GX2126

OLLSCOIL NA hÉIREANN, GAILLIMH
NATIONAL UNIVERSITY OF IRELAND, GALWAY

Diploma In Quality Assurance: Summer Examinations 2000

IE879: *Statistical Quality Control II*

Dr. Wright,
Prof. O'Kelly,
Dr. Sheil.

Answer **Q1** and **any two** from Q2, Q3, Q4, Q5.

Time allowed: **2 hours**

Cambridge Elementary Statistical Tables available.
Control Chart Factors, *Tolerance Limit Factors* supplied.

Q1. (compulsory: 20 marks[10 x 2])

(i) Describe, in the general context of *SPC*, what is meant by the term *rational subgroup.*

(ii) Is it more correct to describe control charts as *Quality Assurance Tools* or as *Quality Improvement Tools*? Justify your answer.

(iii) Differentiate between *np-charts, p-charts, c-charts, u-charts* by listing:
(a) the process performance parameter which each is designed to monitor;
(b) the subgroup quantity/statistic which is plotted in each case.

(iv) Consider a 3-class 10:5:1 *demerit weighting system.* When in statistical control, the process averages for the three defect classes are 0.1, 0.5, and 1.0 occurrences per inspection unit, respectively. Determine an appropriate Upper Control Limit(UCL) for a control chart on demerits for this process.

(v) Differentiate briefly between the terms *natural tolerance interval* and *specification* as they might be used when discussing a critical dimension of machined parts.

(vi) Consider a stable process for which $C_{pu} = 0.8$ and $C_{pl} = 1.8$. Find C_p .

(vii) A c-chart with UCL at $c = 5$ and LCL at $c = 0$ is used in conjunction with a process which, when *in-control*, produces(on average) 2 defects per observation unit. What is the *false alarm* rate?

(viii) Why undertake *Gauge Capability Studies*?
Define/explain the following: *Repeatability, Reproducability, P/T Ratio.*

(ix) Define(verbally) the following terms, in the context of Acceptance Sampling:
Single Sampling Plan, Rectification, AOQ, ASN.

(x) Find the single sampling plan, having *acceptance number* $c = 0$, which will reject (large) lots containing 5% or more defective product, 99% of the time.

Q2. (15 marks)

Differentiate briefly between so-called *probability limits* and *3-sigma limits* for control charts. [1 mark]

A process is to be monitored/controlled for the value of a critical characteristic X of produced units. The following data relates to subgroups of 5 units taken at regular intervals from current production.

Subgroup	$\overline{X}$	R	Subgroup	$\overline{X}$	R
1	103	4	11	105	4
2	102	5	12	103	2
3	104	2	13	102	3
4	107	11	14	105	4
5	104	4	15	104	5
6	103	3	16	105	3
7	102	7	17	106	5
8	105	2	18	102	2
9	106	4	19	105	4
10	104	3	20	103	3
			21	104	4

(i) Estimate the process standard deviation for X. [3 marks]

(ii) Compute center lines and control limits for $\overline{X}$, R charts suitable for controlling future production. [10 marks]

(iii) Why should control limits, such as those derived at (ii) above, be subjected to periodic review? [1 mark]

Q3. (15 marks)

(i) An estimate for a 2-sided natural tolerance interval on a machined dimension is to be based on a sample of n parts. Nothing is known about the (process) probability distribution for this dimension.

How large must n be, if we wish to be 95% confident that the resulting interval describes at least 99% of machine output? [2 marks]

After sample data has been obtained, how is the interval calculated? [2 marks]

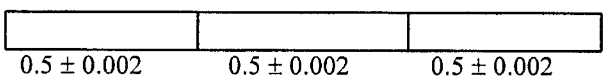
If a 1-sided interval were required for the this dimension, how would you proceed? [2 marks]

Hint: $n \approx \frac{1}{2} + \frac{1}{4}\left[\frac{2 - \alpha}{\alpha}\right] \cdot \chi^2_{1-\gamma,\,4}$ or $\frac{\log(1 - \gamma)}{\log(1 - \alpha)}$.

(ii) Past experience has shown that the wall thickness of pipe produced by a given process is normally distributed. A random sample of 40 pipe sections had mean thickness 0.1264in. and standard deviation 0.002in. Between what limits can we state with 95% confidence that 99% of wall thicknesses will lie? [3 marks]

(iii) Differentiate between the so-called *conventional*(or *additive*) and *statistical* approaches to tolerancing. [1 mark]

The diagram below shows an assembly of three parts. The data shows a specification on the length of each part. The process producing these parts is capable of meeting the specification: Cp = 1.25.



What tolerance should be assigned to overall assembly length under

(a) the conventional approach? [1 mark]

(b) the statistical approach? (state your assumptions). [4 marks]

Q4. (15 marks)

In a gauge capability study, ten parts were each measured three times by the same operator. The resulting data was as shown here:

Part Number	Measurements 1	2	3	4
1	100	101	100	100
2	95	93	97	95
3	101	103	100	102
4	96	95	97	96
5	98	98	96	96
6	99	98	98	99
7	95	97	98	97
8	100	99	98	99
9	100	100	97	99
10	100	98	99	99

Estimate the standard deviation of measurement error that results from the use of this gauge(σ_{gage}). [4 marks]

If the specification on the measured part dimension is 100 ± 5:

(a) find/estimate the P/T ratio for this gauge and comment its adequacy; [3 marks]

(b) estimate product variability and hence the C_{pk} value for the process producing these parts. You may assume that the measured dimension is normally distributed. [8 marks]

Q5. (15 marks)

Let P(θ) represent the *Operating Characteristic* of a single (n,c) sampling plan. If θ is the batch proportion nonconforming and N(>>n) is the batch size, derive/deduce an expression for P(θ). [2 marks]

If this sampling plan is used in conjunction with rectifying inspection, show that the *average outgoing quality* which results, is given by:

$$A(\theta) = \frac{N - n}{N} \theta . P(\theta)$$ [3 marks]

A company receives components in lots of size 1000. A single sampling plan with n = 50, c = 1 is used for receiving inspection. Rejected lots are screened/rectified.

Sketch P(θ), A(θ) for this sampling plan and determine the AOQL. [7 marks]

An investigation of the vendor's capability shows that, on average, the lot proportion nonconforming is $\theta = 0.03$. What is the long-run proportion of nonconforming components getting through inspection? [3 marks]