Chapter 2: Quality Management

End of Chapter Problems

1. **Zeta Automotive Limited**
   Information Provided:
   Upper Tolerance Limit = 75
   Lower Tolerance Limit = 70
   Mean = 72

   For Six Sigma Quality, the distance from the mean to upper and lower tolerance limits should be 6 standard deviations (σ).
   Using Upper Tolerance Limits:
   $6 * \sigma = (75 – 72) = 3$
   $\sigma = 0.5$
   Using Lower Tolerance Limits:
   $6 * \sigma = (72 - 70) = 2$
   $\sigma = 0.33$
   To ensure Six Sigma quality, the standard deviation should be lowered such that the distance from the mean to both Upper and Lower Control Limits are at-least 6 σ. Therefore σ should be lower to 0.33.

2. **Internet Book Retailer**
   Information Provided:
   Upper Tolerance Limit (UTL) = 36 hours
   Lower Tolerance Limit (LTL) = 24 hours
   Mean = 30 hours
   Standard Deviation = 4 hours

   a. The current process sigma level can be calculated by applying equation 1 (page 52)

      Using UTL

      $$\text{Process Sigma} = \frac{36-30}{4} = 1.5$$

      Using LTL

      $$\text{Process Sigma} = \frac{30-24}{4} = 1.5$$

      Therefore it can be concluded that the Internet Book Retailer is currently operating at 1.5 σ level.

   b. For Six Sigma Quality, the distance from the mean to upper and lower tolerance limits should be 6 standard deviations (σ).

Using Upper Tolerance Limits:
$6 * \sigma = (36 - 30) = 6$
$\sigma = 1$
Using Lower Tolerance Limits:
$6 * \sigma = (30 - 24) = 6$
$\sigma = 1$
To ensure Six Sigma quality, therefore σ should be lower to 1.

3. **Pizza Delivery Company**
Information Provided:
Upper Tolerance Limit (UTL) = 60 minutes
Lower Tolerance Limit (LTL) = 0 minutes
Mean = 40 minutes
Standard Deviation = 10 minutes

   a. The current process sigma level can be calculated by applying equation 1 (page 52)
   Using UTL
   $$\text{Process Sigma} = \frac{60 - 40}{10} = 2$$

   Using LTL
   $$\text{Process Sigma} = \frac{40 - 0}{10} = 4$$

   Since the company promises to deliver pizza within an hour, UTL calculation is more relevant. Therefore we can conclude that the company is operating at a 2 σ level.

   b. For Six Sigma Quality, the distance from the mean to upper and lower tolerance limits should be 6 standard deviations (σ). As mentioned in the previous question, the use of UTL is more appropriate. Therefore
   Using Upper Tolerance Limits:
   $6 * \sigma = (60 - 40) = 20$
   $\sigma = 3.33$ minutes
   To ensure Six Sigma quality, therefore σ should be lower to 3.33 minutes.

4. **Customer Service Center**
Information Provided:
Upper Tolerance Limit (UTL) = 90 seconds
Lower Tolerance Limit (LTL) = 30 seconds

Table 2.5 lists waiting times for 50 customers. We can use this information to calculate mean and standard deviation:

Mean = 60.32 seconds
Standard Deviation = 6.51 seconds.

Current process sigma level can be calculated using the above information:

Using UTL

$$\text{Process Sigma} = \frac{90 - 60.32}{6.51} = 4.56$$

Using LTL

$$\text{Process Sigma} = \frac{60.32 - 30}{6.51} = 4.66$$

We can conclude that the customer service center is not able to provide a six-sigma quality at this point. Their current process sigma level is 4.56 considering UTL and is 4.66 considering LTL.

5. **Coffee Temperature**

Information Provided:
Upper Tolerance Limit (UTL) = 180 degrees
Lower Tolerance Limit (LTL) = 160 degrees

Table 2.6 lists waiting times for 40 cups. We can use this information to calculate mean and standard deviation:

Mean = 170.53 seconds
Standard Deviation = 6.29 seconds.

Current process sigma level can be calculated using the above information:

Using UTL

$$\text{Process Sigma} = \frac{180 - 170.53}{6.29} = 1.51$$

Using LTL

$$\text{Process Sigma} = \frac{170.73 - 160}{6.29} = 1.67$$

We can conclude that the Café is not able to provide a six-sigma quality at this point. Their current process sigma level is 1.51 considering UTL and 1.67 considering LTL.

6. **Video Game Console**

Information Provided:
There are 10 production steps.

Each step is operating at 5-sigma level.

Therefore we can conclude that the distances from mean to UTL and LTL are at-least 5 standard deviations.

Hence we can calculate the percentage of defective products made by <u>each production step</u> by calculating the area of the normal distribution curve above UTL and lower than LTL (hint: similar calculations are shown in Solved Example 1 on page 52).

Percentage defective product considering UTL = 1 – NORMSDIST(5) = 0.0000002866
Percentage defective product considering LTL = NORMSDIST(-5) = 0.0000002866

Total percentage defective product = 0.0000002866 + 0.0000002866 = 0.0000005732

Therefore total percentage good product = 1 – 0.0000005732 = 0.9999994268
Since each production steps are independent of each other, the total percent of good product at the end of 10 production steps will be =

$(0.9999994268)^{10} = 0.999994268$

7. **Electronic Product**

Information Provided:
There are 12 production steps.

<u>For the first 6 steps</u>:
First 6 steps are operating at 5 sigma level

Hence we can calculate the percentage of defective products made by <u>each production step</u> by calculating the area of the normal distribution curve above UTL and lower than LTL (hint: similar calculations are shown in Solved Example 1 on page 52).

Percentage defective product considering UTL = 1 – NORMSDIST(5) = 0.0000002866
Percentage defective product considering LTL = NORMSDIST(-5) = 0.0000002866

Total percentage defective product = 0.0000002866 + 0.0000002866 = 0.0000005732

Therefore total percentage good product = 1 – 0.0000005732 = 0.9999994268

<u>For the last 6 steps</u>:
The last 6 steps are operating at 5.5 sigma level

Percentage defective product considering UTL = 1 – NORMSDIST(5.5) = 0.000000019
Percentage defective product considering LTL = NORMSDIST(-5.5) = 0.000000019

Total percentage defective product = 0.000000038

Therefore total percentage good product = 1 – 0.000000038 = 0.999999962

Since each production steps are independent of each other, the total percent of good product at the end of 12 production steps will be =

$(0.9999994268)^{6} * (0.999999962)^{6} = 0.999996$

8. Quick Service Restaurant

<u>Current Process</u>
There are 4 production steps.

Each step is operating at 4-sigma level.

Hence we can calculate the percentage of defective products made by <u>each production step</u> by calculating the area of the normal distribution curve above UTL and lower than LTL (hint: similar calculations are shown in Solved Example 1 on page 52).

Percentage defective product considering UTL = 1 – NORMSDIST(4) = 0.00003167
Percentage defective product considering LTL = NORMSDIST(-4) = 0.00003167

Total percentage defective product = 0.00003167 + 0.00003167 = 0.00006334

Since each production steps are independent of each other, the total percent of good product at the end of 4 production steps will be = 1 – 0.00006334

$(1 - 0.00006334)^{4} = 0.99746664$

<u>New Process</u>
There are 8 production steps.

Each step is operating at 5.5 sigma level.

Percentage defective product considering UTL = 1 – NORMSDIST(5.5) = 0.000000019
Percentage defective product considering LTL = NORMSDIST(-5.5) = 0.000000019

Total percentage defective product = 0.000000038

Therefore total percentage good product = 1 – 0.000000038 = 0.999999962

$(0.999999962)^8 = 0.999999696$

Therefore by new process will slightly increase the percentage of error-free products (0.999999696 - 0.99746664 = 0.000253032).

9. **Manufacturing Facility**
Sigma level for first step: 4.5

Therefore the percentage of good products made by this step = 0.9999932 (refer to earlier example on how to calculate percentage of good products)

Sigma level for second step: 5

Therefore the percentage of good products = 0.9999994268

Sigma level for steps 3 and 4: 5.5

Therefore the percentage of good products = 0.999999962

Therefore percentage of good products after all four steps =

$0.9999932 * 0.9999994268 * (0.999999962)^2 = 0.999992551$

10. **Quick Service Restaurant (Part 2)**
<u>New Process</u>
There are 3 production steps each with same sigma level producing X% good products at each step.

According to the information provided, the new process has the same overall sigma level as the original process with 4 steps. Therefore the new process and the old process should have same number of good products.

Therefore

X * X * X = 0.99746664

Or X = 0.99915

In other words, the area under the normal distribution from LTL to UTL is 0.99915.

Therefore area outside the tolerance limits (or % defective products at each step) = 0.000845

Assuming that the area is equally distributed beyond UTL or LTL, area of each tail is: 0.000423

A NORMSINV function can be used to find the sigma level corresponding to LTL

NORMSINV(0.000423) = -3.33

Similarly we can find sigma level corresponding UTL as
1 – NORMSINV(0.000423) = +3.33

End of Chapter Case Questions

The Case of the Complaining Customer

1. **Why is Mr. Shelton upset? What should be done to address his complaint?**
   Mr. Shelton is upset because the dry-cleaner lost his laundry. However, he is also justifiably upset about the way his complaint was mishandled.
   As Shelton is a regular customer (along with his wife), his business is very valuable. It is worth meeting his demands to keep his business. For example, if Presto makes $12 on the Shelton's business per week, it would only take 1 year to recoup the $600 that Mr. Shelton is requesting. Additionally, word of mouth and reputation are important, as the chapter demonstrates. This is another reason to placate Mr. Shelton.

2. **Based on the information presented in the case, develop a comprehensive quality improvement plan for Presto Cleaner.**
   The Six Sigma DMAIC protocol forms the basis of a good improvement plant.
   Define: The current process for checking in, tracking, and checking out laundry cannot guarantee that the right laundry is returned to customers when they arrive for pickup. The resolution process when laundry is lost is inadequate.
   Measure: Currently, Presto does not know how often or how much laundry is being lost. It does not know the dollar value of the lost laundry or the impact on customer retention. It also needs to know the amount of time it takes to resolve lost-item issues.
   Analyze: Presto should map the processes involved in checking in, tracking, and checking out laundry, as well as the process for locating lost items and returning them to customers. Looking at the process of managing lost laundry, it appears that there are parts of the process that are candidates for improvement. This types of mapping often makes clear many gaps that must be closed. For example, there is no process for identifying customers who have items missing when items that may be theirs come into the store (per item 2 in Hoffner's memo). Per item 5 in the memo, there appears to be no process by which stores receiving lost items can notify other stores (which might be looking for the items).
   Improve: Opportunities for process improvements are apparent from the correspondence in the case. For example, currently all correspondence between the plant, stores, and headquarters must be in writing. This requirement should probably be eliminated. Other procedures should probably be added. For example, having a clerk simply compare the number of items on a return ticket to the number of items in a bundle would alert staff to some problems before bundles are returned to customers. Process analysis should bring to

light many improvement opportunities. These can be evaluated on the basis of cost, feasibility, and the portion of the problem that they will solve.

Control: Process for employee training, written manuals, and other controls will need to be put into place to ensure that the new procedures are institutionalized.