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# Six Sigma Measurements: Concepts

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Six Sigma, a customer-oriented methodology to maximize an organization's profitability while producing the highest quality product, consists of two key components: methodology and measurements. Methodology is customer-centric and focuses on improving processes to achieve desired results. Measurements are in place to ensure that the methodology works—easier said than done! In the current Six Sigma environment, methodology has become a project-based institutionalization of process improvement. Considering the success and failures of well-known corporations, leadership, goal setting and measurement are the key factors that make Six Sigma work. Leadership emphasizes the cultural aspects of the methodology, goal setting lays the groundwork for aggressive improvement, and measurement is a verification of the improvement.

## Take the First Steps

To ensure desired improvements are achieved, measurements for profitability, quality, timeliness, cost and customer satisfaction must be in place. The first step in implementing Six Sigma is to assess the state of business (methods, material, machines and employees), to identify strengths and opportunities, and to establish a baseline for key measurements. For areas with opportunity for improvement, establish improvement objectives prior to implementation of Six Sigma methodology.

The first challenge of the process is to identify what aspects of business should be measured. What is the simplest way to determine important aspects? Ask why. If the quality of a product or service is important, ask *why* quality is important to the company. The following questions may help to explore and identify desired measurements:

- Business objectives—Why is a product, process or business characteristic important to business?
- Success factors—What goals should be achieved?
- Input Measurements—What is needed to achieve these goals?
- Process Measurements—How are these goals achieved?
- Output Measurements—How is achievement of those goals determined?

By asking such questions, a company can identify process measurements to ensure excellence. For service operations, answering these questions would identify process measurements—helping a company understand units, improvement opportunities and the concept of defects per million opportunities (DPMO) to achieve Six Sigma level performance.

## Understanding Measurements

Six Sigma measurements identify customer-critical characteristics, evaluate performance at any given process step, or, for a product, calculate process capability to determine the probability of success and improvement in terms of sigma level. For any given sigma level, an unacceptable level of performance, which can adversely affect profitability, exists. The main purpose of the measurement system is to quantify performance and its impact on profitability. If performance significantly affects profitability adversely, a project can be implemented to solve the problem.

To determine performance, the process defect rate is normalized per the process output, called a unit. A unit is a discrete measure of output that can be counted, verified and measured. In an assembly process, each board assembled could be a unit. Similarly, each board coming from the wave soldering or reflow process is a unit. A unit is used to estimate the quality of the process output in terms of defects per unit, percent yield or the first pass yield.

Defects per unit (DPU) is defined as a ratio of the total number of defects observed in the inspected or verified units over the total number of units processed or built.

*DPU = Total number of defects/Total number of units verified*

Know the difference between a defect and a defective unit. One defective unit may contain many defects—the goal is to count all defects.

When unacceptable DPU exists, the problem may be addressed by understanding which process step is involved, where the problem occurs in the process and the root cause, which may be the result of any part or process. Plenty of opportunities for things to go wrong exist in the manufacturing process. Such opportunities become critical when comparing products of various complexities and solving process problems.

DPMO is a measurement that normalizes the reject rate based on opportunities instead of units:

$$\frac{\text{Total number of defects} \times 1{,}000{,}000}{\text{Total number of units verified} * \text{Average number of opportunities in a unit}}$$

To understand the relationship between DPU and DPMO, the formula above can be restated as:

$$\frac{\text{DPU} \times 1{,}000{,}000}{\text{Average number of opportunities in a unit}}$$

Avoid misuse of the formula. Improving DPMO, by increasing the number of opportunities, is unacceptable. Instead, the objective must be to reduce the number of opportunities by reducing part counts and process steps. Quality is improved by reducing defects—resulting in actual improvement, not just an arithmetic improvement.

Units or opportunities and defects or errors are countable items—the formulae above work in cases of assembly or service processes. In cases of continuous processes, where variation is measured, the probabilities of producing defects should be applied to the formula. Probabilities consider expected shifts in the process—established at 1.5 sigma. Probabilities are calculated and transformed in DPMO measurement.

After calculating DPMO, using an established z-distribution table or software, sigma level can be calculated (Table 1).

| DPMO | Sigma Level |
|---|---|
| 66,810 | 3 |
| 6210 | 4 |
| 233 | 5 |
| 3.4 | 6 |

**TABLE 1:** DPMO and related probabilities.