7 Quality Tools
The 7 Quality Tools for Process Improvements

- Control Chart
- Scatter Plot
- Pareto Chart
- Histogram
- Flow Charts
- Cause-Effect Diagrams
- Check Sheet
Where did the Basic Seven come from?

Kaoru Ishikawa

- Known for “Democratizing Statistics”

- The Basic Seven Tools made statistical analysis less complicated for the average person

- Good Visual Aids make statistical and quality control more comprehensible.
What Is a Flowchart?

A diagram that uses *graphic symbols* to depict the *nature* and *flow* of the steps in a process.
Benefits of Using Flowcharts

• Promote process understanding
• Provide tool for training
• Identify problem areas and improvement opportunities

"Draw a flowchart for whatever you do. Until you do, you do not know what you are doing, you just have a job."

-- Dr. W. Edwards Deming.
Keys to Success

- Start with the big picture
- Observe the current process
- Record process steps
- Arrange the sequence of steps
- Draw the Flowchart
Interpreting Your Flowchart

- Determine who is involved
- Form theories about root causes
- Identify ways to simplify and refine
- Determine how to implement changes
- Locate cost-added-only steps
- Provide training

Interpretation Steps

Step 1 - Examine each process step
Bottlenecks? Weak links? Poorly defined steps? Cost-added-only steps?

Step 2 - Examine each decision symbol
Can this step be eliminated?

Step 3 - Examine each rework loop
Can it be shortened or eliminated?

Step 4 - Examine each activity symbol
Does the step add value for the end-user?
EXERCISE 1
Flowchart for Cut Grass Process

Spouse says "Cut the grass"

Prepare to cut the grass

Cut the grass

Put mower away

Spouse says "Cut grass"

Open garage door

Pull lawnmower to driveway

Check gas and oil

Need gas or oil?

Yes

Get gas & oil from garage

Put in gas and oil as needed

No

Start lawnmower

Mow the yard

Turn lawnmower off

Does lawnmower need to be washed?

Yes

Get hose

Wash mower

No

Return mower to garage

Close garage door
What Is a Cause and Effect Diagram?

A graphic tool that helps identify, sort, and display possible causes of a problem or quality characteristic.
Benefits of Using a Cause-and-Effect Diagram

- Helps determine root causes
- Encourages group participation
- Uses an orderly, easy-to-read format
- Indicates possible causes of variation
- Increases process knowledge
- Identifies areas for collecting data
Basic Layout of Cause-and-Effect Diagrams

CAUSE A → CAUSE C → EFFECT → CAUSE B → CAUSE D

Step 1 - Identify and Define the Effect

- Decide on the effect to examine
- Use Operational Definitions
- Phrase effect as
  > positive (an objective) or
  > negative (a problem)
Step 2 - Fill in the Effect Box and Draw the Spine

POOR GAS MILEAGE

Step 3 - Identify Main Categories

METHODS

MACHINERY

POOR GAS MILEAGE

PEOPLE

MATERIALS
Step 4 - Identify Causes Influencing the Effect

METHODS
- Drive too fast
- Use wrong gears

MACHINERY
- Carburator adjustment
- Underinflated tires

POOR GAS MILEAGE

PEOPLE
- Poor maintenance
- Poor driving habits

MATERIALS
- Improper lubrication
- Wrong octane gas
Example of How the Cause-and-Effect Diagram Could Be Constructed for the Detailed Exercise

SOFTWARE
- Faulty Design
- Inadequate Documentation

Faulty Installation
- Faulty Media

Users
- Lack of Training
- Misapplication of Software
- Misuse of Hardware

Computer Downtime

Hardware
- Faulty Component
- Power Fluctuations

Faulty Power
- Inadequate Power

Environment
- Corrosion
- Humidity
- Temperature Gradients
- Mechanical Shock
Data Collection

- Where
- What
- Who
- How
Uses for Checksheets

- Record data for further analysis
- Provide historical record
- Introduce Data Collection methods

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### Types of Checksheets

**Tabular Format**

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**Graphic Format**

- Workers plot each data point on the graph.

**Check Sheet**

- Graph showing temperature over time of day.
Making a Useful Checksheets

- Tailored for specific purpose
- Workers help develop form
- Columns labeled clearly
- User-friendly format
What Is a Histogram?

- A bar graph that shows the distribution of data
- A snapshot of data taken from a process
When Are Histograms Used?

- Summarize large data sets graphically
- Compare measurements to specifications
- Communicate information to the team
- Assist in decision making
Parts of a Histogram

DAYS OF OPERATION PRIOR TO FAILURE FOR AN HF RECEIVER

MEAN TIME BETWEEN FAILURE (IN DAYS) FOR R-1051 HF RECEIVER
Data taken at SIMA, Pearl Harbor, 15 May - 15 July 94

1. Title
2. Horizontal / X-axis
3. Bars
4. Vertical / Y-axis
5. Legend
Constructing a Histogram

Step 1 - Count number of data points
Step 2 - Summarize on a tally sheet
Step 3 - Compute the range
Step 4 - Determine number of intervals
Step 5 - Compute interval width

Histogram

Constructing a Histogram

Step 6 - Determine interval starting points
Step 7 - Count number of points in each interval
Step 8 - Plot the data
Step 9 - Add title and legend
How to Construct a Histogram

Step 1 - Count the total number of data points

Number of yards long (+ data) and yards short (- data) that a gun crew missed its target.

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**TOTAL = 135**

How to Construct a Histogram

Step 2 - Summarize the data on a tally sheet

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<td>410</td>
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</table>
How to Construct a Histogram

Step 3 - Compute the range for the data set

Largest value = + 410 yards past target
Smallest value = - 180 yards short of target
Range of values = 590 yards
Calculation: + 410 - (- 180) = 410 + 180 = 590

How to Construct a Histogram

Step 4 - Determine the number of intervals required

<table>
<thead>
<tr>
<th>IF YOU HAVE THIS MANY DATA POINTS</th>
<th>USE THIS NUMBER OF INTERVALS:</th>
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<tr>
<td>Less than 50</td>
<td>5 to 7 intervals</td>
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<tr>
<td>50 to 99</td>
<td>6 to 10 intervals</td>
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<td>100 to 250</td>
<td>7 to 12 intervals</td>
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<tr>
<td>More than 250</td>
<td>10 to 20 intervals</td>
</tr>
</tbody>
</table>

How to Construct a Histogram

Step 5 - Compute the interval width

\[
\text{Interval Width} = \frac{\text{Range}}{\text{Number of Intervals}} = \frac{590}{10} = 59
\]

Use 10 for the number of intervals

Round up to 60
### How to Construct a Histogram

**Step 6** - Determine the starting point of each interval

**Step 7** - Count the number of points in each interval

<table>
<thead>
<tr>
<th>INTERVAL NUMBER</th>
<th>STARTING VALUE</th>
<th>INTERVAL WIDTH</th>
<th>ENDING VALUE</th>
<th>NUMBER OF COUNTS</th>
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- Equal to or greater than the **STARTING VALUE**
- But less than the **ENDING VALUE**
Interpreting Histograms

Location and Spread of Data

A

Target

B

Target

C

Target

D

Target

Interpreting Histograms

Is Process Within Specification Limits?

LSL = Lower specification limit
USL = Upper specification limit

WITHIN LIMITS

OUT OF SPEC

LSL Target USL

LSL Target USL
What Is a Pareto Chart?

- Bar chart arranged in descending order of height from left to right

- Bars on left relatively more important than those on right

- Separates the "vital few" from the "trivial many" (Pareto Principle)
Why Use a Pareto Chart?

- Breaks big problem into smaller pieces
- Identifies most significant factors
- Shows where to focus efforts
- Allows better use of limited resources
Pareto Principle

• Vilfredo Pareto (1848-1923) Italian economist
  – 20% of the population has 80% of the wealth

• adapted by Joseph Juran.
  • Remember the 80/20 rule states that approximately 80% of the problems are created by approximately 20% of the causes.
Constructing a Pareto Chart

Step 1 - Record the data
Step 2 - Order the data
Step 3 - Label the vertical axis
Step 4 - Label the horizontal axis
Step 5 - Plot the bars

Constructing a Pareto Chart

Step 6 - Add up the counts
Step 7 - Add a cumulative line
Step 8 - Add title, legend, and date
Step 9 - Analyze the diagram
Pareto Charts
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Acme Pizza

- The completed Pareto Analysis results in the following:
Scatter Diagrams

Slide 1 of 4

• Scatter Diagrams Defined
  – Scatter Diagrams are used to study and identify the possible relationship between the changes observed in two different sets of variables.
Constructing a Scatter Diagram

1. Collect two pieces of data and create a summary table of the data.
2. Draw a diagram labeling the horizontal and vertical axes.
   3. It is common that the “cause” variable be labeled on the X axis and the “effect” variable be labeled on the Y axis.
3. Plot the data pairs on the diagram.
4. Interpret the scatter diagram for direction and strength.
Scatter Diagram
What Is a Control Chart?

A statistical tool used to distinguish between process variation resulting from common causes and variation resulting from special causes.

Why Use Control Charts?

- Monitor process variation over time
- Differentiate between special cause and common cause variation
- Assess effectiveness of changes
- Communicate process performance
What Are the Control Chart Types?

Chart types studied in this module:
- X-Bar and R Chart
- Individual X and Moving Range Chart
  - For Variables Data
  - For Attribute Data

Other Control Chart types:
- X-Bar and S Chart
- Median X and R Chart
- c Chart
- u Chart
- p Chart
- np Chart
Control Chart Decision Tree

1. Are you charting attribute data?
   - YES: Use XmR chart for attribute data
   - NO: Data are variables data

2. Data are variables data
   - NO: Is sample size equal to 1?
     - YES: Use XmR chart for variables data
     - NO: For sample size between 2 and 15, use X-Bar and R Chart
# Elements of a Control Chart

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Step 12b - Constructing an XmR Chart

Upper Plot

\[ UCL_X = \bar{X} + (3.144) \text{ (Median Moving Range)} \]
\[ LCL_X = \bar{X} - (3.144) \text{ (Median Moving Range)} \]
\[ \text{Centerline}_X = \bar{X} \]

Lower Plot

\[ UCL_{mR} = (3.865) \text{ (Median Moving Range)} \]
\[ LCL_{mR} = \text{None} \]
\[ \text{Centerline}_{mR} = \text{Median Moving Range} \]
Control Chart Zones

UCL

ZONE A

ZONE B

Centerline

ZONE C

ZONE C

ZONE B

ZONE A

LCL

1/3 distance from Centerline to Control Limits