RC
11/13/02

ECE 4000
Quiz #2 Solution

1. BATCH A $\mu_A = 1.75 \times 10^{-6}$ h/m
$\sigma_A = 3.00 \times 10^{-6}$ h/m

BATCH B $\mu_B = 2.20 \times 10^{-6}$ h/m
$\sigma_B = 1.00 \times 10^{-6}$ h/m

BATCH C $\mu_C = 2.50 \times 10^{-6}$ h/m
$\sigma_C = 1.50 \times 10^{-6}$ h/m

USL $= 4.00 \times 10^{-6}$ h/m

Since the mean of BATCH B is less than the mean of BATCH C, AND Also $\sigma_B < \sigma_C$, the number of Defects of B is less than that of C, so we only have to compare Batches A and B.

$$\gamma_A = \frac{4-1.75}{3} = .75$$

$$\gamma_B = \frac{4-2.2}{1} = 1.8$$

Largest γ corresponds to fewest Defects.

$\therefore$ BATCH B

Number of Defects $= Z(1.8) \cdot 20{,}000 = .03593(20{,}000)$

Number of Defects $= 719$

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2. Design with modular components is associated with design for reuse; defective components can be replaced.

Design with easily separable materials is associated with design for recycling; one difficulty with recycling of many items is that the component materials cannot be separated.

Development of long product lifetimes is more usually associated with reuse. However, in the limit of essentially infinite product life, the underlying competing products or technology may change, so then a case can be made for association with recycling.

3. $LSL = 32\,K\Omega$ $\quad TM = 41\,K\Omega$ $\quad \sigma = 8\,K\Omega$

$USL = 50\,K\Omega$ $\quad AM = 38\,K\Omega$

$$C_p = \frac{USL - LSL}{6\sigma} = \frac{50-32}{6(8)} = \frac{3}{8} = .375$$

$$C_{pK} = C_p(1-K) \qquad K = \frac{|TM - AM|}{\frac{1}{2}(USL-LSL)} = \frac{41-38}{\frac{1}{2}(50-32)} = \frac{3}{9} = .333$$

$$C_{pK} = \frac{3}{8}\left(1-\frac{1}{3}\right) = .25$$

$$\text{Defects Below LSL} = Z\left(\frac{AM-LSL}{\sigma}\right) = Z\left(\frac{38-32}{8}\right) = Z(.75)$$

$$\text{Defects Above USL} = Z\left(\frac{USL-AM}{\sigma}\right) = Z\left(\frac{50-38}{8}\right) = Z(1.5)$$

Since $C_p < 1$, the process is incapable (b)

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4. A. Per unit failure rate $= 5\times10^{-3}\ hr^{-1}$

Number surviving $= N_o e^{-\lambda t}$

Number failing between 100 and 150 hours is equal to the difference in the number surviving.

Number failing $= 10000\{e^{-100(5\times10^{-3})} - e^{-150(5\times10^{-3})}\}$

$= 1342$ (a)

B. Probability of 3 defects $= \dfrac{dpu^{K}\, e^{-dpu}}{K!} =$

$\dfrac{(1.6)^3 e^{-1.6}}{3!} = .138 = 13.8\%$ (c)

C. 1000 good units out, FTY = 75%

with perfect repair, Every unit goes out, so 1000 units in, 750 are good, the remaining 250 are defective. The total number of inspections is equal to 2 (number of defective units in) + 1 (number of non-defective units in) = 2(250) + 750

= 1,250 (b)

D. An inspection finds all defects for which the inspection is designed. Coverage is the fraction of all defects of the particular type. Coverage does not relate to the probability of detection for a particular type of defect. (a)

E. The decision on the dollar amount to assign to represent the perception of increased

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safety is representative of the quantification of an intangible idea. (a)

F. the video made the point that most disasters are related to a rare combination of unexpected events. there is usually some human error, but the disaster occurs because there are natural events that are exaggerated by the human errors. (d)

5. A. Fundamentals of Engineering Exam:
   Morning Portion – general exam
   Afternoon Portion – general or discipline specific exam
   False

   B. For strict liability, negligence does not have to be proved. False

   C. Most government product standards are written in the form of design standards because design standards are easier to regulate and enforce, normally. True

   D. the patent application must contain a "preferred" embodiment" in sufficient detail that one of ordinary skill in the art could produce a device, the patent application does not require a working model. True

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E. we have conversion factors P/A and P/F1.

$F_1 = A(P/A)(P/F_1)^{-1}$, therefore given A, we can determine F_1, the geometric gradient series. In verbal form, A uniform series has a present value. We can adjust the gradient series to the same present value, and therefore by the equivalence principle, the two series are equal. True

F. A patent application is publically available, and must disclose enough information for the idea to be duplicated by others (see answer D). true

G. $C_{pK} = C_p(1-K) \quad K = \dfrac{|\text{Actual Mean} - \text{Target Mean}|}{\frac{1}{2}(USL-LSL)}$

Since we desire actual mean equal to target mean, this means we design for K to be close to zero, or $C_{pK} \simeq C_p$. True

H. Two systems in parallel are always more reliable than either by itself.

$R = 1-(1-R_1)(1-R_2) = R_1 + R_2 - R_1R_2 = R_1 + R_2(1-R_1) > R_1$,

for $0 < R_1, R_2 < 1$ TRUE

I. For the "bathtub" model of device reliability, there is an approximately constant per-unit failure rate. True

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6. System Alpha

cost: \$1,000

Benefit: \$200/year, $P=.6$

\$250/year, $P=.3$

\$300/year, $P=.1$

System Beta

cost: \$1,800

Benefit: \$200/year $P=.4$

\$600/year first 4 years } $P=.6$
\$800/year last 2 years }

Expected Benefit of Alpha, present value

$$Benefit_{\alpha} = \{200(.6)+250(.3)+(300(.1)\}(P/A,8\%,6)$$
$$= \{225\}(4.6229) = \$1,040$$

$$Benefit_{\beta} = \{200(.4)\}(P/A,8\%,6) +$$
$$(.6)\{600(P/A,8\%,4)+800(P/A,8\%,2)(P/F,8\%,4)\}$$

$$= 80(4.6229) + 360(3.3121) + 480(1.7833)(.7350)$$
$$= \$2,191$$

$$\left.\frac{B}{C}\right)_{\alpha} = \frac{1040}{1000} = 1.04 \qquad \left.\frac{B}{C}\right)_{\beta} = \frac{2191}{1800} = 1.22$$

Choose: System Beta