Therefore, the smaller distance of the two calculations will have to be reduced to equal 6 standard deviations.

$$6 * \sigma = 22 \text{ hours}$$

$$\sigma = 3.67 \text{ hours}$$

Therefore, the computer manufacturer will have to reduce its standard deviation from 6 hours to 3.67 hours to achieve a Six Sigma quality level.

Many products and services are produced in multistage processes, and mistakes can occur during each step. The sigma level (and corresponding quality) of the entire production process can be found by multiplying the percentages of good outcomes achieved at each stage of the production process. Examples of the calculations are presented next.

### Solved Example 3: Sigma and Quality Level for a Multistage Production Process

A routine visit to a dentist's office could involve four process steps: (1) checking in at the reception desk, (2) getting dental x-rays taken by the nurse, (3) having teeth cleaned by a dental hygienist, and (4) being examined by the dentist.

Calculate the percentage of error-free outcomes for the entire process if the percentages of error-free outcomes for each step is as specified in (a) Figure 2.14 and (b) Figure 2.15.

**SOLUTION**

(a) The fraction of error-free outcomes for the entire production process is found by multiplying the percentage of error-free outcomes for each of the four production stages:

$$0.9332 * 0.9332 * 0.9332 * 0.9332 = 0.7584$$

$$= 75.84 \text{ percent error-free outcomes}$$

(b) The percentage of error-free outcomes for the entire production process represented in Figure 2.15 is

$$0.9938 * 0.9938 * 0.9938 * 0.9938 = 0.9754$$

$$= 97.54 \text{ percent error-free outcomes}$$

This example illustrates that by going from a lower (Figure 2.14) to a higher process (Figure 2.15) sigma level at each step, the overall quality improves from 75.84 percent to 97.54 percent—a significant improvement.

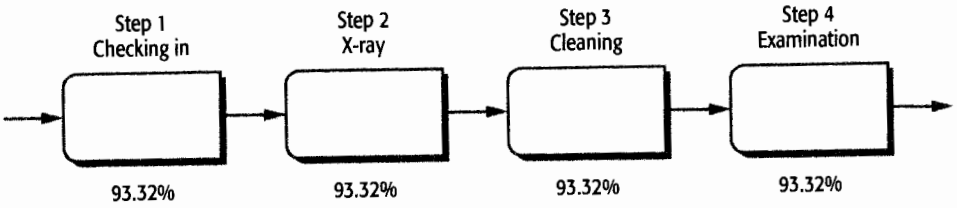


**FIGURE 2.14 Percentage of Error-Free Outcomes at Each Step**

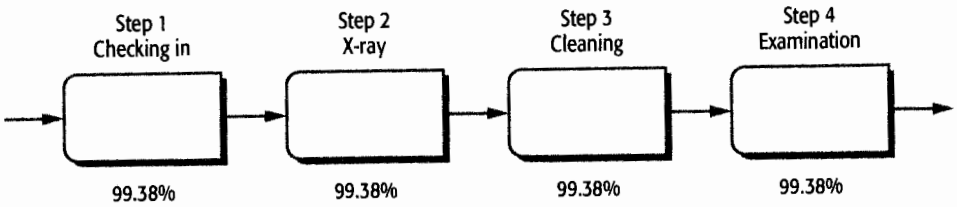


**FIGURE 2.15 Percentage of Error-Free Outcomes at Each Step**

## Implementing Six Sigma

The Six Sigma approach described here is implemented using a structured five-step plan known as *DMAIC* (define, measure, analyze, improve, and control). DMAIC defines the steps that a Six Sigma practitioner is expected to follow, starting with identifying the problem and ending with the implementation of long-lasting solutions (Figure 2.16):

- ***Define*** a problem or improvement opportunity.
- ***Measure*** process performance.
- ***Analyze*** the process to determine the root causes of poor performance.
- ***Improve*** the process by attacking the root causes.
- ***Control*** the improved process to hold the gains.

The first three steps in the DMAIC plan are also called the *process characterization* phase because they provide descriptive information about the existing process. The remaining two steps are also known as the *process optimization* phase because they attempt to move the performance of the process to its best possible level.

Implementation of the Six Sigma approach goes beyond the quality improvement tools and steps outlined here. The improvement projects within an organi-