Samples from: MINITAB BOOK

Quality and Six Sigma Tools using MINITAB Statistical Software: A complete Guide to Six Sigma DMAIC Tools using MINITAB®

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One of the major objectives of this text is to teach quality, data analysis and statistical tools used in the Six Sigma DMAIC (Define, Measure, Analyze, Improve, and Control) process. The chapters in this book provide concepts, understanding, and computer applications of Six Sigma DMAIC tools. The statistical tools used in the DMAIC process are discussed with step-wise MINITAB computer applications. The following are samples from the book randomly selected from different chapters:

CHAPTER 4: Quality Tools: The Basic Tools and Seven New Tools of Quality

[Pareto Charts, Cause-and-effect Diagrams, Multi-vari Charts, Process maps, Check sheets, Run charts, control charts, Tree Diagrams, Prioritization matrix, Activity Network Diagrams and others)]

Note: The graphical tools described in this chapter are not all available in MINITAB. The tools available in MINITAB are indicated after their names.

Chapter Highlights

This chapter deals with the quality tools widely used in Six Sigma and quality improvement programs. The chapter includes the seven basic tools of quality, the seven new tools of quality, and another set of useful tools in Lean Six Sigma that we refer to –"beyond the basic and new tools of quality." The objective of this chapter is to enable you to master these tools of quality and use these tools in detecting and solving quality problems in Six Sigma projects. You will find these tools to be extremely useful in different phases of Six Sigma. They are easy to learn and very useful in drawing meaningful conclusions from data. In this chapter, you will learn the concepts, various applications, and computer instructions for these quality tools of Six Sigma. This chapter will enable you to:

1. *Learn the seven graphical tools - considered the basic tools of quality. These are:*
   - *(i) Process Maps*
   - *(ii) Check sheets*
   - *(iii) Histograms*
   - *(iv) Scatter Diagrams*
   - *(v) Run Charts/Control Charts*
   - *(vi) Cause-and-Effect (Ishikawa)/Fishbone Diagrams*
   - *(vii) Pareto Charts/Pareto Analysis*

2. *Construct the above charts using MINITAB*
3. *Apply these quality tools in Six Sigma projects*
4. *Learn the seven new tools of quality and their applications:*
   - *(i) Affinity Diagram*
   - *(ii) Interrelationship Digraph*
   - *(iii) Tree Diagram*
   - *(iv) Prioritizing Matrices*
   - *(v) Matrix Diagram*
   - *(vi) Process Decision Program Chart*
   - *(vii) Activity Network Diagram*
5. *Learn the construction and applications of some other quality tools including the stem-and-leaf and box plot.*
6. *Learn a set of powerful tools beyond the basic and new tools of quality that include multi-vari charts, symmetry plots, and variations of scatter plots.*
7. *Learn how to construct the symmetry plots, and multi-vari charts using MINITAB.*

Chapter Outline

Seven Basic Tools of Quality

1. Process Maps
2. Check Sheets
3. Histograms ***(MINITAB)***
   - Using Histograms to Detect the Shift and the Variation in the Process
   - Evaluating Process Capability Using Histogram
4. Scatter Plots ***(MINITAB)***
5. Run Chart / Control Charts ***(MINITAB)***
   - Constructing a Run Chart
   - A Run Chart with Subgroup Size Greater than 1
   - A Run Chart with Subgroup Size Greater than 1
   - Run Chart Showing a Stable Process, a Shift, and a Trend
6. Cause-and-Effect Diagram or Fishbone Diagram ***(MINITAB)***
   - Cause-and-Effect Diagram (1)
   - Cause-and-effect Diagram (2)
   - Creating other Types of Cause-and-effect Diagram
7. Pareto Chart ***(MINITAB)***
   - A Simple Pareto Chart
   - Pareto Chart with Cumulative Percentage
   - Pareto Chart with Cumulative Percentage when Data are in One Column
   - Pareto Chart by Variable

Some other Quality Tools:

8. Stem-and-leaf Plot ***(MINITAB)***
9. Box Plot ***(MINITAB)***

The Seven New Tools for Quality Improvement

(1) Affinity Diagram
(2) Interrelationship Digraph
(3) Tree Diagram
(4) Prioritizing Matrices
(5) Matrix Diagram
(6) Process Decision Program Chart
(7) Activity Network Diagram

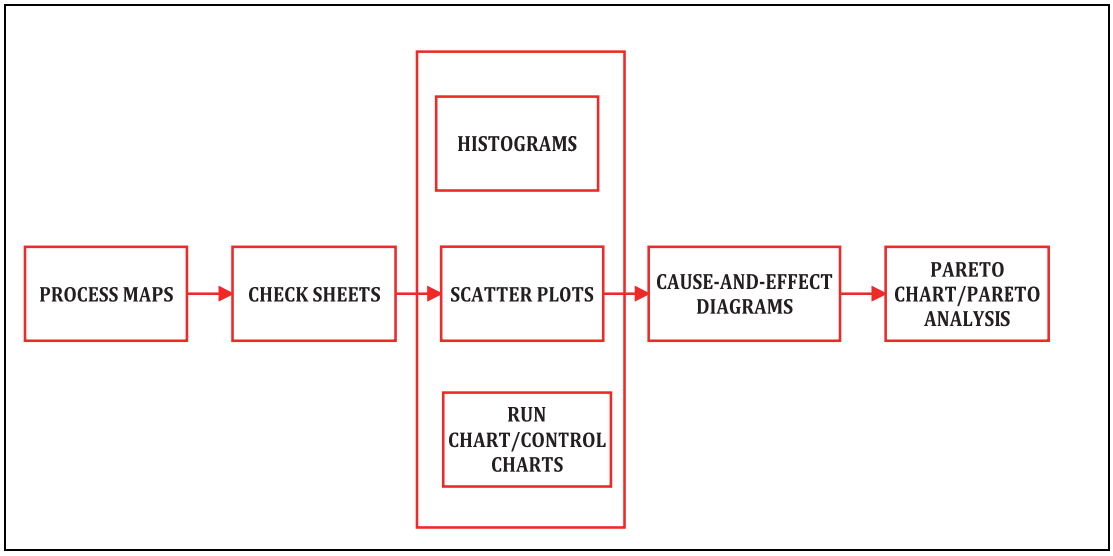
Beyond the New Tools of Quality

All the tools in this section are available in MINITAB.

1. **Bivariate Data: Measuring and Describing Two Variables**
   Variations of Scatter Plots
   Scatterplots with Histogram, Box-plots and Dot plots
   Scatterplot with Fitted Line or Curve
   Scatterplot Showing an Inverse Relationship between X and Y
   Scatterplot Showing a Nonlinear Relationship between X and Y
   Scatterplot Showing a Nonlinear (Cubic) Relationship between X and Y
2. **Multi-Vari Charts**
   1. A Multi-vari Chart for Two-factor Design
      Main Effects and Interaction Plots
   2. Another Multi-vari Chart for a Two-factor Design
      Box Plots, Main Effects Plot, and Interaction Plot
   3. Mult-vari chart for a Three-factor Design
      Multi-Vari Chart, Box Plots, and Main Effects Plot
   4. Multi-vari Chart for a Four-factor Design
      Multi-Vari Chart, Box Plots, Main Effects and Interaction Plots
      Determine a Machine-to-Machine, Time-to-Time variation
      Part-to-Part Variation in a Production Run using Multi-vari Plots
3. **Symmetry Plots**
   Chapter Summary and Applications

Samples and Examples from this Chapter

Figure 5.1: A Logical Sequence of Seven Basic Tools of Quality



Example 5.1: A SIPOC Process Map of Online Order Processing

SIPOC ANALYSIS AND MAP: ONLINE ORDER PROCESSING

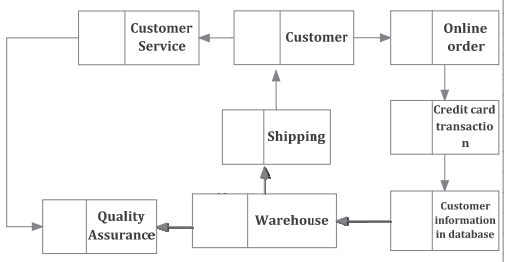
Suppliers	Inputs	Process	Outputs	Customers
Online Store **Multiple Vendors and Manufacturers** Insurance Company	**Customer Orders** **Custoers**	**Process description: Receive, process, and ship customer orders** **Process map:** Online Order Process 	**Processed Orders**	**Satisfied Customers**

Figure 5.5: Symbols and their Meaning in Process Mapping

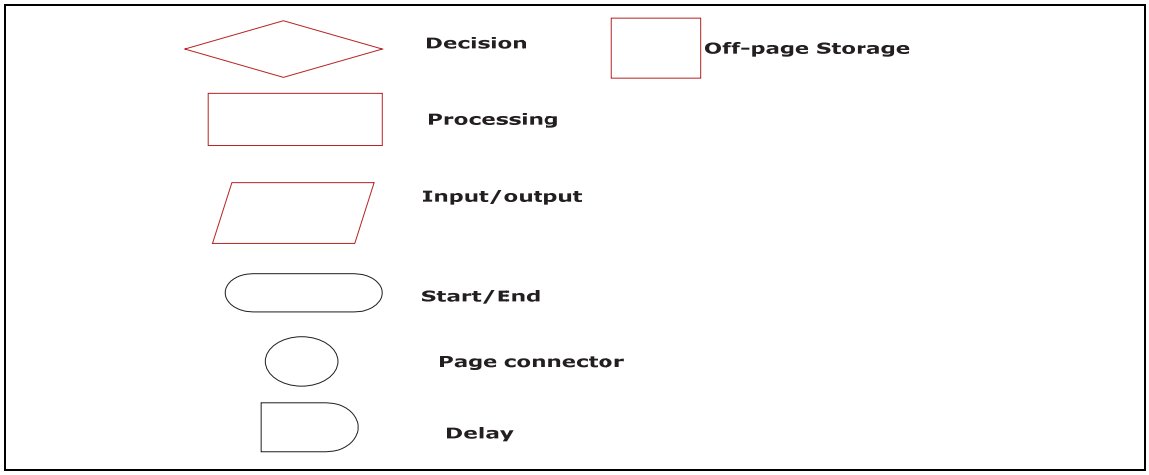


Figure 5.6 (a): A Current State Value Stream Map of a Production and Distribution System

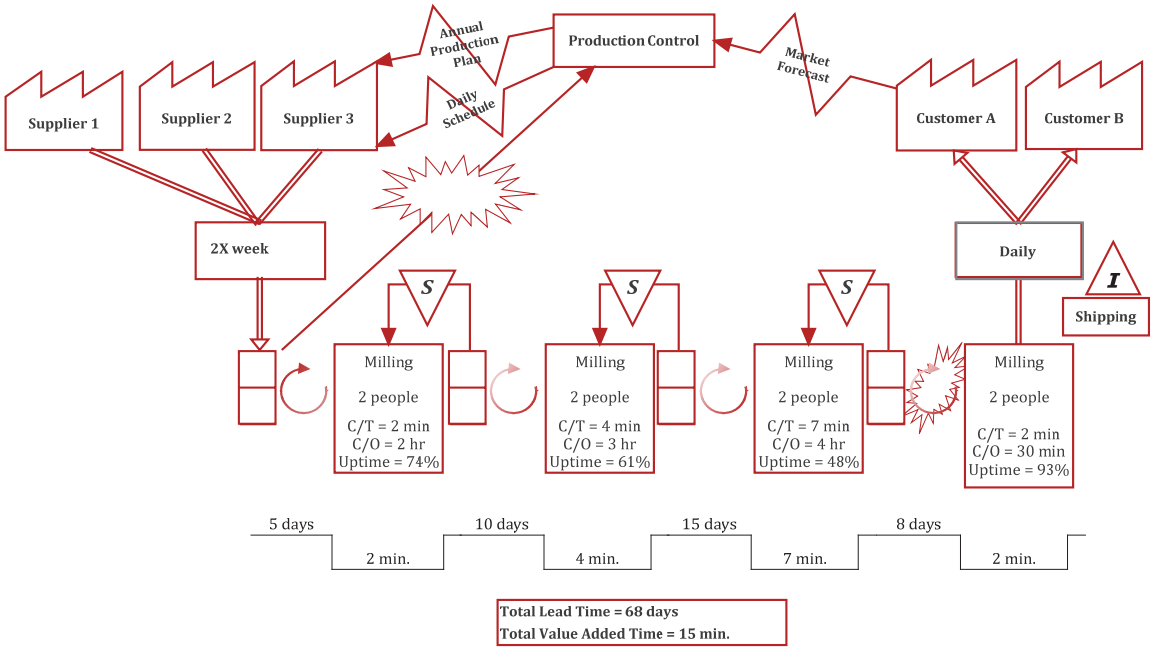
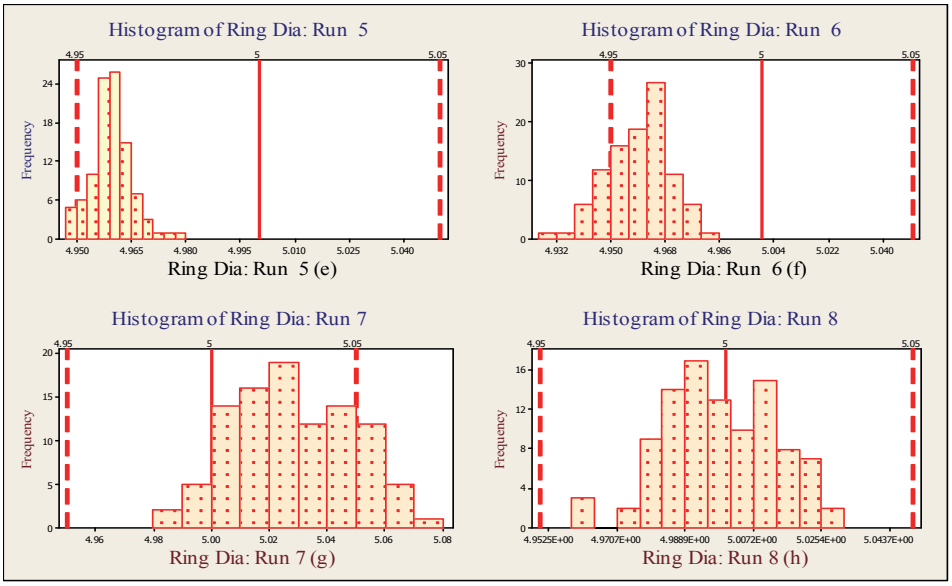
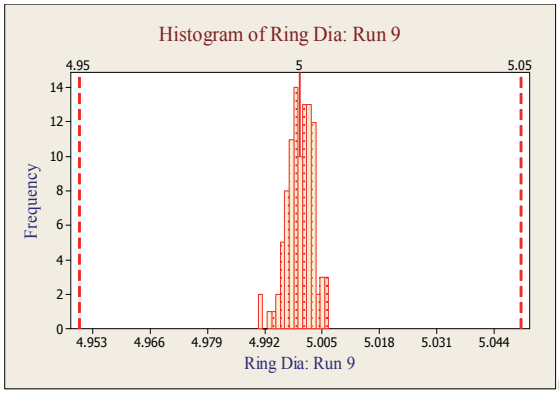


Figure 5.6 (a): A Current State Value Stream Map of a Production and Distribution System

HISTOGRAM	Open the worksheet **PROCESSHIST.MTW** From the main menu, select **Graph ➢Histogram** Click on **With Outline and Groups** then click **OK** For **Graph …….. Ring Dia: Run1** Click on **Scale** then click the **Reference Lines** tab : : type **4.95 5.0 5.05** (with a space between each value) Click **OK** in all dialog boxes.





(i)

Figure 5.9(e) The process has shifted to the left; products out of specification, Figure 5.9(f) Process shift to the left; more variation compared to (e), Figure 5.9(g) Process out of control and has large variation, Figure 5.9(h) Process within control but has large variation, Figure 5.9 (i) Process stable and close to the target (desirable)

SCATTER PLOT WITH BOX PLOTS	Open the worksheet **SALES&AD.MTW** Select **Graph ➢.....** In the **Marginal Plots** dialog box, select **With Box Plots** In the **Marginal Plot–With Boxplots** dialog box, select the following : Do not use the **Histograms Labels** tab. Click **OK** in all dialog boxes

Repeat the steps in the above table to construct a scatter plot with dots plots of x and

y variables. The plots will be similar to Figures 5.16 and 5.17.

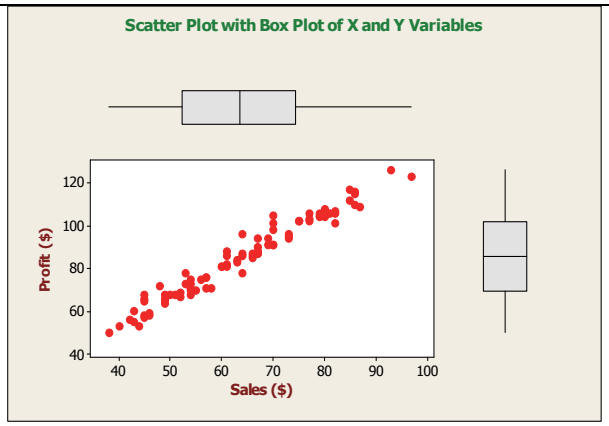


Figure 5.16: Scatterplot with Box Plots of x and y Variables

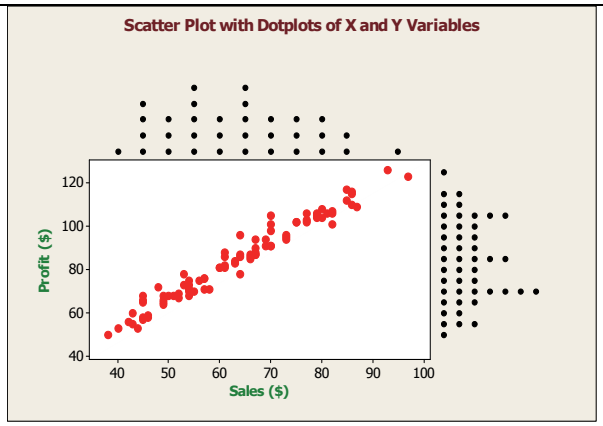
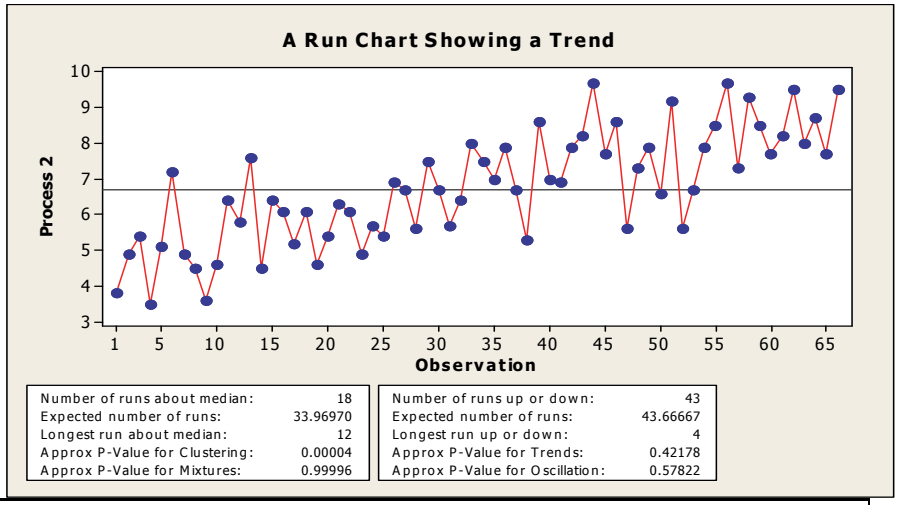


Figure 5.17: Scatterplot with Dot Plots of x and y Variables

Table 5.15

RUN CHART	Open the worksheet **RUNCHART2.MTW** From the main menu, select **Stat ➢Quality Tools ➢....** Under **Data are arranged as** click the circle next to **Single column** and : : Click the **Options** tab and type a title for your plot Click **OK**



Example 5.18: Analyzing a Control Chart- Controlling the Shaft Diameter

Table 5.20: Tests for Assignable Causes

Test Results for Xbar Chart of n1, ..., n5

```
TEST 1. One point more than 3.00 standard deviations from center line.
Test Failed at points:  14, 38, 39

TEST 5. 2 out of 3 points more than 2 standard deviations from center
```

```
        line (on one side of CL).
Test Failed at points:  37, 38, 39, 40

TEST 6. 4 out of 5 points more than 1 standard deviation from center
        line (on one side of CL).
Test Failed at points:  14, 38, 39, 40

* WARNING * If graph is updated with new data, the results above may no
            longer be correct.
```

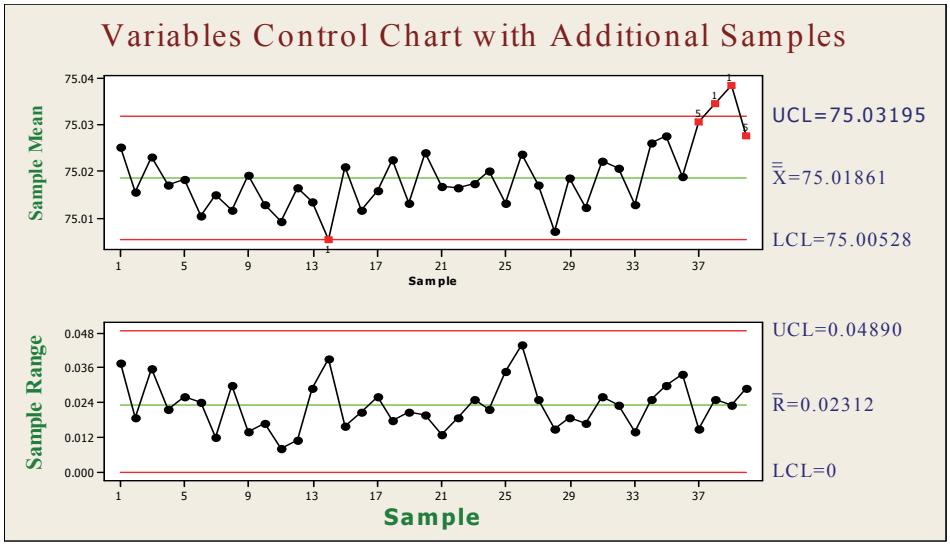


Figure 5.31: Control Charts showing Out of Control Conditions

Figure 5.34: A Cause-and-Effect Diagram of Production Problems using MINITAB

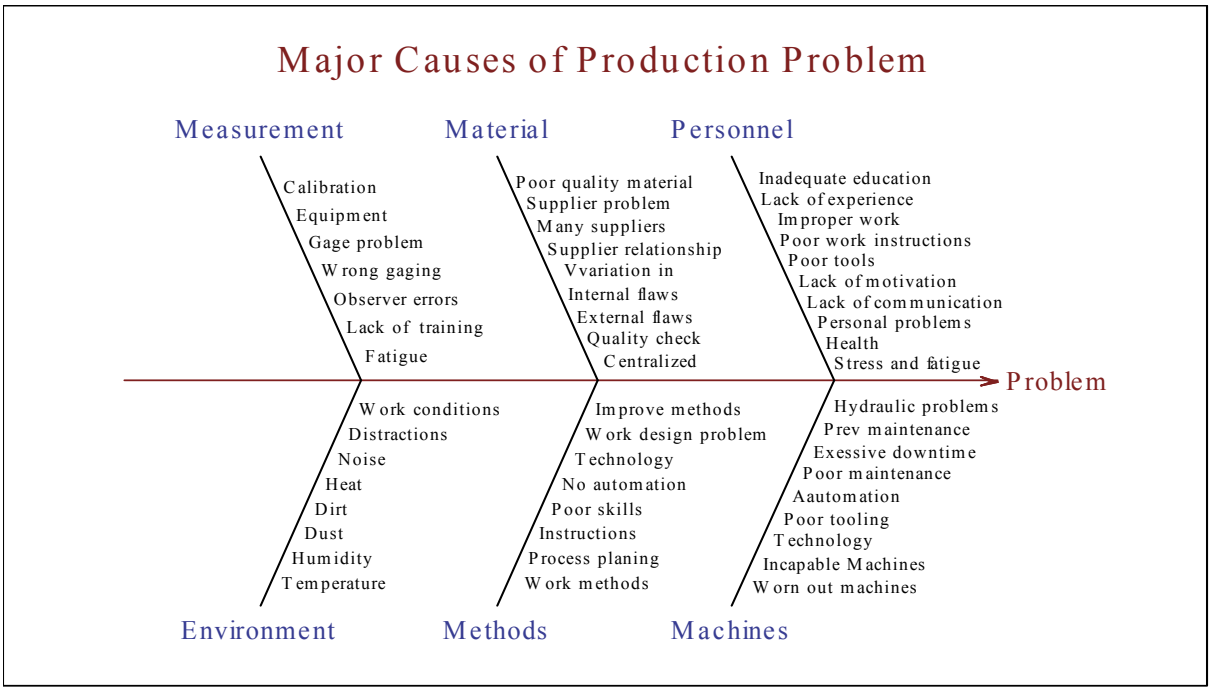


Figure 5.36: A Cause-and-Effect Diagram of Cost of Poor Quality

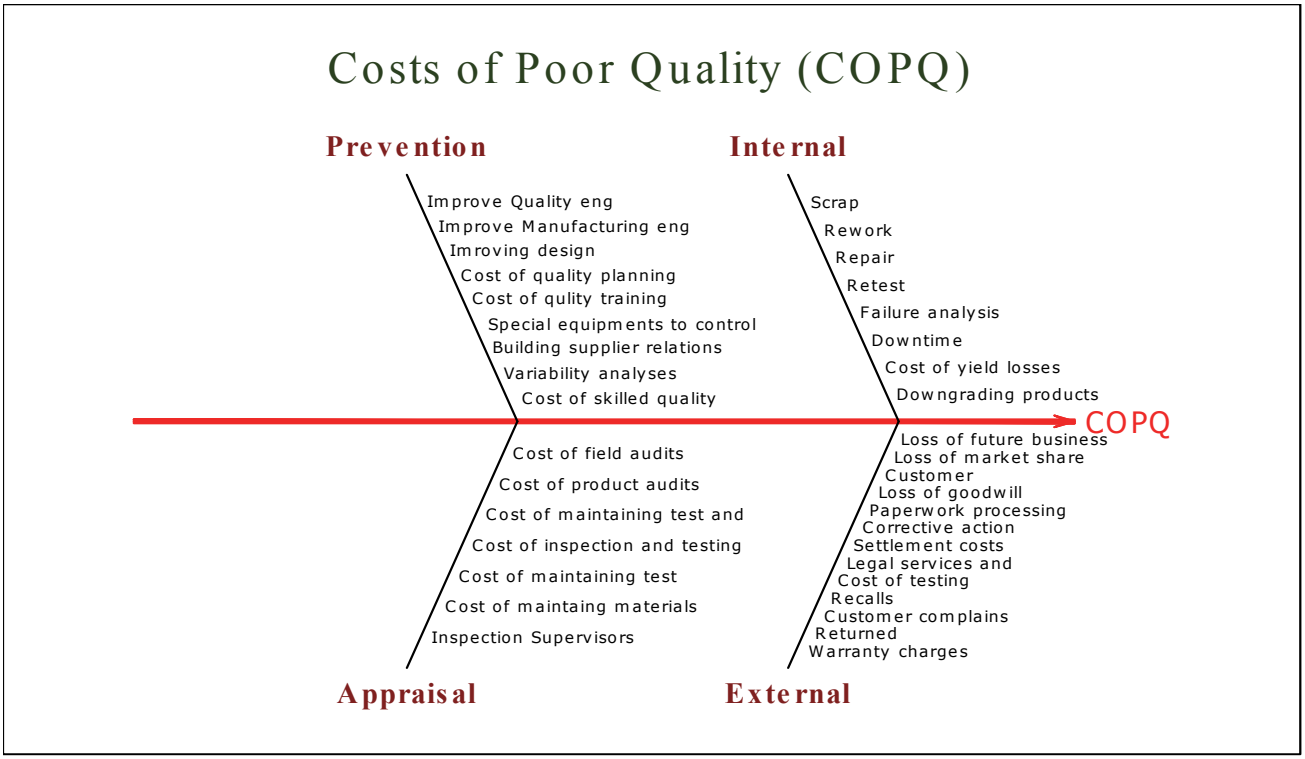


Table 5.23

A SIMPLE PARETO CHART	Open the worksheet **PARETOCHART.MTW** From the main menu, select **Stat ➢Quality Tools ➢ Pareto Chart** Defect or attribute data in: select **C1** or **Failure Cause** Frequencies in: **C2 or Count** In the **Combine remaining defects into one category after this :** Check the box **Do not chart cumulative percentage** Next**,** type a title for your plot **and** click **OK** in all the boxes

The Pareto chart as shown in figures will be displayed in the graphics

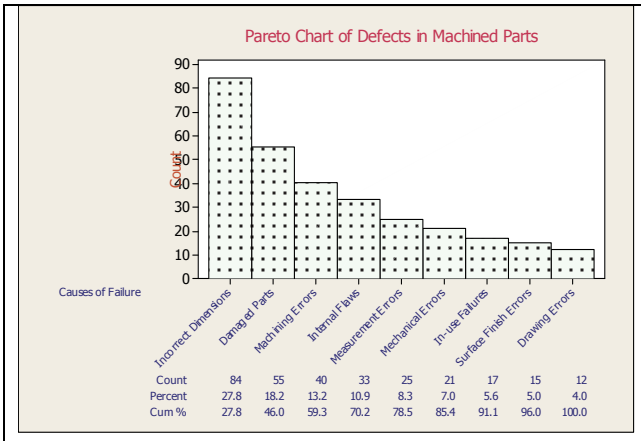


Figure 5.37: Pareto Chart of Defect Data with No Cumulative Points Plotted

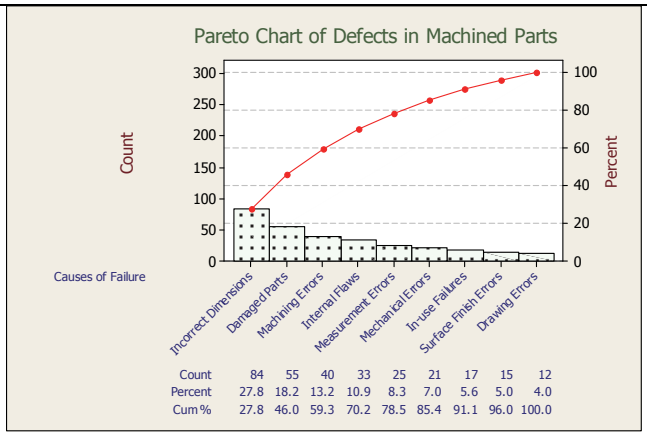
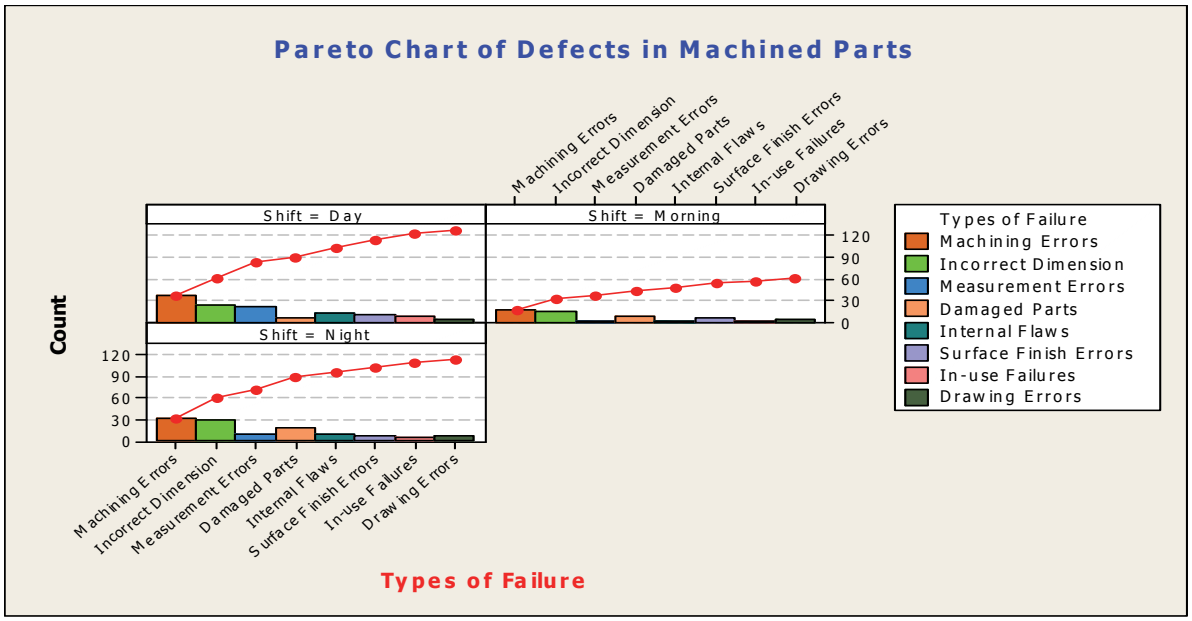
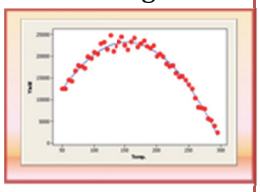
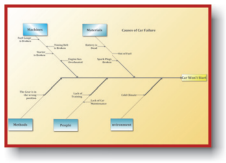
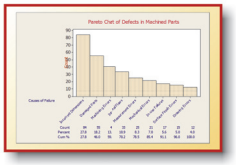
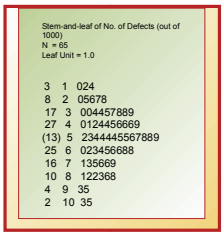
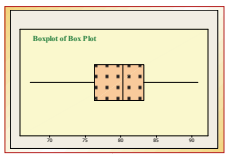


Figure 5.38: Pareto Chart of Defect Data with Cumulative Points Plotted



Summary and Applications of Basic Tools of Quality

Type of Chart/Graph	Description/Application	Number of Variables Plotted
Process Maps	Process mapping is flow charting a production or service process. The chart provides a model of an operation that facilitates communication about the ….	
Check sheets	Check sheets are data gathering tools. The purpose of check sheets is to ……	
Histogram	• Determining the shape and location of data measured on one characteristic. Also used for detecting process problems including a shift in the process either to the left or right …. •	
Scatter Diagrams 	Scatter diagrams investigate the relationship between two …….	bivariate relationship Continued…
Run Chart	……	One variable plotted: Univariate data

Cause-and-Effect (Ishikawa)/Fish-bone Diagrams 	A cause-and-Effect diagram is a useful tool in establishing the relationship ……	
Pareto Chart 	The chart shows (in descending order) the contribution of the vital few versus the trivial many. …..	One variable ….
Stem-and-leaf Plot 	A simple and useful way for summarizing and presenting data. The stem-and-leaf plot displays …..	
Box-plot 	Plot of five measures: the minimum, …..	Univariate data

All the above graphs except the Cause-and-Effect diagram are used to summarize or describe one characteristic at a time, and therefore, describe ……

(1) Multi-vari Plot

The multi-vari plots of data in Table 5.40 are shown in Figures 5.67 and 5.68. The difference in appearance between the two plots is due to the order of selection of the two factors. When you select the command sequence **Stat ➢Quality Tools ➢Multi-Vari Chart**, you must select the response variable and then factor 1 and factor 2. For our example, the response variable is strength and the two factors are alloy type and thickness. If you select **alloy type** for factor 1 and **thickness** for factor 2**,** ….

- Solid lines connect the means of factor 1 levels (at each level of factor 2).
- A dotted line connects the means of factor 2 levels.

Both the plots above show that alloy type 2 and thickness 2 has the maximum strength. ….

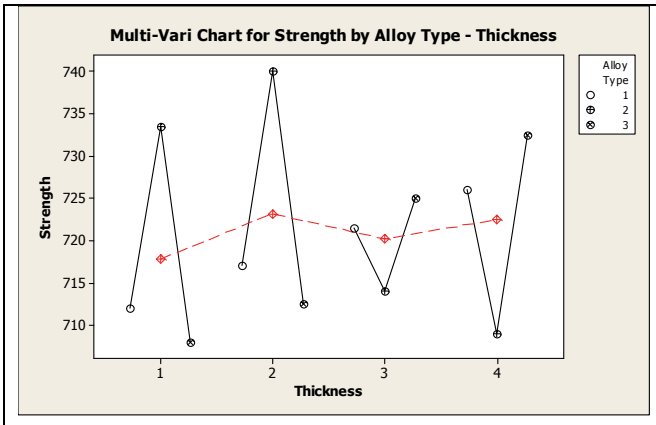


Figure 5.67: A Multi-Vari Chart for Strength by Alloy Type and Thickness

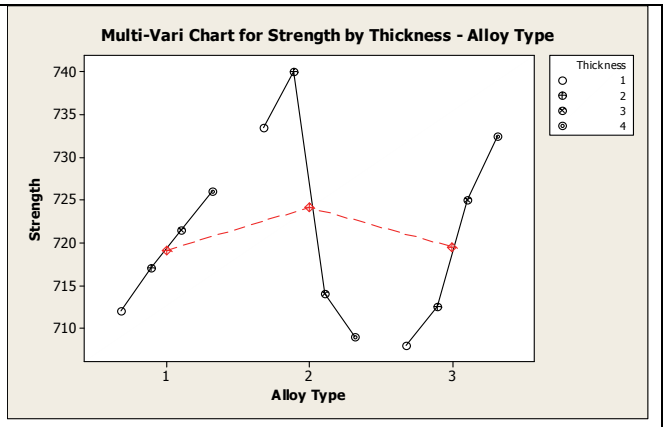
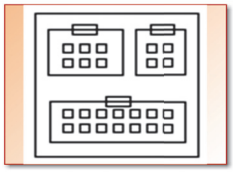
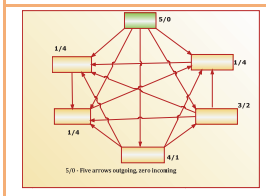
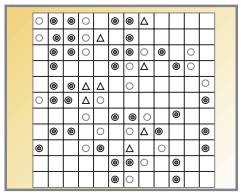
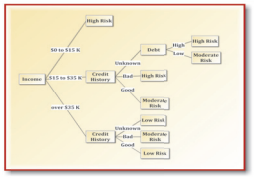


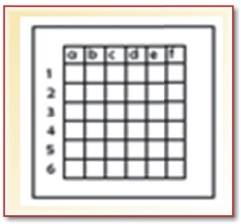
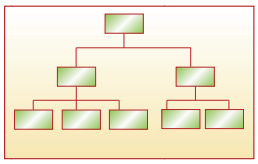
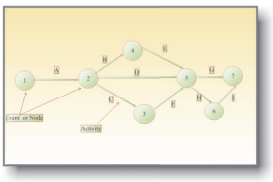
Figure 5.68: A Multi-Vari Chart for Strength by Thickness and Alloy Type

Figure 5.72: Interaction Plot of Strength by Thickness and Strength by Alloy Type

Summary of Seven New Tools for Quality

The seven new tools for quality are a powerful set of tools that have been successfully used as decision making tools for managing projects that involve team. Combined with the basic seven tools of quality (discussed earlier in this chapter), these tools provide simple visual tools to understand different processes. These tools are particularly useful in solving unstructured problems. The table below provides a summary of these tools.

Affinity Diagram	
	Affinity diagram is a visual tool that gathers large amounts ….
Interrelationship Digraph	
	The interrelationship digraph is used to identify the relationships between different issues relating to a problem. …. : :.
Matrix Diagram	
	The matrix diagram is a tool used to identify, analyze, and rate the relationship among two or more variables. It defines the relationship : :
Tree Diagram	
	The tree diagram is used to break down broad categories into different levels of detail. It starts : : :

Prioritizing Matrix	
	A prioritization grid is used to make decisions involving multiple criteria and multiple alternatives. This tool prioritizes : : :
Process Decision Program Chart	
	The Process Decision Program Chart (PDPC) is a tool for contingency planning. This tool can be used to : : :
Activity Network Diagram	
	The Activity Network Diagram is also known as the PERT (Program Evaluation and Review Technique) network, and CPM - the Critical Path Method (CPM) : : :