	0.774
40	0.755	0.803
50	0.779	0.824

Table 11-2 *Values of Constant k Versus Termination Failures r_F for $\alpha = 0.05$ and $\alpha = 0.10$. Sample Size n Is Multiple of r_F.* [Based on DoD Handbook H108, Tables 2C-1(b), 2C-1(c), 2C-2(b), and 2C-2(c)].*

r_F	Yes $2r_F$	No $2r_F$	Yes $3r_F$	No $3r_F$	Yes $4r_F$	No $4r_F$	Yes $5r_F$	No $5r_F$	Yes $6r_F$	No $6r_F$	Yes $7r_F$	No $7r_F$	α
1	0.026	0.026	0.017	0.017	0.013	0.013	0.010	0.010	0.009	0.009	0.007	0.007	0.05
	0.053	0.053	0.035	0.035	0.026	0.026	0.021	0.021	0.018	0.018	0.015	0.015	0.10
2	0.089	0.104	0.059	0.065	0.044	0.048	0.036	0.038	0.030	0.031	0.025	0.026	0.05
	0.133	0.155	0.089	0.098	0.066	0.071	0.053	0.056	0.044	0.046	0.038	0.039	0.10
3	0.136	0.168	0.091	0.103	0.068	0.075	0.055	0.058	0.045	0.048	0.039	0.041	0.05
	0.184	0.226	0.122	0.139	0.092	0.101	0.073	0.079	0.061	0.065	0.052	0.055	0.10
4	0.171	0.217	0.114	0.132	0.085	0.095	0.068	0.074	0.057	0.061	0.049	0.052	0.05
	0.218	0.277	0.145	0.168	0.109	0.121	0.087	0.095	0.073	0.078	0.062	0.066	0.10
5	0.197	0.254	0.131	0.153	0.099	0.110	0.079	0.086	0.066	0.071	0.056	0.060	0.05
	0.243	0.314	0.162	0.189	0.122	0.136	0.097	0.106	0.081	0.087	0.070	0.074	0.10
6	0.218	0.284	0.145	0.170	0.109	0.122	0.087	0.095	0.073	0.078	0.062	0.066	0.05
	0.263	0.343	0.175	0.206	0.131	0.147	0.105	0.115	0.088	0.094	0.075	0.080	0.10
7	0.235	0.309	0.156	0.185	0.117	0.132	0.094	0.103	0.078	0.084	0.067	0.072	0.05
	0.278	0.366	0.185	0.219	0.139	0.157	0.111	0.122	0.093	0.100	0.079	0.085	0.10
8	0.249	0.330	0.166	0.197	0.124	0.141	0.100	0.110	0.083	0.090	0.071	0.076	0.05
	0.291	0.386	0.194	0.230	0.146	0.164	0.116	0.128	0.097	0.105	0.083	0.089	0.10
9	0.261	0.348	0.174	0.207	0.130	0.148	0.104	0.115	0.087	0.094	0.075	0.080	0.05
	0.302	0.402	0.201	0.239	0.151	0.171	0.121	0.133	0.101	0.109	0.086	0.092	0.10
10	0.271	0.363	0.181	0.216	0.136	0.154	0.109	0.120	0.090	0.098	0.078	0.083	0.05
	0.311	0.416	0.207	0.247	0.156	0.176	0.124	0.137	0.104	0.112	0.089	0.095	0.10
15	0.308	0.417	0.205	0.246	0.154	0.175	0.123	0.136	0.103	0.112	0.088	0.094	0.05
	0.343	0.465	0.229	0.275	0.172	0.196	0.137	0.152	0.114	0.124	0.098	0.105	0.10
20	0.331	0.451	0.221	0.266	0.166	0.189	0.133	0.147	0.110	0.120	0.095	0.102	0.05
	0.363	0.494	0.242	0.291	0.182	0.207	0.145	0.161	0.121	0.132	0.104	0.112	0.10

* α is producer's risk; Yes, designates testing with replacement of failed items; No, designates testing without replacement of failed items.

LAMPIRAN 3
APPENDIX 3

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

OBSERVATIONS IN SAMPLE, n	CHART FOR AVERAGES: FACTORS FOR CONTROL LIMITS A	A_2	A_3	CHART FOR STANDARD DEVIATIONS: FACTOR FOR CENTRAL LINE c_4	FACTORS FOR CONTROL LIMITS B_3	B_4	B_5	B_6	CHART FOR RANGES: FACTOR FOR CENTRAL LINE d_2	FACTORS FOR CONTROL LIMITS d_1	D_1	D_2	D_3	D_4
2	2.121	1.880	2.659	0.7979	0	3.267	0	2.606	1.128	0.853	0	3.686	0	3.267
3	1.732	1.023	1.954	0.8862	0	2.568	0	2.276	1.693	0.888	0	4.358	0	2.574
4	1.500	0.729	1.628	0.9213	0	2.266	0	2.088	2.059	0.880	0	4.698	0	2.282
5	1.342	0.577	1.427	0.9400	0	2.089	0	1.964	2.326	0.864	0	4.918	0	2.114
6	1.225	0.483	1.287	0.9515	0.030	1.970	0.029	1.874	2.534	0.848	0	5.078	0	2.004
7	1.134	0.419	1.182	0.9594	0.118	1.882	0.113	1.806	2.704	0.833	0.204	5.204	0.076	1.924
8	1.061	0.373	1.099	0.9650	0.185	1.815	0.179	1.751	2.847	0.820	0.388	5.306	0.136	1.864
9	1.000	0.337	1.032	0.9693	0.239	1.761	0.232	1.707	2.970	0.808	0.547	5.393	0.184	1.816
10	0.949	0.308	0.975	0.9727	0.284	1.716	0.276	1.669	3.078	0.797	0.687	5.469	0.223	1.777
11	0.905	0.285	0.927	0.9754	0.321	1.679	0.313	1.637	3.173	0.787	0.811	5.535	0.256	1.744
12	0.866	0.266	0.886	0.9776	0.354	1.646	0.346	1.610	3.258	0.778	0.922	5.594	0.283	1.717
13	0.832	0.249	0.850	0.9794	0.382	1.618	0.374	1.585	3.336	0.770	1.025	5.647	0.307	1.693
14	0.802	0.235	0.817	0.9810	0.406	1.594	0.399	1.563	3.407	0.763	1.118	5.696	0.328	1.672
15	0.775	0.223	0.789	0.9823	0.428	1.572	0.421	1.544	3.472	0.756	1.203	5.741	0.347	1.653
16	0.750	0.212	0.763	0.9835	0.448	1.552	0.440	1.526	3.532	0.750	1.282	5.782	0.363	1.637
17	0.728	0.203	0.739	0.9845	0.466	1.534	0.458	1.511	3.588	0.744	1.356	5.820	0.378	1.622
18	0.707	0.194	0.718	0.9854	0.482	1.518	0.475	1.496	3.640	0.739	1.424	5.856	0.391	1.608
19	0.688	0.187	0.698	0.9862	0.497	1.503	0.490	1.483	3.689	0.734	1.487	5.891	0.403	1.597
20	0.671	0.180	0.680	0.9869	0.510	1.490	0.504	1.470	3.735	0.729	1.549	5.921	0.415	1.585

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TABLE C Continued

c \ np_0	11.0	12.0	13.0	14.0	15.0
0	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
1	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
2	0.001 (0.001)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
3	0.004 (0.005)	0.002 (0.002)	0.001 (0.001)	0.000 (0.000)	0.000 (0.000)
4	0.010 (0.015)	0.005 (0.007)	0.003 (0.004)	0.001 (0.001)	0.001 (0.001)
5	0.022 (0.037)	0.013 (0.020)	0.007 (0.011)	0.004 (0.005)	0.002 (0.003)
6	0.041 (0.078)	0.025 (0.045)	0.015 (0.026)	0.009 (0.014)	0.005 (0.008)
7	0.065 (0.143)	0.044 (0.089)	0.028 (0.054)	0.017 (0.031)	0.010 (0.018)
8	0.089 (0.232)	0.066 (0.155)	0.046 (0.100)	0.031 (0.062)	0.019 (0.037)
9	0.109 (0.341)	0.087 (0.242)	0.066 (0.166)	0.047 (0.109)	0.032 (0.069)
10	0.119 (0.460)	0.105 (0.347)	0.086 (0.252)	0.066 (0.175)	0.049 (0.118)
11	0.119 (0.579)	0.114 (0.461)	0.101 (0.353)	0.084 (0.259)	0.066 (0.184)
12	0.109 (0.688)	0.114 (0.575)	0.110 (0.463)	0.099 (0.358)	0.083 (0.267)
13	0.093 (0.781)	0.106 (0.681)	0.110 (0.573)	0.106 (0.464)	0.096 (0.363)
14	0.073 (0.854)	0.091 (0.772)	0.102 (0.675)	0.106 (0.570)	0.102 (0.465)
15	0.053 (0.907)	0.072 (0.844)	0.088 (0.763)	0.099 (0.669)	0.102 (0.567)
16	0.037 (0.944)	0.054 (0.898)	0.072 (0.835)	0.087 (0.756)	0.096 (0.663)
17	0.024 (0.968)	0.038 (0.936)	0.055 (0.890)	0.071 (0.827)	0.085 (0.748)
18	0.015 (0.983)	0.026 (0.962)	0.040 (0.930)	0.056 (0.883)	0.071 (0.819)
19	0.008 (0.991)	0.016 (0.978)	0.027 (0.957)	0.041 (0.924)	0.056 (0.875)
20	0.005 (0.996)	0.010 (0.988)	0.018 (0.975)	0.029 (0.953)	0.042 (0.917)
21	0.002 (0.998)	0.006 (0.994)	0.011 (0.986)	0.019 (0.972)	0.030 (0.947)
22	0.001 (0.999)	0.003 (0.997)	0.006 (0.992)	0.012 (0.984)	0.020 (0.967)
23	0.001 (1.000)	0.002 (0.999)	0.004 (0.996)	0.007 (0.991)	0.013 (0.980)
24		0.001 (1.000)	0.002 (0.998)	0.004 (0.995)	0.008 (0.988)
25			0.001 (0.999)	0.003 (0.998)	0.005 (0.993)
26			0.001 (1.000)	0.001 (0.999)	0.003 (0.996)
27				0.001 (1.000)	0.002 (0.998)
28					0.001 (0.999)
29					0.001 (1.000)

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TABLE C Continued

c \ np_0	3.6	3.7	3.8	3.9	4.0
0	0.027 (0.027)	0.025 (0.025)	0.022 (0.022)	0.020 (0.020)	0.018 (0.018)
1	0.098 (0.125)	0.091 (0.116)	0.085 (0.107)	0.079 (0.099)	0.073 (0.091)
2	0.177 (0.302)	0.169 (0.285)	0.161 (0.268)	0.154 (0.253)	0.147 (0.238)
3	0.213 (0.515)	0.209 (0.494)	0.205 (0.473)	0.200 (0.453)	0.195 (0.433)
4	0.191 (0.706)	0.193 (0.687)	0.194 (0.667)	0.195 (0.648)	0.195 (0.628)
5	0.138 (0.844)	0.143 (0.830)	0.148 (0.815)	0.152 (0.800)	0.157 (0.785)
6	0.083 (0.927)	0.088 (0.918)	0.094 (0.909)	0.099 (0.899)	0.104 (0.889)
7	0.042 (0.969)	0.047 (0.965)	0.051 (0.960)	0.055 (0.954)	0.060 (0.949)
8	0.019 (0.988)	0.022 (0.987)	0.024 (0.984)	0.027 (0.981)	0.030 (0.979)
9	0.008 (0.996)	0.009 (0.996)	0.010 (0.994)	0.012 (0.993)	0.013 (0.992)
10	0.003 (0.999)	0.003 (0.999)	0.004 (0.998)	0.004 (0.997)	0.005 (0.997)
11	0.001 (1.000)	0.001 (1.000)	0.001 (0.999)	0.002 (0.999)	0.002 (0.999)
12			0.001 (1.000)	0.001 (1.000)	0.001 (1.000)

c \ np_0	4.1	4.2	4.3	4.4	4.5
0	0.017 (0.017)	0.015 (0.015)	0.014 (0.014)	0.012 (0.012)	0.011 (0.011)
1	0.068 (0.085)	0.063 (0.078)	0.058 (0.072)	0.054 (0.066)	0.050 (0.061)
2	0.139 (0.224)	0.132 (0.210)	0.126 (0.198)	0.119 (0.185)	0.113 (0.174)
3	0.190 (0.414)	0.185 (0.395)	0.180 (0.378)	0.174 (0.359)	0.169 (0.343)
4	0.195 (0.609)	0.195 (0.590)	0.193 (0.571)	0.192 (0.551)	0.190 (0.533)
5	0.160 (0.769)	0.163 (0.753)	0.166 (0.737)	0.169 (0.720)	0.171 (0.704)
6	0.110 (0.879)	0.114 (0.867)	0.119 (0.856)	0.124 (0.844)	0.128 (0.832)
7	0.064 (0.943)	0.069 (0.936)	0.073 (0.929)	0.078 (0.922)	0.082 (0.914)
8	0.033 (0.976)	0.036 (0.972)	0.040 (0.969)	0.043 (0.965)	0.046 (0.960)
9	0.015 (0.991)	0.017 (0.989)	0.019 (0.988)	0.021 (0.986)	0.023 (0.983)
10	0.006 (0.997)	0.007 (0.996)	0.008 (0.996)	0.009 (0.995)	0.011 (0.994)
11	0.002 (0.999)	0.003 (0.999)	0.003 (0.999)	0.004 (0.999)	0.004 (0.998)
12	0.001 (1.000)	0.001 (1.000)	0.001 (1.000)	0.001 (1.000)	0.001 (0.999)
13					0.001 (1.000)

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APPENDIX 3

TABLE C Continued

c \ np_0	4.6	4.7	4.8	4.9	5.0
0	0.010 (0.010)	0.009 (0.009)	0.008 (0.008)	0.008 (0.008)	0.007 (0.007)
1	0.046 (0.056)	0.043 (0.052)	0.039 (0.047)	0.037 (0.045)	0.034 (0.041)
2	0.106 (0.162)	0.101 (0.153)	0.095 (0.142)	0.090 (0.135)	0.084 (0.125)
3	0.163 (0.325)	0.157 (0.310)	0.152 (0.294)	0.146 (0.281)	0.140 (0.265)
4	0.188 (0.513)	0.185 (0.495)	0.182 (0.476)	0.179 (0.460)	0.176 (0.441)
5	0.172 (0.685)	0.174 (0.669)	0.175 (0.651)	0.175 (0.635)	0.176 (0.617)
6	0.132 (0.817)	0.136 (0.805)	0.140 (0.791)	0.143 (0.778)	0.146 (0.763)
7	0.087 (0.904)	0.091 (0.896)	0.096 (0.887)	0.100 (0.878)	0.105 (0.868)
8	0.050 (0.954)	0.054 (0.950)	0.058 (0.945)	0.061 (0.939)	0.065 (0.933)
9	0.026 (0.980)	0.028 (0.978)	0.031 (0.976)	0.034 (0.973)	0.036 (0.969)
10	0.012 (0.992)	0.013 (0.991)	0.015 (0.991)	0.016 (0.989)	0.018 (0.987)
11	0.005 (0.997)	0.006 (0.997)	0.006 (0.997)	0.007 (0.996)	0.008 (0.995)
12	0.002 (0.999)	0.002 (0.999)	0.002 (0.999)	0.003 (0.999)	0.003 (0.998)
13	0.001 (1.000)	0.001 (1.000)	0.001 (1.000)	0.001 (1.000)	0.001 (0.999)
14					0.001 (1.000)

c \ np_0	6.0	7.0	8.0	9.0	10.0
0	0.002 (0.002)	0.001 (0.001)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
1	0.015 (0.017)	0.006 (0.007)	0.003 (0.003)	0.001 (0.001)	0.000 (0.000)
2	0.045 (0.062)	0.022 (0.029)	0.011 (0.014)	0.005 (0.006)	0.002 (0.002)
3	0.089 (0.151)	0.052 (0.081)	0.029 (0.043)	0.015 (0.021)	0.007 (0.009)
4	0.134 (0.285)	0.091 (0.172)	0.057 (0.100)	0.034 (0.055)	0.019 (0.028)
5	0.161 (0.446)	0.128 (0.300)	0.092 (0.192)	0.061 (0.116)	0.038 (0.066)
6	0.161 (0.607)	0.149 (0.449)	0.122 (0.314)	0.091 (0.091)	0.063 (0.129)
7	0.138 (0.745)	0.149 (0.598)	0.140 (0.454)	0.117 (0.324)	0.090 (0.219)
8	0.103 (0.848)	0.131 (0.729)	0.140 (0.594)	0.132 (0.456)	0.113 (0.332)
9	0.069 (0.917)	0.102 (0.831)	0.124 (0.718)	0.132 (0.588)	0.125 (0.457)
10	0.041 (0.958)	0.071 (0.902)	0.099 (0.817)	0.119 (0.707)	0.125 (0.582)
11	0.023 (0.981)	0.045 (0.947)	0.072 (0.889)	0.097 (0.804)	0.114 (0.696)
12	0.011 (0.992)	0.026 (0.973)	0.048 (0.937)	0.073 (0.877)	0.095 (0.791)
13	0.005 (0.997)	0.014 (0.987)	0.030 (0.967)	0.050 (0.927)	0.073 (0.864)
14	0.002 (0.999)	0.007 (0.994)	0.017 (0.984)	0.032 (0.959)	0.052 (0.916)
15	0.001 (1.000)	0.003 (0.997)	0.009 (0.993)	0.019 (0.978)	0.035 (0.951)
16		0.002 (0.999)	0.004 (0.997)	0.011 (0.989)	0.022 (0.973)
17		0.001 (1.000)	0.002 (0.999)	0.006 (0.995)	0.013 (0.986)
18			0.001 (1.000)	0.003 (0.998)	0.007 (0.993)
19				0.001 (0.999)	0.004 (0.997)
20				0.001 (1.000)	0.002 (0.999)
21					0.001 (1.000)

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TABLE C The Poisson Distribution $P(c) = \frac{(np_0)^c}{c!} e^{-np_0}$ (Cumulative Values Are in Parentheses).

c \ np_0	0.1	0.2	0.3	0.4	0.5
0	0.905 (0.905)	0.819 (0.819)	0.741 (0.741)	0.670 (0.670)	0.607 (0.607)
1	0.091 (0.996)	0.164 (0.983)	0.222 (0.963)	0.268 (0.938)	0.303 (0.910)
2	0.004 (1.000)	0.016 (0.999)	0.033 (0.996)	0.054 (0.992)	0.076 (0.986)
3		0.010 (1.000)	0.004 (1.000)	0.007 (0.999)	0.013 (0.999)
4				0.001 (1.000)	0.001 (1.000)

c \ np_0	0.6	0.7	0.8	0.9	1.0
0	0.549 (0.549)	0.497 (0.497)	0.449 (0.449)	0.406 (0.406)	0.368 (0.368)
1	0.329 (0.878)	0.349 (0.845)	0.359 (0.808)	0.366 (0.772)	0.368 (0.736)
2	0.099 (0.977)	0.122 (0.967)	0.144 (0.952)	0.166 (0.938)	0.184 (0.920)
3	0.020 (0.997)	0.028 (0.995)	0.039 (0.991)	0.049 (0.987)	0.061 (0.981)
4	0.003 (1.000)	0.005 (1.000)	0.008 (0.999)	0.011 (0.998)	0.016 (0.997)
5			0.001 (1.000)	0.002 (1.000)	0.003 (1.000)

c \ np_0	1.1	1.2	1.3	1.4	1.5
0	0.333 (0.333)	0.301 (0.301)	0.273 (0.273)	0.247 (0.247)	0.223 (0.223)
1	0.366 (0.699)	0.361 (0.662)	0.354 (0.627)	0.345 (0.592)	0.335 (0.558)
2	0.201 (0.900)	0.217 (0.879)	0.230 (0.857)	0.242 (0.834)	0.251 (0.809)
3	0.074 (0.974)	0.087 (0.966)	0.100 (0.957)	0.113 (0.947)	0.126 (0.935)
4	0.021 (0.995)	0.026 (0.992)	0.032 (0.989)	0.039 (0.986)	0.047 (0.982)
5	0.004 (0.999)	0.007 (0.999)	0.009 (0.998)	0.011 (0.997)	0.014 (0.996)
6	0.001 (1.000)	0.001 (1.000)	0.002 (1.000)	0.003 (1.000)	0.004 (1.000)

c \ np_0	1.6	1.7	1.8	1.9	2.0
0	0.202 (0.202)	0.183 (0.183)	0.165 (0.165)	0.150 (0.150)	0.135 (0.135)
1	0.323 (0.525)	0.311 (0.494)	0.298 (0.463)	0.284 (0.434)	0.271 (0.406)
2	0.258 (0.783)	0.264 (0.758)	0.268 (0.731)	0.270 (0.704)	0.271 (0.677)
3	0.138 (0.921)	0.149 (0.907)	0.161 (0.892)	0.171 (0.875)	0.180 (0.857)
4	0.055 (0.976)	0.064 (0.971)	0.072 (0.964)	0.081 (0.956)	0.090 (0.947)
5	0.018 (0.994)	0.022 (0.993)	0.026 (0.990)	0.031 (0.987)	0.036 (0.983)
6	0.005 (0.999)	0.006 (0.999)	0.008 (0.998)	0.010 (0.997)	0.012 (0.995)
7	0.001 (1.000)	0.001 (1.000)	0.002 (1.000)	0.003 (1.000)	0.004 (0.999)
8					0.001 (1.000)

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TABLE C Continued

c \ np_0	2.1	2.2	2.3	2.4	2.5
0	0.123 (0.123)	0.111 (0.111)	0.100 (0.100)	0.091 (0.091)	0.082 (0.082)
1	0.257 (0.380)	0.244 (0.355)	0.231 (0.331)	0.218 (0.309)	0.205 (0.287)
2	0.270 (0.650)	0.268 (0.623)	0.265 (0.596)	0.261 (0.570)	0.256 (0.543)
3	0.189 (0.839)	0.197 (0.820)	0.203 (0.799)	0.209 (0.779)	0.214 (0.757)
4	0.099 (0.938)	0.108 (0.928)	0.117 (0.916)	0.125 (0.904)	0.134 (0.891)
5	0.042 (0.980)	0.048 (0.976)	0.054 (0.970)	0.060 (0.964)	0.067 (0.958)
6	0.015 (0.995)	0.017 (0.993)	0.021 (0.991)	0.024 (0.988)	0.028 (0.986)
7	0.004 (0.999)	0.005 (0.998)	0.007 (0.998)	0.008 (0.996)	0.010 (0.996)
8	0.001 (1.000)	0.002 (1.000)	0.002 (1.000)	0.003 (0.999)	0.003 (0.999)
9				0.001 (1.000)	0.001 (1.000)

c \ np_0	2.6	2.7	2.8	2.9	3.0
0	0.074 (0.074)	0.067 (0.067)	0.061 (0.061)	0.055 (0.055)	0.050 (0.050)
1	0.193 (0.267)	0.182 (0.249)	0.170 (0.231)	0.160 (0.215)	0.149 (0.199)
2	0.251 (0.518)	0.245 (0.494)	0.238 (0.469)	0.231 (0.446)	0.224 (0.423)
3	0.218 (0.736)	0.221 (0.715)	0.223 (0.692)	0.224 (0.670)	0.224 (0.647)
4	0.141 (0.877)	0.149 (0.864)	0.156 (0.848)	0.162 (0.832)	0.168 (0.815)
5	0.074 (0.951)	0.080 (0.944)	0.087 (0.935)	0.094 (0.926)	0.101 (0.916)
6	0.032 (0.983)	0.036 (0.980)	0.041 (0.976)	0.045 (0.971)	0.050 (0.966)
7	0.012 (0.995)	0.014 (0.994)	0.016 (0.992)	0.019 (0.990)	0.022 (0.988)
8	0.004 (0.999)	0.005 (0.999)	0.006 (0.998)	0.007 (0.997)	0.008 (0.996)
9	0.001 (1.000)	0.001 (1.000)	0.002 (1.000)	0.002 (0.999)	0.003 (0.999)
10				0.001 (1.000)	0.001 (1.000)

c \ np_0	3.1	3.2	3.3	3.4	3.5
0	0.045 (0.045)	0.041 (0.041)	0.037 (0.037)	0.033 (0.033)	0.030 (0.030)
1	0.140 (0.185)	0.130 (0.171)	0.122 (0.159)	0.113 (0.146)	0.106 (0.136)
2	0.216 (0.401)	0.209 (0.380)	0.201 (0.360)	0.193 (0.339)	0.185 (0.321)
3	0.224 (0.625)	0.223 (0.603)	0.222 (0.582)	0.219 (0.558)	0.216 (0.537)
4	0.173 (0.798)	0.178 (0.781)	0.182 (0.764)	0.186 (0.744)	0.189 (0.726)
5	0.107 (0.905)	0.114 (0.895)	0.120 (0.884)	0.126 (0.870)	0.132 (0.858)
6	0.056 (0.961)	0.061 (0.956)	0.066 (0.950)	0.071 (0.941)	0.077 (0.935)
7	0.025 (0.986)	0.028 (0.984)	0.031 (0.981)	0.035 (0.976)	0.038 (0.973)
8	0.010 (0.996)	0.011 (0.995)	0.012 (0.993)	0.015 (0.991)	0.017 (0.990)
9	0.003 (0.999)	0.004 (0.999)	0.005 (0.998)	0.006 (0.997)	0.007 (0.997)
10	0.001 (1.000)	0.001 (1.000)	0.002 (1.000)	0.002 (0.999)	0.002 (0.999)
11				0.001 (1.000)	0.001 (1.000)