National Exams December 2010
98-Ind-A5, Quality Planning, Control and Assurance

Notes:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumption made.
2. This is a Closed Book Examination.
3. Candidates may use one of two calculators, the Casio or Sharp approved models.
4. Candidates are permitted to bring into the examination room one aid sheet 8 1/2" x 11" written on both sides.
5. Any five questions constitute a complete paper. Only the first five questions as they appear in your answer book will be marked.
6. All questions are of equal value.
7. Relevant statistical tables are attached.
Question 1 (20 marks)

5 a) Explain briefly the Taguchi’s approach to quality improvement and discuss the traditional and Taguchi’s definition of quality and difference between the traditional and Taguchi’s loss functions. What is the relation between continuous quality improvement and the Taguchi’s philosophy?

5 b) Describe the quality cost categories. When applying a successful quality improvement program, which quality costs should decrease and why? Discuss the role of management in reducing total quality costs and improving quality.

5 c) Explain the difference in objectives of the quality prizes and the quality certification. Describe recent trends in supplier-producer relations and discuss the purpose of vendor certification. Describe typical phases of certification.

5 d) Explain briefly the philosophy, history and the key principles of Six Sigma. Describe the five phases of the problem solving methodology used by Six Sigma.

Question 2 (20 marks)

5 a) What rules should be followed when taking samples for statistical process control (SPC) and why? What is a run length, average run length and the average time to signal? Give examples of the charts for which it is appropriate to use zone rules and the charts for which it is not. Explain.

7 b) Explain the difference between the engineering process control (EPC) and SPC and how these two types of control can be applied in a real situation. Why can EWMA chart be used for both EPC and SPC?

8 c) Explain why the traditional $\bar{X}$ chart is not very effective to detect small shifts in the process mean and why EWMA or CUSUM charts are better alternatives. Why is the probability of detecting a shift in process mean on the sample following the shift very small for EWMA and yet EWMA outperforms $\bar{X}$ chart when the size of the shift is small?

Question 3 (20 marks)

6 a) Consider R chart and S chart. What are these charts used for and which of the two is preferable? Explain why. What is the difference between C chart and U chart?

7 b) A sample of size 100 is taken every 2 hours and the number of nonconforming cables is found. The results after taking 20 samples are in the table below.

<table>
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<th>Number of Nonconforming Cables</th>
<th>Sample</th>
<th>Number of Nonconforming Cables</th>
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<td>2</td>
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</table>
Construct a control chart for the proportion of nonconforming cables. Revise the control limits, if necessary, assuming special causes for points outside the control limits.

Estimate \( p_0 \), the in-control proportion of nonconforming cables and calculate the average run length (ARL) and the average time to signal for the chart when the process is in control and also when the proportion of nonconforming cables shifts from \( p_0 \) to \( 1.5p_0 \).

7 c) To control future production, design a control chart satisfying the following requirement:

when the proportion of nonconforming cables shifts from \( p_0 \) to \( p_1 = 1.5p_0 \), we want \( ARL_{p_1} \leq 10 \). Find the sample size and calculate the control limits for this chart.

Question 4 (20 marks)

6 a) Explain the effect of using zone rules on the average run length of an \( \bar{X} \) chart when the process is in control and also out of control. Is it appropriate to apply a zone rule when controlling a process with an EWMA chart? Explain.

7 b) Each half an hour a 3-ft length is cut from a continuous extruded sheet of plastic. The weights of these cross sections are used to monitor the uniformity of the extrusion process. The weights (in pounds) of the last 20 cross sections are:

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Set-up control charts to control process mean and standard deviation. If necessary, revise the trial control limits. Estimate the in-control process parameters.

7 c) Calculate the average run length and the average time to signal for the $I$ chart in 4b) when the process is in control and also when the process mean shifts from the in-control value $\mu_0$ estimated in 4b) to $\mu_1 = 185$.

Question 5 (20 marks)

Consider the data in Question 4 and assume that the specification limits are $175 \pm 35$.

6 a) Estimate the proportion nonconforming when the process is in control and also when the process mean shifts to $\mu_1 = 185$.

6 b) Calculate the estimates of the capability indexes $C_p$ and $C_{pk}$.

Find the natural tolerance limits for the process if the percentage of the population between limits is required to be at least 99% and the confidence level is 95%. Explain the meaning of the tolerance limits and comment on the process capability.

8 c) To control future production, find the minimum sample size $n$ for an $\bar{X}$ chart such that the probability of detecting a shift in the process mean from the in-control value $\mu_0$ estimated in Question 4b) to $\mu_1 = 185$ on the first or second sample following the shift be greater than 0.7.

Question 6 (20 marks):

6 a) Discuss the advantages and disadvantages of 100% inspection and acceptance sampling. Explain the difference between the acceptance sampling plans for variables and attributes.

7 b) Explain the following terms: acceptable quality level (AQL), limiting quality level (LQL), rectifying inspection, average outgoing quality, average outgoing quality limit. What is the difference between an LTPD plan such as the Dodge-Romig sampling plan and a sampling plan obtained using MIL-STD-105E?

7 c) Parts are submitted for inspection in lots of size 1000 using MIL-STD-105E. The required AQL is 1.5%. Consider normal inspection, general inspection level II. Determine a single sampling plan satisfying the requirements. Calculate the producer's risk when using this plan.
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\frac{(1 - \nu)^2}{\pi} + (1 - a^2) &= \gamma \\
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\end{align*}
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Appendix II  Cumulative Standard Normal Distribution

\[ \Phi(z) = \int_{-\infty}^{z} \frac{1}{\sqrt{2\pi}} e^{-u^2/2} du \]

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