QI STORY
A. WHAT IS THE QI STORY?

The Quality Improvement problem-solving process is a systematic, data-based approach to problem solving. The QI Story is a structure to help illustrate the steps to be taken by a team in the improvement process. It also provides a standard way of communicating team progress.

<table>
<thead>
<tr>
<th>TEAM INFORMATION</th>
<th>1) REASON FOR IMPROVEMENT</th>
<th>2) CURRENT SITUATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Planning Worksheet</td>
<td>Graph Good Target</td>
<td>Pareto Chart Graph Good</td>
</tr>
</tbody>
</table>

3) ANALYSIS | 4) COUNTERMEASURES

Fishbone (Ishikawa) Diagram | Pareto Chart | Countermeasures Matrix | Action Plan

5) RESULTS | 6) STANDARDIZATION | 7) FUTURE PLANS

Pareto Chart | Graph Good | Control System | AP CD

Adapted from the concept of the QC Story, originally named by Mr. Nogawa, president of Komatsu, for the purpose of reporting improvement activities. Professor Kusawa and others expanded the procedure to include its use as a guide for solving a problem.

B. WHY IS IT USEFUL?

- It helps the team to organize, collect and analyze information and to monitor how they are doing.
- It allows the team to obtain understanding and input from non-team members.
The QI Story form is essentially a structure which allows the team to display its work in a standardized fashion. The Story has seven steps:

1. Reason for Improvement
2. Current Situation
3. Analysis
4. Countermeasures
5. Results
6. Standardization
7. Future Plans

As we proceed through the course, these steps are explained in detail and reinforced by exercises and the case study. The Team Information space at the beginning is typically used for placement of team information and/or a photo which tells who is doing the improvement, the team meeting minutes which tell what and when, and the Project Planning Sheet which outlines how we intend to do it.

C. HOW IS IT USED?

The QI Story is a guide for us as we go through the problem-solving process; it serves as a guide for planning, doing and checking. If we follow it step-by-step, it will provide both the team and others with a clear picture of the logical process used for improvement.

D. WHEN IS IT USED?

We use it at every stage of the team’s activity and every step of the improvement process.
A. WHAT ARE THE SEVEN BASIC QC TOOLS?

The seven basic QC (Quality Control) tools are common analytical methods that are used to solve problems.

The seven basic QC tools are:

CHECKSHEET

GRAPH

HISTOGRAM

PARETO CHART

CAUSE AND EFFECT DIAGRAM (FISHBONE OR ISHIKAWA)

SCATTER DIAGRAM

CONTROL CHART

Eighty percent of all problems can be solved by using just three of these seven basic tools: Checksheet, Pareto Chart, and Cause and Effect (Fishbone or Ishikawa) Diagram.

B. WHY ARE THEY USEFUL?

The major use of QC tools is to provide us with objectivity and clarity in the way we do our work. It helps us separate opinions from data-based logic, thereby allowing us to "speak with facts."
C. HOW ARE THEY USED?

QC tools can be used by everyone. We are “speaking with facts” when:

- We know what the work process involves: its inputs, activities and outputs.
- We track the facts about this process and keep records, which can be compared to discover how well we are doing and/or where we need to change or improve.
- We gradually learn ways of analyzing what the data can tell us (simple statistical analysis techniques).

D. WHEN ARE THEY USED?

They can be used by individuals or teams to examine and improve both work processes and outcomes. The use of QC tools is particularly necessary for Quality Improvement Teams since it provides a common means of communicating and decision making.
b. **Variables (continuous) data:**

When it is important not only to identify and rank items, but also to precisely measure the distribution (the distance or interval between them), we must collect "variables data." If attribute data is black or white, variables data is concerned with measuring the shades of gray. Not only do we identify our data by category, but we measure "distance" (pounds, feet, rate of disabling accidents, etc.).

This type of data is usually more expensive to collect (after all, to find out whether a customer is over or under age 50 is less time consuming than finding the actual date of birth), but it provides a lot more information on the subject.

B. **WHY ARE DATA COLLECTED?**

Data are collected:

- To quantify the present situation (baseline) as well as future changes to be able to compare the two.
- To identify improvement opportunities.
- To analyze root causes and select countermeasures.
- To track a process and/or a countermeasure.
- To explain a problem/opportunity clearly to others.
- To enable us to “speak with facts.”
INTRODUCTION

When teams select a theme or opportunity for improvement, they will begin to gather data, or facts, about the theme/opportunity. This data will help the team to focus on the gap of “what is” versus “what should be” and, therefore, understand the reason for improvement.

A. WHAT IS DATA?

1. Webster defines data as “facts or figures from which conclusions can be drawn; a basis for reasoning, discussion or calculation.”

2. Data (facts), when properly organized and analyzed, provide useful information and serve as the basis for decision making and action.

3. There are different types of numerical, or “quantitative,” data. The different types have different characteristics, and this affects how the data can be used.

4. Data can be subjective (based on experience, intuition, gut feel, opinion or observation) and objective (based on verifiable external events). Data may be represented in either words, pictures (graphs) or numbers.

5. In our search for objective data, numbers become very important. There are two broad categories of numerical data: attribute and variables. Understanding each kind and their differences will help to use each effectively.

a. Attribute (discrete) data:

When characteristics are identified only by name, label, or class, this is called “attribute data.” For example, at receiving inspection you either accept or reject parts. During a test of circuit breakers, it either passes or fails. The important point is that the situation is either “go” or “no go,” “green” or “not green,” “over $150” or “not over $150.”
Graphically it looks like this:

![Diagram showing data types]

C. **HOW ARE DATA COLLECTED?**

Data are collected through the use of standardized forms called Check-sheets. They are collected with consideration of *stratification*, the breaking down of the total area of concern into smaller related functions or items (see Stratification). Generally, data should be collected at the smallest grouping practical; that data should include *variables* data when available.

When you plan for data collection:

- Collect only needed data
- Get the right data for the problem
- Measure things as accurately as possible, given reasonable time and cost constraints

D. **WHEN ARE DATA COLLECTED?**

Data are collected only after planning and only when needed. In general, Steps 2, 3, and 4 will require attention to data gathering in order to verify problems, causes and countermeasures through facts.
1. REASON FOR IMPROVEMENT

**OBJECTIVE:**
Identify a theme (problem area) and the reason for working on it.

**KEY ACTIVITIES:**
- Research for themes:
  - Review Departmental indicators
  - Survey internal/external customers
  - Interview individuals from the work area
- Consider customer needs to help select the theme.
- Set indicator to track theme.
- Determine how much improvement is needed.
- Show impact of theme.
- Schedule the QI Stories activities.
- Describe the procedure used in the problem area.

**HELPFUL TOOLS/TECHNIQUES:**
- Graph
- Control Chart
- Process Flow Chart
- Control System

**CHECKPOINTS:**
1. The criteria for selection was customer oriented.
2. The indicator correctly represented the theme.
3. The need for improvement was demonstrated using data.
4. A schedule for completing the QI Story was developed.
OVERVIEW: REASON FOR IMPROVEMENT

The objective of the first step of the QI Story is:

To identify a theme and the reason for working on it.

Various activities and techniques are used by the team to graphically demonstrate the reason(s) for improvement. This step begins a clear logic to carry the team through the improvement process. When complete, it will likely depict appropriate indicators, such as a graph or a control chart, to help visualize the need. A flowchart of the process must be displayed up front in the QI Story, either here or in Current Situation (Step 2).

The objective of this step of the QI Story is to identify a theme (problem area) and the reason for working on it.
A. WHAT IS BRAINSTORMING?

1. Brainstorming is a way of using a group of people to quickly generate, clarify and evaluate a sizable list of ideas, problems, issues, etc.

2. These three phases are like the gears on a car; you can only be in one gear at a time without injuring the mechanism.

3. The emphasis is on quantity of ideas, not quality.

4. It can be an excellent technique for tapping the creative thinking of a team.

B. WHY IS IT USEFUL?

Brainstorming helps to document “what we know” as a team. It stimulates team creativity and gets everyone involved.

C. HOW IS IT DONE?

1. During the Generation Phase of brainstorming, the leader reviews these Rules for Brainstorming with team members.

   - Clearly state purpose (what to improve in our work area)
   - Each person takes a turn, in sequence, around the group
   - Present one thought at a time
   - Do not criticize or discuss any idea
   - OK to pass
   - Build on ideas of others
   - Record ideas where visible for group

a. The leader states the topic to be brainstormed in specific, precise terms and makes it visible.

b. A recorder is selected.

c. The generation phase begins, and continues until all ideas have been exhausted.
Brainstorming
TOOLS/TECHNIQUES

2. During the *Clarification Phase* of brainstorming, the team goes over the list to make sure that everyone understands all the items. Don’t discuss ideas; criticism and discussion will take place later, during the evaluation stage and in multivoting.

3. Finally, during the *Evaluation Phase*, the team reviews the list to eliminate duplications, irrelevancies or issues that are off limits.

D. **WHEN IS IT USED?**

As a data gathering technique:

- To collect improvement opportunities and/or problems (themes)
- To identify possible causes when constructing a Cause-and-Effect Analysis diagram
- To suggest possible countermeasures
- To identify barriers or aids
Multivoting
TOOLS/TECHNIQUES

A. WHAT IS MULTIVOTING?

The multivoting technique is a structured series of votes by a team, used to help teams reduce a list containing a large number of items to a manageable few (usually three to five).

B. WHY IS IT USEFUL?

Multivoting helps to accomplish "list reduction" quickly and with a high degree of group agreement. This technique tends to eliminate each individual's close identification with items.

C. HOW IS IT DONE?

1. First vote — Each person votes for as many items as desired, but only once per item. Circle the items receiving a relatively higher number of votes than the other items. (Example: A team has ten members. Items receiving five or more votes are circled.)

2. Count the circled items. 2nd vote — Each person gets to vote a number of times equal to half the circled items. (Example continued: If six items received five or more votes, then each person gets to vote three times during the second vote.)

3. Continue multivoting until the list is reduced to three to five items, which can then be further analyzed. NEVER MULTIVOTE DOWN TO ONLY ONE ITEM!

D. WHEN IS IT USED?

Multivoting (a subjective prioritizing technique) may be used after a team discusses the various items on a brainstorm list, which is too lengthy to be addressed at once. Multivoting is often used to narrow the list of themes down to four or five.
A. WHAT IS THE THEME SELECTION MATRIX?

The Theme Selection Matrix is a technique which helps the team to select a theme quickly on which to begin gathering data. If the theme selected using their judgment can be shown to need improvement, then the team should proceed.

### Theme Selection Matrix

<table>
<thead>
<tr>
<th>Themes:</th>
<th>Impact on Customer:</th>
<th>X Need to Improve:</th>
<th>= Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are those 4 or 5 remaining after the team has multivoted. Teams should consider only those themes within their responsibility and control.</td>
<td>A rating based on the team's present knowledge and judgement of the direct effect this theme has on customer satisfaction. (How severe is each occurrence?) Higher ratings are given to themes which have a more direct effect on customers.</td>
<td>A rating based on the team's present knowledge and judgement of the difference between the present performance and that needed to meet the customer's valid requirements. (How frequently does it occur?) Higher ratings are given to themes with greater need to improve.</td>
<td>The product of Impact on Customers X Need to Improve. Overall: The theme receiving the highest ranking should be investigated setting an indicator and actually measuring the present level and comparing it to the valid requirements. If there is a difference, then the team should proceed. If not, it should investigate the next theme.</td>
</tr>
</tbody>
</table>

- Scale: 1 None  2 Somewhat  3 Moderate  4 Very  5 Extreme

B. WHY IS IT USEFUL?

The matrix allows the team to rank its themes by considering the impact on the customer and the need to improve. Thus the team is able to focus its energies on improvements which are customer-oriented. The matrix also helps the team achieve ownership and clarity in the selection of its theme.

C. WHEN IS IT USED?

The team has reduced its list of themes to four or five. The list is then placed onto the matrix, and the team works to complete the remaining categories.
THEME SELECTION

1. In choosing a project for improvement, the team is trying to select a "theme" (problem area) which is more general than specific. The theme must be one which has an impact on the customer and one in need of improvement.

2. The team may research for potential themes or problem areas by:
   - reviewing department indicators
   - surveying internal or external customers
   - interviewing individuals from the work area
   - identifying what the team knows (brainstorming)

3. The team should also select a quality indicator to help track the theme and illustrate how much improvement is needed. The indicator should be set from a customer's (internal or external) point of view.

4. When many themes or problem areas are initially identified by the team, the multivoting technique can be used to reduce this list to four or five themes which can be analyzed in a Theme Selection Matrix.

Note: In order to learn and use the QI problem-solving process and the tools/techniques most effectively, it is recommended that the problem be simple and specific. The team may choose an important theme but only address a piece. (See stratification.)

5. A Review Form has been developed which lays out in detail what is expected at each step of the story. It will be reviewed later in this Unit.
A. WHAT IS A CHECKLIST?

Another technique is the use of a checklist, which is simply a list of the items to be attended to or steps to be taken. In data gathering it is an inventory of the information needed so that you can check your progress in gathering data and be sure that the data is complete.

A checklist might look like this:

**Auxiliary Power Usage - Partial Checklist**

<table>
<thead>
<tr>
<th>Equipment</th>
<th>To Be Off</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Boiler Feed Pumps (except when filling)</td>
<td></td>
</tr>
<tr>
<td>2. Condensate Pump</td>
<td></td>
</tr>
<tr>
<td>3. Heater Drain Pump</td>
<td></td>
</tr>
<tr>
<td>4. Service Air Compressor</td>
<td></td>
</tr>
<tr>
<td>5. Closed Cooling Water Pump</td>
<td></td>
</tr>
<tr>
<td>6. Stator Oil Pump</td>
<td></td>
</tr>
<tr>
<td>7. Instrument Air Compressor</td>
<td></td>
</tr>
<tr>
<td>8. Standby Vacuum Pump</td>
<td></td>
</tr>
<tr>
<td>9. B,F,P. Room Exhaust Fans</td>
<td></td>
</tr>
<tr>
<td>10. F.D. Fans</td>
<td></td>
</tr>
</tbody>
</table>

B. WHY IS IT USEFUL?

A checklist provides for a common and organized way of proceeding. It ensures completeness and makes it easier for those involved in the gathering of data. Checklists can be as simple as the shopping list you prepare before heading to the grocery store or as complicated as the one used by airline pilots as they prepare for takeoff. In designing its own checklists, your team should strive for simplicity, clarity, objectivity and completeness.
C. **HOW IS IT DONE?**

When making a checklist the team needs to think about the information it needs and the order in which it should be collected. Sometimes a technique like brainstorming will help generate a good list. Careful planning of the checklist at this stage will eliminate the need to backtrack to fill in what might otherwise be missed.

D. **WHEN IS IT USED?**

A checklist is used whenever you want to assure that things are done in an organized and thorough way. It may also be used to verify conformance to a set of standards or procedures.
A. WHAT IS A CHECKSHEET?

A checksheet is a form on which data may be collected systematically and recorded in a uniform manner.

A simple checksheet might look like this.

Data Collected:
Jan. '88 - Dec. '88
By: Jack Smith

Plant Site
Packaging Line Interruptions, 1988

<table>
<thead>
<tr>
<th>JAN</th>
<th>FEB</th>
<th>MAR</th>
<th>APR</th>
<th>MAY</th>
<th>JUN</th>
<th>JUL</th>
<th>AUG</th>
<th>SEP</th>
<th>OCT</th>
<th>NOV</th>
<th>DEC</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td>II</td>
<td>II</td>
<td>III</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>11</td>
</tr>
<tr>
<td>PM</td>
<td></td>
<td></td>
<td>I</td>
<td>I</td>
<td>I</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>21</td>
</tr>
<tr>
<td>AM</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>AM</td>
<td>I</td>
<td>I</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td>78</td>
</tr>
<tr>
<td>PM</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>III</td>
<td>173</td>
</tr>
</tbody>
</table>

TOTAL: 288

B. WHY IS IT USEFUL?

A checksheet enables us to gather a variety of data in a systematic fashion. If the categories are complete, especially if they include the source, this tool can give us a clear and objective picture of the facts.

Other more complex checksheets with which we are familiar include expense account forms, multiple-entry ledgers and payroll check attachments.
C. HOW IS IT DONE?

We make a checksheet by laying out the categories of information and data we wish to gather about the items on the checklist onto a standardized form or grid. We determine the categories by asking such fact-finding questions as:

- What (what happens)?
- Who (who does it, who receives it, who is responsible)?
- Where (what place, what part, what section)?
- When (what time of day, month, how often)?
- How (how does it happen, how much, how long, etc.)?

Use all the journalistic questions except “Why” (which will mislead us into a search for causes while we are still trying to determine IF a problem exists and what it looks like) to obtain categories for the checksheet. The checksheet should be designed to facilitate the collection of as many different kinds of data as are useful. The team can brainstorm items and then refine the list through multivoting. It is also helpful to gather a little data prior to setting up your checksheet. You may learn the categories from this smaller sample.

The checksheet should also clearly indicate who collected the data and where, when and how it was collected. In a sample, the total population from which the data was collected should also be indicated.

* On each checksheet, graph, chart, etc., a box should be placed indicating who, what, where, when and how data were collected.

D. WHEN IS IT USED?

The checksheet is used whenever the team needs to collect data to help identify and quantify problems and improvement opportunities (themes), especially in Steps 1, 2, 3 and 4. The use of both checklists and checksheets will minimize the risk of errors and facilitate the organized collection and analysis of data.
OBJECTIVE:
Select a problem and set a target for improvement.

KEY ACTIVITIES:
- Collect data on all aspects of the theme.
- Stratify the theme from various viewpoints.
- Select a problem from the stratification of the theme.
- Identify the customers valid requirements.
- Write a clear problem statement.
- Utilize the data to establish the target.

HELPFUL TOOLS/TECHNIQUES:
- Checksheet
- Control Chart
- Histogram
- Graph
- Pareto Diagram

CHECKPOINTS:
5. The situation was stratified to a component level specific enough to analyze.
6. Customer valid requirements were identified.
7. Problem statement addressed the gap between the current and targeted values.
8. The methodology in establishing goals/target was identified.
Step 2: Current Situation

OVERVIEW

The Current Situation step allows the team to narrow its focus from the broader Reason for Improvement step. At this point, the team is collecting and interpreting data to help them “key in” on one project.

The objective of the second step of the QI story is to select a problem and set a target for improvement.

### Quality Improvement Story

<table>
<thead>
<tr>
<th>☐ Current Situation</th>
</tr>
</thead>
</table>

- **Pareto Chart**
- **Graph**

The key activities of this step are to:

1. Collect data on all aspects of the theme.
2. Stratify the theme from various viewpoints.
3. Select a problem from the stratification of the theme.
4. Identify the customer’s valid requirements.
5. Utilize data to establish a target.
6. Write a clear problem statement. (Unit 3)

Helpful tools include:

- Checksheet
- Graphs
- Histogram
- Pareto Chart
- Control Chart
A. WHAT IS STRATIFICATION?
Stratification is a technique used for breaking down the whole (total area of concern) into smaller, related subgroups. For example, the Eastern sales region can be stratified into cities, then a particular city further stratified into sales districts.

```
Sales Regions          Cities            Sales Districts
Northern              Boston             Manhattan
Southern              New York           Queens
Eastern               Philadelphia      Long Island
Western
```

B. WHY IS IT USEFUL?
Stratification of information specifies the data and enables the team to do a more precise analysis of it. It is also a useful tool for verifying root cause.

C. HOW IS IT DONE?
1. Review the whole to determine smaller, natural groups made up of relatively similar units.
2. Collect data relative to those smaller groups, rather than the entire area of concern as a single entity.
3. Analyze data based on those smaller groups.

D. WHEN IS IT USED?
During data gathering:
- When creating a checklist
- When designing a checksheet
- When selecting a sample
- When verifying root causes

During data analysis when using:
- Histograms
- Pareto charts
- Cause and Effect diagrams (Fishbone or Ishikawa)
A. WHAT ARE GRAPHS?

1. Graphs are visual displays of quantitative data. They lay out, describe or summarize a set of numbers or statistics.

2. Graphs come in many different forms; some of the major ones are shown in detail on the following pages. In general, all graphs have these elements in common:

   ![Chart Form with Y and X axes]

   - **Y**
   - **X**
   - **F**
   - **r**
   - **e**
   - **q**
   - **u**
   - **n**
   - **x**
   - **↑**
   - **= Good**

   **Collected**
   - **By:**
   - **On:**
   - **At:**
   - **Formula:**

   a. **All graphs should have a title which tells what is being portrayed.**

   b. **The vertical, or Y, axis represents FREQUENCY, how many times something has happened, percentage of something, number of dollars, etc.**

   c. **The horizontal, or X, axis represents distribution or division of the data; how often something happens (days, weeks, months), how many times things happened within a particular measure (how many data points between 7.34 and 7.45), etc. Both the X and the Y axes should be clearly labeled.**

   d. **The scale used in a graph can be adjusted to show the situation; expanded to emphasize variables, compressed to show control. All graphs should have an indication of the total number of data points represented, as is indicated by n = _____.**

   e. **If appropriate, the average of the data points should also be indicated by \( \bar{X} = \).**
f. If there is a "good" direction, this should be indicated with an arrow.

g. Every graph should indicate:
  - when the data was gathered
  - where it was gathered
  - by whom it was gathered
  - whether it is raw data, a percentage, averages
  - how the data was calculated (a formula)

B. WHY ARE THEY USEFUL?

Graphs are useful because they visually display complex data; they aid us in understanding and interpreting data, in speaking with facts.

C. WHEN TO USE GRAPHS

The following lists some of the graphs that are used throughout the QI process and when they are most often used.

<table>
<thead>
<tr>
<th>Graphs</th>
<th>Most Often Used in QI Story Step</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reason for Improvement</td>
</tr>
<tr>
<td>Line, Bar, Pie Graphs</td>
<td>X</td>
</tr>
<tr>
<td>Pareto Chart</td>
<td>X</td>
</tr>
<tr>
<td>Cause-and-Effect Analysis (Fishbone diagram)</td>
<td>X</td>
</tr>
<tr>
<td>Histogram</td>
<td>X</td>
</tr>
<tr>
<td>Scatter Diagram</td>
<td>X</td>
</tr>
<tr>
<td>Control Chart</td>
<td>X</td>
</tr>
</tbody>
</table>

D. HOW ARE THEY DONE?

Each type of graph is explained in this manual under its individual entry.
I. PIE CHART

A. WHAT IS IT?

A pie chart is a graphic representation that compares the relative magnitudes or frequencies of things.

Production Delays by Category

B. WHY IS IT USED?

It is used to show the percentage an item contributes to the whole.

C. HOW IS IT DONE?

Divide a circle (pie) by several radii such that each wedge, for its respective item, represents the desired proportional part of the whole.

To calculate the size of the wedge, take the value of the item and divide it by the total value of all items; then multiply

- by 100 to get percentage (%)
  \[
  \frac{315}{1542} = \frac{204 \times 100}{1542} = 20.4\% \text{ (rework, above)}
  \]

- by 360 to get degrees
  \[
  \frac{315}{1542} = \frac{204 \times 360}{1542} = 74^\circ
  \]

A protractor should be used to plot the degrees accurately.
II. LINE GRAPH

A. WHAT IS A LINE GRAPH?
A line graph is another way to visually display data for purposes of comparison. Specific items are entered by number and the data points are connected by a line.

![Delays in Production Graph]

B. WHY IS IT USEFUL?
A line graph sketches an outline of the data pattern and is easy to construct.

The analysis of the shape of a line graph will provide information on areas needing further investigation.

C. HOW IS IT DONE?
1. The center of each class interval is labeled on the horizontal axis.
2. A trend line displays some variable over a period of time. Here, the display is not of frequencies of occurrence, but of variable values (vertical axis) over time (horizontal axis).
When using line graphs in the QI Story, follow these rules.

a. If using several lines, the solid black line is of greatest emphasis. It should be your own department or actual data. Dotted lines are used for projections only.

b. If the line graph tracks over time, ensure that the most recent data is shown.

c. If the degree of conformance is above 80%, then track the degree of non-conformance.

III. BAR CHART

A. WHAT IS A BAR CHART?

A bar chart is a graphic representation which compares quantities by means of rectangles (bars) of uniform widths but of length proportional to the number being represented.

Production Output

B. WHY IS IT USEFUL?

A bar chart is useful for purposes of comparing collected data in a visual representation.
C. HOW IS IT DONE?

On the horizontal (X) axis show the items or things being compared through vertical bars of uniform width. On the vertical (Y) axis, show the quantities (frequencies of events in different locations, costs of different types of breakdowns, etc.) through the height of the bars. For a horizontal bar chart, reverse the content of the axes.

COMPARISON OF THE ADVANTAGES OF THE PIE, LINE AND BAR CHART

<table>
<thead>
<tr>
<th>Pie Chart</th>
<th>Line Graph</th>
<th>Bar Chart</th>
</tr>
</thead>
<tbody>
<tr>
<td>This chart is useful for more than one level of stratification; all on one graph, equivalent to several bar charts. This chart shows the relative proportion of each category to the whole.</td>
<td>Lines make trends and data variations over time easy to track. Line graphs are an excellent tool for highlighting change and can be used to track more than one set of data at a time.</td>
<td>Bars make it easier to recognize small differences in quantities or frequencies and to compare one category with another.</td>
</tr>
</tbody>
</table>
A. WHAT IS A HISTOGRAM?

1. A histogram (also called frequency distribution) is a visual representation of the spread or distribution of data (for example, the height in inches of thirty-six employees). Information in a histogram is represented by a series of rectangles or "bars" which are proportional in height to the frequency (Y axis) of the data groups or class sizes (X axis).

2. Since the class sizes or data groups are equal in size (but not in number), the rectangles are of equal width. Therefore, the heights of these "bars" indicate the relative number of data points in each class.

3. As discussed, the frequency is plotted on the Y axis and the data groups, or classes, are plotted on the X axis. In analyzing a histogram, we need to calculate the central tendency of the data.
4. There are three measures of central tendency:

- **Mean (Average)** – the sum of all the measured or counted data divided by the total number of data points; for example, all the data points added together equal 2,464 divided by 36 = 68.44 inches.

- **Mode** – the value repeated most often in the raw data or, in the case of this histogram, the most common class interval; for example, there are 9 people between 68.5-71.5 inches.

- **Median** – the middle of all the measured or counted data points; for example, in our data of 36 measurements, the median value is the average of the two middle values since there is not a single middle value (69 + 70 = 139 divided by 2 = 69.5 inches)

B. **WHY IS IT USEFUL?**

1. It's not always easy to review a page of measured data and be able to recognize patterns or analyze what the data is trying to tell us. A histogram can provide information on the degree of variation of the data as well as indicate what distribution pattern we are working with. Drawing a curve around the heights of the bars of a histogram gives you the the general shape. This curve is called a distribution.

2. Distribution of the data can produce a wide variety of histogram shapes depending upon the process or subject that you have collected data on. Some of the more common types of distributions are shown on the next page.
a. **Normal Distribution (Example A)**

This is the most commonly occurring histogram that we will work with. Most values fall towards the center of the distribution (central tendency) with the variation balanced on both sides of the center (hence, giving a “bell-shaped” curve). As we begin learning about applying other QC tools, such as control charts, we will focus on using NORMAL distributions.

b. **Exponential Distribution (Example B)**

Most of the values appear on the extreme left. This could occur in areas where there is a natural barrier or in cases where the data has been sorted (i.e., products which do not meet a particular specification limit are removed from the data set).

c. **Skewed Distribution (Example C)**

A skewed distribution appears nearly like a normal curve, but the variation is more on one side than the other indicating a shift of some variable during the process.

d. **Bi-Modal Distribution (Example D)**

In a bi-modal (or twin-peaked) distribution there appears to be two peaks. This usually occurs when two different data groups are mixed; e.g. a population of very short people is added to a population of extremely tall people. In effect, we have two histograms pushed together.

Determining whether the data set has a NORMAL distribution will be particularly important later if we wish to apply another QC tool, called Control Charts (refer to Unit 2, page 34). If the distribution is not NORMAL, then further analysis will be required. For additional information on histograms consult one of your SPC Specialists.
C. HOW IS IT DONE?

<table>
<thead>
<tr>
<th>STEP</th>
<th>EQUATION</th>
<th>EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start with an unorganized set of at least 30 data points.</td>
<td></td>
<td>64, 63, 66, 73, 60, 67, 68, 70, 65, 61, 66, 76, 69, 71, 73, 62, 70, 65, 72, 63, 74, 70, 66, 68, 72, 75, 76, 69, 70, 72, 70, 76, 76, 76, 65, 69</td>
</tr>
<tr>
<td>Arrange the numbers in ascending or descending order.</td>
<td></td>
<td>60, 61, 62, 63, 63, 64, 65, 65, 65, 66, 66, 66, 67, 68, 68, 69, 69, 69, 70, 70, 70, 70, 71, 72, 72, 72, 73, 73, 73, 73, 74, 75, 76, 76, 76</td>
</tr>
<tr>
<td>Each number is a data point. Count the number of data points.</td>
<td>N</td>
<td>N = 36</td>
</tr>
<tr>
<td>The range (R) of the set is the smallest (minimum) data point</td>
<td>R = MAX - MIN</td>
<td>R = 76 - 60 = 16</td>
</tr>
<tr>
<td>subtracted from the largest (maximum) data point.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The class (K) is used to calculate the number of bars. Class equals</td>
<td>K = \sqrt{N}</td>
<td>K = \sqrt{36} = 6</td>
</tr>
<tr>
<td>the square root of N. Rule of thumb 6-12.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The class width (H) is used to calculate the width of the bars.</td>
<td>H = R/K</td>
<td>H = 16/6 = 2.6</td>
</tr>
<tr>
<td>It is calculated by dividing the range by the class.</td>
<td></td>
<td>(Round-up H) = 3</td>
</tr>
<tr>
<td>To begin constructing the histogram, establish the starting point</td>
<td>Measurement</td>
<td>60 - 1/2 = 59.5</td>
</tr>
<tr>
<td>for the first class. This is calculated by subtracting from the</td>
<td>Unit (M)</td>
<td></td>
</tr>
<tr>
<td>minimum data point, the measurement unit divided by 2.</td>
<td>M = 1</td>
<td></td>
</tr>
<tr>
<td>Min. - M/2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Histogram

#### TOOLS/TECHNIQUES

<table>
<thead>
<tr>
<th>STEP</th>
<th>EQUATION</th>
<th>EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Now that the first class limit is established, construct a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>frequency table.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>For Column 1 add to your</td>
<td>$59.5 + H$</td>
<td>$59.5 + 3$</td>
</tr>
<tr>
<td>starting point the class width (H).</td>
<td></td>
<td>CLASS WIDTH is</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$59.5 - 62.5$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$62.5 - 65.5$, etc.</td>
</tr>
</tbody>
</table>

| For Column 2, calculate your                                       | $59.5 + 62.5$ | MIDPOINT OF CLASS |
| midpoint.                                                           | $2$       | $61$     |

| For Column 3, go back to your set of data points.                  |          |         |
| Tally those that fall within each class limit. Add each item        |          |         |
| in Column 3 and enter the                                          |          |         |
| total frequency in Column 4.                                        |          |         |

<table>
<thead>
<tr>
<th>CLASS LIMITS</th>
<th>MIDPOINT OF CLASS</th>
<th>Tally</th>
<th>Freq.</th>
</tr>
</thead>
<tbody>
<tr>
<td>59.5 - 62.5</td>
<td>61</td>
<td>IIII</td>
<td>3</td>
</tr>
<tr>
<td>62.5 - 65.5</td>
<td>64</td>
<td>IIII</td>
<td>6</td>
</tr>
<tr>
<td>65.5 - 68.5</td>
<td>67</td>
<td>IIII</td>
<td>6</td>
</tr>
<tr>
<td>68.5 - 71.5</td>
<td>70</td>
<td>IIIII</td>
<td>9</td>
</tr>
<tr>
<td>71.5 - 74.5</td>
<td>73</td>
<td>IIIII</td>
<td>8</td>
</tr>
<tr>
<td>74.5 - 77.5</td>
<td>76</td>
<td>IIIII</td>
<td>4</td>
</tr>
</tbody>
</table>

To construct a graph, draw horizontal and vertical axes. The horizontal (X axis) shows class intervals, the vertical (Y axis) shows frequencies. Draw a bar to represent the frequency of data in each class. The bars should be touching.

**D. WHEN IS IT USED?**

A histogram is especially useful in the Current Situation step of the QI Story when we want to get an accurate picture of the dispersion or spread of the data.
EXERCISE

PURPOSE

To construct two graphs, one of which must be a histogram.

AGENDA

Individually

1. Fill out personal data form for you and spouse (if applicable):

<table>
<thead>
<tr>
<th>Personal Data Form</th>
<th>You</th>
<th>Spouse</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data Description</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Height</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Round it off to nearest inch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Weight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Round it off to nearest pound</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Today, in years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Normal commuting distance to work</td>
<td></td>
<td></td>
</tr>
<tr>
<td>One way, to nearest mile</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Your sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(M/F)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Golfer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(at least 27 holes/year)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Y/N)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Smoker</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(at least 14/week)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Y/N)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Tennis Player</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(at least 3 sets/year)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Y/N)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Choose which questions provide us with attribute data and which provide us with variables data.

LIMIT

5 minutes to complete individually.
Exercise: Histograms
TOOLS/TECHNIQUES

3. In teams, 30 minutes will be provided to construct two graphs based on the personal data forms. One will be a histogram and the other can be either a bar, line or pie graph.

Team 1 should use personal data items 1 and 5.
Team 2 should use personal data items 2 and 6.
Team 3 should use personal data items 3 and 7.
Team 4 should use personal data items 4 and 8.
A. WHAT IS A PARETO CHART?

1. Pareto analysis is a way of organizing data to show what major factor(s) make up the subject being analyzed. It is a search for significance.

2. A Pareto Chart is a type of chart in which the bars are arranged in descending order from the left.

3. The basis for Pareto analysis is the “80-20” rule; 80% of the problems result from 20% of the causes.

Pareto Chart of Injuries - 1988

B. WHY IS IT USEFUL?

Arranging data on a Pareto chart helps to highlight “the vital few” in contrast to “the trivial many.” Selecting categories, tabulating data, ordering data and constructing the Pareto chart can enhance communication among team members and with management.
C. HOW IS IT DONE?

1. Identify what data is to be analyzed, such as defects.

2. Select the categories to be used (defects by shift, location, type) and sort your data into the categories. For instance, how many defects related to shift, location and type.

3. If possible, further stratify the data; for instance, "shift" may be broken down into "day," "night" and "graveyard."

4. Make a graph with the bars ordered in decreasing frequency from the left.

Verify:
   a. Bars touching.
   b. Left axis for actual data.
   c. Right axis for % of total.
   d. Cumulative line from zero.
   e. Second stage Pareto, as applicable.
   f. Before/After Pareto in Results Step.

5. Check your graph for the Pareto pattern; a "flat" Pareto — categories with similar percentages — indicates the need for different stratification of the data.
6. Be careful not to mix *dissimilar categories of problems* on Pareto charts. To illustrate this danger, look at the Pareto chart on the right. Consider the three categories.

These are three types of categories.

a. **Defects is a zero-base problem**: the ideal situation is to reduce it to zero (no defects).

b. **Sales is an increase problem**: we want to know how to increase sales, not reduce them to zero. We should project how much of a product is possible and then try to increase to that amount.

c. **Inventory is a reduction problem**: We cannot do without inventory, but we would like to reduce the unnecessary portion of it. Category A should be subdivided into necessary and unnecessary inventory. Unnecessary inventory is a zero-base problem. It can then be compared to Category B.

d. Here are further examples of the three types of problems:

```plaintext
<table>
<thead>
<tr>
<th>PROBLEMS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ZERO PROBLEM</strong></td>
<td>ideally zero</td>
</tr>
<tr>
<td></td>
<td>(examples: defects, trouble calls, errors, etc.)</td>
</tr>
<tr>
<td><strong>REDUCTION PROBLEM</strong></td>
<td>not zero, even ideally</td>
</tr>
<tr>
<td></td>
<td>(example: inventory, staffing, costs)</td>
</tr>
<tr>
<td><strong>INCREASE PROBLEM</strong></td>
<td>not zero, even ideally</td>
</tr>
<tr>
<td></td>
<td>(example: service reliability, KWH usage, sale of other products)</td>
</tr>
</tbody>
</table>
```

D. **WHEN IS IT USED?**

Pareto analysis can be used to identify major factors in a subject being analyzed, and help prioritize and select countermeasures. It is a useful way of identifying problems in the Current Situation step. It can also be of use in the Analysis and the Results steps.
A manufacturing company has been experiencing a problem with equipment failure. The company's Lead Team decided to do an analysis of the causes of these failures. Five causes were noted as occurring at least once.

A form was constructed to record the cause of each failure by plant and by day. The five causes were as follows (with corresponding symbols to be used on the form for an occurrence):

- **X** - Incorrect mounting of connector hose
- **O** - Premature “break point” for circuit breaker
- **C** - Incorrect dial setting
- **#** - Frayed wiring
- **★** - Defective component

The results of recording the cause of each failure over a period of time gave the following:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0 0 X</td>
<td>C o 0 #</td>
<td>0 0 X</td>
<td>0 0 #</td>
<td>0 0 #</td>
<td>0 0 #</td>
</tr>
<tr>
<td></td>
<td>C O</td>
<td>C O</td>
<td>C #</td>
<td>O #</td>
<td>O #</td>
<td>O #</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>O #</td>
<td>O #</td>
</tr>
<tr>
<td>B</td>
<td>0 0 #</td>
<td>0 0 #</td>
<td>0 0 #</td>
<td>0 0 #</td>
<td>0 0 #</td>
<td>0 0 #</td>
</tr>
<tr>
<td></td>
<td>C o</td>
<td>C o</td>
<td>C o</td>
<td>C o</td>
<td>C o</td>
<td>C o</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>0 0 #</td>
<td>0 0 #</td>
<td>0 0 #</td>
<td>0 0 #</td>
<td>0 0 #</td>
<td>0 0 #</td>
</tr>
<tr>
<td></td>
<td>C O</td>
<td>C O</td>
<td>C O</td>
<td>C O</td>
<td>C O</td>
<td>C O</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Pareto Analysis
TOOLS/TECHNIQUES

EXERCISE

PURPOSE
To construct a Pareto Chart.

AGENDA

- Team 1 will construct a Pareto Chart for the 5 causes of equipment failure.
- Team 2 will construct a Pareto Chart for the six different days of equipment failure (without regard to cause).
- Team 3 will construct a Pareto Chart for the three different plants in which equipment failure occurs (without regard to cause).
- All teams will answer: What do you suggest for further investigation?

LIMIT
15 minutes to construct the Pareto Chart.
3 minutes for each team spokesperson.
Step 2: Problem Statements

TOOLS/TECHNIQUES

OVERVIEW

At this point the team has selected a theme to work on, has gathered data and is in the process of analyzing it to better understand the Current Situation. Stratification of the gathered data should result in the team's problem statement. A good problem statement summarizes the team's findings with clarity and objectivity.

A good problem statement describes in specific, concrete terms what the data has revealed. It describes the present undesirable situation while avoiding "hidden" solutions.

A. Criteria for a good problem statement include:

- **It states the effect.** It states "what" is wrong, not why it is wrong. Avoid "lack of" statements. These always imply solutions.

- **It focuses on the gap between what is and what should be.** The gap may be a change or deviation from the norm, standard or the customer's expectation.

- **It is measurable.** It says how often, how much, when.

- **It is specific.** It avoids broad and ambiguous categories like "morale," "productivity," "communication," and "training."

- **It is stated in a positive manner.** Do not state problems as questions. This may tend to imply that the answer to the question is the solution.

- **It focuses on the pain.** The problem statement highlights "how" people are affected, the areas of discomfort, hurt or annoyance.

Encouraging teams to work at writing problem statements will sometimes be difficult since the problems often seem "obvious" to them. It is necessary to summarize steps 1 and 2 of the QI Story.
B. Samples of Problem Statements

1. Simple, basic statements that an individual might use:

   - My program won't run. (Who, What)
   - My car won't start. (Who, What)
   - My checkbook didn't balance two of the last three months. (Who, What)

2. Examples of Who, What, When and Where Statements teams might use:

   - This customer has been billed incorrectly for 3 months.
   - There is an average of 3 typing errors per page on the Quarterly Report.
   - The 2A air compressor overheats when it runs for 2 hours.
   - Accounts Payable missed its deadline 30% of the time in the 1st half of '88.
   - In August, the Time-Sharing system was down 16 hours more than the monthly average of 26 hours.
   - Data Entry overtime cost is 20% over budget.
   - The Computer Center missed its customer bill schedule 9 times in May.
   - #3 Electronic Inserter is not selecting any blue return envelopes.

3. All of these statements are the EFFECT of some problem, focus on the gap between What-is-happening and What-should-be-happening, have no implied solutions, focus on “the pain,” and are measurable.

4. They do not include any “Why’s,” “Lack of,” “Due to” elements. However, some might be more specific.

5. After this the team can begin analyzing “What could CAUSE this?”
C. The Problem Statement Matrix

Here is an example of a matrix that can be used to evaluate problem statements. It should be used after the team has developed its problem statement.

<table>
<thead>
<tr>
<th>Problem Statement (Who, What, When, Where-But NOT Why.)</th>
<th>(A) States the Effect NOT the cause.</th>
<th>(B) Focuses on the Gap between &quot;what is&quot; and &quot;what should be.&quot;</th>
<th>(C) It is measurable.</th>
<th>(D) It is specific. Avoids broad categories.</th>
<th>(E) It is stated in a positive manner. Avoids questions.</th>
<th>(F) It focuses on the pain. HOW things are affected.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Problem statements do not need to meet all six categories. But, obviously, the more categories each potential problem statement meets, the clearer it is likely to be.
Problem Statements
TOOLS/TECHNIQUES

EXERCISE

PURPOSE

To develop an understanding that effective problem statements are most easily derived if the team has sufficient and accurate data.

AGENDA

- Each team is assigned a problem situation (A,B,C,D). Using the Reason for Improvement and Current Situation information, each team forms a statement.
- The statements are then rotated to another team, who critiques the problem statement using the Problem Statement Matrix, and may improve it. The restatement is added to the worksheet (if applicable).
- Finally, the original team ends up with its worksheet and reviews the results. The Teams discuss what they learned and the implications of the exercise in their efforts to help QIP teams write problem statements. The teams select a presenter to report their findings to the entire group.

LIMIT

- 15 minutes to write the problem statement.
- 10 minutes for review and critique by the second team.
- 5 minutes for review and selection of a presenter by the original team. The presenters will provide a 2-minute summary based on the team's original problem statement.
Exercise: Problem Statements
TOOLS/TECHNIQUES

PROBLEM STATEMENT WORKSHEET A

REASON FOR IMPROVEMENT
During the past month in Blanca District Office, there have been at least two hundred lost calls.

CURRENT SITUATION
One hundred and seventy were calls to specific number holders when they were not in the office. Thirty calls were lost while being transferred from the general number to specific extensions. Twelve of the lost calls were to the manager directly. Blanca District Office averages 712 calls a day.

TEAMS A's PROBLEM STATEMENT:

TEAM B's PROBLEM STATEMENT:
Exercise: Problem Statements

TOOLS/TECHNIQUES

PROBLEM STATEMENT WORKSHEET B

REASON FOR IMPROVEMENT
During the course of the past two months, unauthorized people have been found somewhere on the grounds of the St. Regis Plant.

CURRENT SITUATION
Two were vagrants, two were school kids and two were tourists. In the course of a day, an average of 125 people (non-employees) are approved for entry to the plant.

TEAM A's PROBLEM STATEMENT:


TEAM B's PROBLEM STATEMENT:


Exercise: Problem Statements
TOOLS/TECHNIQUES

PROBLEM STATEMENT WORKSHEET C

REASON FOR IMPROVEMENT.
During the past quarter, the computer system has been down for 72 working hours. Delays in processing vendor payments have led to complaints.

CURRENT SITUATION
There are 1207 vendors waiting for payment. Forty-five have lodged written complaints. Fifteen have major contracts (over $500,000). Seven of the fifteen are single source vendors.*

TEAM C's PROBLEM STATEMENT:

---------------------------------------------------------------------

TEAM D's PROBLEM STATEMENT:

---------------------------------------------------------------------

* Single source vendor – This vendor is the only one producing this product.
REASON FOR IMPROVEMENT

The Accounting Department has six Quality Improvement teams. As of this date (April 1988), only one functional team (formed in October 1986) has completed its project and moved on to a new problem.

CURRENT SITUATION

There are four functional teams and two task teams. The four functional teams were formed between August 1986 and May 1987. The first task team (formed June 1987) is in Step 6, Standardization, and the second (formed in January 1988) is in Step 3, Analysis.

TEAM C'S PROBLEM STATEMENT:

_____________________________________________________________________

_____________________________________________________________________

_____________________________________________________________________

_____________________________________________________________________

TEAM D'S PROBLEM STATEMENT:

_____________________________________________________________________

_____________________________________________________________________

_____________________________________________________________________

_____________________________________________________________________
DISCUSSION QUESTIONS

1. Did the criteria help to state the problem in such a way that predetermined solutions were avoided?

2. Did the criteria help to state the problem in such a way that people were not to blame?

3. Did the criteria help to state the problem in such a way that everyone on the team understood the problem?

4. Which of the criteria were most useful in helping to refine your skills in writing problem statements?
A. **WHAT ARE TARGETS AND GOALS?**

A goal is a desired state or standard tracked through an indicator. A target is a milestone towards the accomplishment of that desired goal. Examples of indicators where you would set targets are:

- number of minutes per changeover (goal: reduced changeover time).
- number of days to process a payment (goal: timely processing).
- number of orders read per day (goal: increase number processed per day).

B. **WHEN ARE THEY USEFUL?**

Targets are set to give the team as well as others a milestone to measure the effectiveness of performance, to see if countermeasures are successful in addressing the problem and therefore moving the indicator closer to the target.

C. **HOW DO YOU SET THEM?**

Targets should be set to be challenging but achievable during a reasonable amount of time, normally not more than a year. They should be based on logic and not just pulled out of the air. An ultimate goal may be needed but interim targets can be set as milestones towards its accomplishment.

1. In setting targets, first consider the needs and reasonable expectations of the customer. This may also help to restructure an indicator.

   Example: Response time by the maintenance shops to priority work orders - customers would like immediate response. However, in most situations, if the shop is already fully assigned to other priority jobs, a response within 1 to 4 hours is acceptable.
If a customer's needs and reasonable expectations are not immediately achievable, they should be kept as an ultimate goal. Set an interim target which is challenging but achievable.

2. A second consideration is the performance of similar operations or competitors.

Example: A target may be set based on past performance, such as processing time for the same activity or product. Frequently, the target will be set to "average" or to consistently achieve the best earlier performance.

This target again should be compared to your present performance to see if it is achievable. If not, it may become a goal and interim targets set to ultimately achieve it.

3. Third, your own past performance can be used to set a target.

Example: If at one time your performance was significantly better, you may want to set that target and discover what has changed in the operation to make your performance worse.

4. Fourth, it is possible to set goals by analyzing processes to determine if waste is present.

Example: If a process is broken down into processing-assaying-storing-shipping, you could try analyzing the process.

D. **WHEN ARE THEY USEFUL?**

Once a performance indicator is identified, targets may be set, usually in the Reason for Improvement or the Current Situation step of the QI Story.
PROCESS FLOW CHARTS

A. WHAT ARE PROCESS FLOW CHARTS?
   - Flow charts are graphic representations of a process, which show us clearly just how the process proceeds.
   - They show a systematic sequence of steps to take in completing a job.

B. WHY ARE THEY USEFUL?
   - To document or describe an existing process.
   - To develop modifications to an existing process, or to investigate where problems might occur.
   - To design an entirely new process.
   - To identify how, when or where to measure an existing process to see if it complies with valid requirements.

C. WHAT DO THEY LOOK LIKE?

1. A “Macro” level flowchart:

   ![Diagram showing process flow chart]

   - Step 1
   - Step 2
   - Step 3

   (COMPANY)

<table>
<thead>
<tr>
<th>Step</th>
<th>Customer</th>
<th>Other Departments</th>
<th>Own Department</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td></td>
</tr>
</tbody>
</table>

   - Step 1
   - Step 2
   - Step 3
2. A "Micro" level flowchart:

**Going to the Movies**

- **Decide on type of movie you would like to see**
  - **Ask spouse for type of movie preferred**
    - **Do you agree?**
      - Yes
      - **Negotiate and try to reach consensus**
        - **Agreement possible?**
          - Yes
            - **Still on speaking terms with spouse**
          - No
            - **Stay at home**
      - No
        - **Is a preferred movie playing nearby?**
          - Yes
            - **GO TO THE MOVIES!**
          - No
            - **Look in the paper to see what's playing**
D. **HOW ARE THEY DONE?**

Think of a process flow chart as a map of steps to follow in order to complete a job.

There are symbols used to indicate certain activities.

- **CIRCLE**
  - Beginning and ending steps
  - (Inputs or Outputs from the Process)

- **BOX**
  - Steps, activities within the Process

- **DIAMOND**
  - Points where decisions are required

- **ARROW**
  - To show the direction of flow from one activity to the next one in sequence

The first row is used to separate the process into responsible areas.

The first column is used to designate general steps and their durations.

When you lay out your steps, remember to organize them so that each step falls under the correct area responsible.

E. **WHEN ARE THEY USED?**

Most Current Situations and Standardization steps require process flow charts; however, they can also be used in Reason for Improvement, Analysis and Countermeasures.
A. **WHAT ARE PROCEDURES AND STANDARDS?**

Procedures and Standards are techniques to be used to document the steps of a successful countermeasure.

B. **WHY ARE THEY USEFUL?**

They provide a systematic method for other work groups to implement the successful recommendations of Quality Improvement teams.

C. **HOW ARE THEY DONE?**

Two of the common methods are step by step written flow and/or a graphic flow chart of the process.

D. **WHEN ARE THEY USED?**

Procedures/Standards are used once the Results step of the QI Story is complete, and the team objectively concludes that the countermeasures have positively impacted the problem.
QI STORY
OBJECTIVE:
Identify and verify the root causes of the problem.

KEY ACTIVITIES:
- Perform cause and effect analysis on the problem.
- Continue analysis to the level of actionable root causes.
- Select the root causes with probable greatest impact.
- Verify the selected root causes with data.

HELPFUL TOOLS/TECHNIQUES:
- Cause & effect diagram
- Checksheet
- Pareto Diagram
- Histogram
- Graph
- Scatter diagram

CHECKPOINTS:
9. Cause & effect analysis was performed on the problem.
10. Root causes were taken to an actionable level.
11. Root causes with probable greatest impact were selected.
12. Data was used to verify the root causes.
Step 3: Analysis
TOOLS/TECHNIQUES

OVERVIEW

The objective of the third step of the QI Story is to show the team's identification and verification of the root causes of the problem.

The analysis stage is designed to help teams focus on root causes rather than symptoms of problems.

When complete, this section will contain many analytical tools, such as Pareto Chart, Cause and Effect Diagram (Fishbone, or Ishikawa), Scatter Diagram, Graphs and others which are arranged to logically demonstrate the selection of the root cause(s) of the problem.

It is vital to confirm the root cause(s) before proceeding to the Countermeasures step.

---

**Quality Improvement Story**

<table>
<thead>
<tr>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cause and Effect Analysis (Fishbone Diagram)</td>
</tr>
</tbody>
</table>

---

2
Step 3: Analysis

TOOLS/TECHNIQUES

The key activities of this step are to:

1. Perform cause and effect analysis on the problem.
2. Continue analysis to the level of actionable root causes.
3. Select the root causes with probable greatest impact.
4. Verify the root causes with data.*

The tools/techniques which may be utilized in this step include the Cause and Effect Diagram (Fishbone, or Ishikawa), Histogram, Graph(s), Pareto, Scatter Diagram and Checksheet.

* It is not enough to verify that the root causes exist where the problem occurs. You must also verify that the root cause does not exist where the problem doesn't exist.
A. WHAT IS CAUSE-AND-EFFECT ANALYSIS?

1. The main purpose of Cause-and-Effect Analysis is to help the team solve problems by the identification of a root cause so that corrective action can be taken.

2. A Cause-and-Effect Diagram is a picture composed of lines and words designed to represent a meaningful relationship between an effect and its causes. The specific tool that we will focus on is called the Fishbone or Ishikawa Diagram.

B. WHY IS IT USEFUL?

This tool helps teams reach a common understanding of problems and exposes gaps in existing knowledge.
C. HOW IS IT DONE?

1. The problem is the effect. This was identified in Step 2 through stratification. Other parts of the theme are no longer considered. Review at least one instance of the problem you will analyze in detail. Be sure you understand how it occurred and what the situation was when it occurred. This should help you identify the possible root causes based on the data you have gathered.

2. **Brainstorm** a list of other possible and specific causes.

3. Define the major categories of the job process. Significant steps in a Process Control System flowchart could also serve as potential categories. For small problems the categories of people, methods, materials and machine may be used.

4. Draw the diagram. Write the effect clearly and objectively in a box. Start at the right, building the major categories (bones) toward the left. Build the diagram by linking the brainstormed causes under appropriate categories. Lines should flow toward the "effect" and touch with arrowheads. Refine categories where necessary and continue asking:
   - What causes this?
   - Why does this condition exist?

Keep asking these questions and building the fishbone until the causes are specific enough to verify. A guide might be to "ask why five times." Be sure to work from the level of symptoms to cause.

5. Identify the likely root causes and circle (or cloud) the last element in the chain.

6. **Verify** the most likely root cause. This is done through additional data gathering.

7. If a potential cause seems to have many complicated subcauses, break it into a separate diagram.
8. Be sure to walk through the logic of your diagram in both directions. *(This a1 is caused by this a2, which is caused by this a3. Then, in reverse, a3 caused a2, which causes a1.)* Often illogic will not surface until the second direction is tried.

Little bones represent subcauses and should reflect a chain of logic leading from step to step; e.g. a3 causes a2 which causes a1 which causes A which causes the Effect. If subcause a3 is complex enough, it may in turn be broken out into a separate fishbone diagram.

---

D. WHEN IS IT USED?

After a problem is selected and carefully defined, construct a Fishbone Diagram so the team can systematically analyze cause and effect relationships and identify the most likely root cause of a problem.
Example #1:

Mike, who is a computer analyst, has been experiencing headaches on a regular basis both at work and at home. Mike would take aspirin on a regular basis to relieve the headaches; however, they continued to return. Mike’s wife suggested he go see a doctor about his headaches. Upon visiting the doctor, Mike discovered his eyesight was weak. The doctor prescribed some glasses for Mike and the headaches disappeared.

It's clear that Mike was treating the symptom (headache); thus his solution (aspirin) was not solving the problem. However, the real root cause (bad eyesight) was confirmed by the elimination of the headaches when he wore his glasses.

Example #2:

A power plant alarm system had been experiencing a high number (average 125 per day) of false alarms. A task team was formed to find out why the problem was occurring and to correct it. The allowed number of false alarms through the Infrared beam system that circles the plant is 25.

The team interviewed security personnel. These interviews led the team to believe that most of the alarms were due to raccoons. At this point the team decided to do some data gathering on raccoons. They designed a checksheet and counted the types of animals that were entering the plant and how often. They found that 76% of the time, it was a raccoon that was setting off the alarm. Aha, the team thought, we have the root cause.

![Graph showing frequency and types of animals that triggered alarms]
The team decided to set raccoon traps and soon caught well over 120 raccoons. The false alarms quickly fell below 30 per day. Two weeks later though, the false alarms were again well over 100 per day.

As in example #1, the team was treating a symptom, when what they should have done is ask, “What is causing the raccoons to enter the power plant?” When they finally did this, as seen in the fishbone diagram below, they discovered a small garbage dump that was enticing the wily bandits to enter the plant. When the root cause (garbage dump) was eliminated, the false alarms went well below 30 and stayed there.

In some instances, a symptom may be apparent until trial implementation, when the problem is not eliminated or reduced, or when the problem recurs after a few weeks or months. Building the fishbone by continuing the analysis to the level of “asking why 5 times” will help to identify the most likely root cause(s).
EXERCISE

PURPOSE
To construct a Fishbone (Ishikawa) Diagram.

AGENDA
Break out in teams to construct the diagram. Use the first problem statement your team wrote in the previous exercise (page 17), or one provided by the instructor.

After you have brainstormed possible causes, decide on the categories you will use and build the cause and effect diagram. Finally circle three most likely causes for further investigation.

Two of the teams will present to the whole group.

LIMIT
20 minutes
A. WHAT IS A SCATTER DIAGRAM?

A scatter diagram is a tool for showing the relationship between two variables (for example, speed and gas consumption, or hours worked and production output).

![Example 1](image)

**Positive (Direct) Correlation:**
When X increases, Y increases.

**Date:**
**By:**

B. WHY IS IT USEFUL?

It shows clearly if there is a relationship, or correlation, between the two variables:

1. Positive correlation - as X increases, so does Y.
2. Negative correlation - as X increases, Y decreases.
3. No correlation - one quantity has no particular relation to the other.
C. HOW IS IT DONE?

1. Collect at least 30 sets of paired data.

2. Find the lowest and highest values for X and Y. Determine the scales of the axes so that they are more or less equal in length, but try to have no more than 10 gradations. (Rule of thumb is between 3 and 10 gradations.)

3. Arrange the axes so that the suspected driving factor (cause or one which influences the other) is on the X axis and the one influenced by it (the effect or quality characteristic) is on the Y axis. In example 1, the relationship between smoking and cancer, smoking would go on the X axis and cancer on the Y axis, since smoking causes the effect of cancer.
In example 2, the incidence of bad air is decreased as the amount of air filters increases. Air filters cause a reduction of the amount of bad air, so they go on the X axis.

Example 3 illustrates how the no. of marriages (X axis) may cause change in % of divorces (Y axis). The diagram shows no correlation.

4. Plot the data on the chart point by point; be sure to make the chart complete with titles, dates, places, etc.

5. A correlation analysis of the data can be made. The correlation measure or coefficient is called “r,” and “r” can have values from -1.0 to 1.0. The closer “r” is to 1.0, the stronger the positive correlation. The formula and guidance to calculate this correlation can be obtained from the statistical process control specialist.

D. WHEN IS IT USED?

The scatter diagram is probably most useful in the Analysis Step for further examination of the elements isolated in the fishbone diagram; it may well verify a cause identified through cause and effect analysis. Care needs to be taken in plotting a scatter diagram to assure a valid relationship is showing.
EXERCISE

PURPOSE

To construct a scatter diagram and recognize the type of relationship.

AGENDA

Break out in teams to construct the diagrams. Use the data sheet assigned to your team. Discuss results and possible intervening variables which could affect the positive or negative casual relationship.

LIMIT

15 minutes.

TITLE

\[ N = \quad \]

Date: 
By: 

scatter diagrams
Tools/techniques
QI STORY
The fourth step of the QI Story is intended to show the countermeasures (proposed solutions) selected by the team that will correct the identified root cause(s) of the problem. You will recall that the Analysis step helped identify and verify these root causes.

The key activities of this step are to:

1. Develop and evaluate potential countermeasures that:
   - Attack verified root causes
   - Meet the customer's valid requirements
   - Prove to be cost beneficial
Step 4: Countermeasures

QI STORY

2. Develop an action plan that answers who, what, when, where and how, and that also reflects the barriers and aids necessary for success.

3. Obtain cooperation and approvals.

4. Implement countermeasures.

The tools/techniques which may be utilized in this step include the Action Plan, Barriers and Aids Analysis, Cost Estimation.
4 COUNTERMEASURES

OBJECTIVE:
Plan and implement countermeasures that will correct the root causes of the problem.

KEY ACTIVITIES:
- Develop & evaluate potential countermeasures that:
  - Attack verified root causes
  - Meet customers valid requirements
  - Prove to be cost beneficial
- Develop an action plan that:
  - Answers who, what, when, where & how
  - Reflects the barriers and aids needed for success
- Obtain cooperation and approvals.
- Implement countermeasures.

HELPFUL TOOLS/TECHNIQUES:
- Cost benefit analysis
- Countermeasures matrix
- Barriers and aids
- Action plan

CHECKPOINTS:
13. Selected countermeasures attacked verified root causes.
14. Countermeasures were consistent with meeting customer valid requirements.
15. Countermeasures were cost beneficial.
17. Action plan reflected the barriers & aids necessary for successful implementation.
A. WHAT IS THE COUNTERMEASURES MATRIX?

It is a matrix of factors to help the team to show the relationship between effect, root causes, and countermeasures. It also helps the team to evaluate which countermeasures should be implemented.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Root Cause</th>
<th>Countermeasures</th>
<th>Practical Methods</th>
<th>Effectiveness</th>
<th>Feasibility</th>
<th>Overall</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>This is the problem that needs correction.</td>
<td>These are identified on your cause and effect diagram and have been verified.</td>
<td>These are specifically aimed at the root causes and are within the team's ability to implement.</td>
<td>A specific task needed to accomplish the countermeasure.</td>
<td>A countermeasure is the what. The practical method is the how.</td>
<td>A rating based on how much the countermeasure will reduce the root cause. The higher rating goes to the more effective countermeasure.</td>
<td>A rating based on the time, cost, work, acceptance, etc. needed to implement the countermeasure. The higher rating goes to the more feasible countermeasure.</td>
<td>The product of Effectiveness X Feasibility. This should serve as a ranking of the countermeasures for action.</td>
</tr>
<tr>
<td>SCALE:</td>
<td>1 None</td>
<td>2 Somewhat</td>
<td>3 Moderate</td>
<td>4 Very</td>
<td>5 Extreme</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B. WHY IS IT USEFUL?

We use it to ensure that the countermeasures address the significant root causes.
OVERVIEW: CHOOSING COUNTERMEASURES (SOLUTIONS)

- Sometimes those who have been involved in Quality Improvement talk as though the solution “falls out automatically” at the end of the process. And there are occasions on which only one solution is possible (build or not build, buy or not buy). But these are rare.

- Ordinarily as much care should be taken in choosing a solution, or countermeasure, as at any other stage of the process. The team should work from its data base, should research options, should be as creative as the issue will allow, and certainly should be as diligent in the pursuit of not just an adequate answer but the “right” answer.

- Some possible solutions, or countermeasures, will be obvious, but brainstorming, interviewing, and management suggestion are all good sources. Once the most likely have been chosen, they should be investigated. What will they involve, how many people, manhours, money, time, etc?

- A principle tool at this stage is the Countermeasures Matrix. After the team has selected the appropriate countermeasures, it will develop an Action Plan to implement these countermeasures. The term “countermeasure” is appropriate because, at this point, we are not sure that the action to be taken is really a solution. Only after the results are obtained and tracked over time, can we be sure of a “solution.”
The Countermeasures Matrix is similar to the Theme Selection Matrix discussed in Unit 1. This Matrix guides the team in verifying root cause(s), identifying alternative countermeasures, and determining the effectiveness and feasibility* of their countermeasures. Other prioritization matrices may be used to evaluate countermeasures, but the example is one which can be easily used by most teams.

C. **HOW IS IT DONE?**

1. After verifying the significant root causes, the first two columns of the matrix may be filled in.

2. Next, the team identifies alternative countermeasures which address each of the root causes.

3. In the “practical methods” box, a specific task(s) is listed to accomplish the countermeasure.

4. The team then rates each of the countermeasures numerically by effectiveness and feasibility. The higher ratings go to those countermeasures which are more effective and more feasible.

5. The ratings are then multiplied and the countermeasures ranked for implementation according to their overall rating.

6. To determine how many of the countermeasures should be implemented, the team will need to consider its resources and its target for improvement. Sufficient countermeasures need to be implemented to achieve the target.

7. The team will indicate if the countermeasure will be implemented by writing either “yes” or “no” in the action column.

D. **WHEN IS IT USED?**

The Countermeasures Matrix is used after the team has identified those countermeasures which address the significant root cause(s).

---

* Effectiveness and Feasibility may be broken down into several components, if the team feels this is necessary. Feasibility may be broken down to cost and time.
A. **WHAT IS COST ESTIMATION?**

1. Cost Estimation is a technique for determining the dollar impact of problems and countermeasures.

2. There are two approaches to estimating costs: The "Bottom-Up Approach" and the "Top-Down Approach."

3. It is not necessary to have precise and detailed accounting data in order to get a general idea of the financial impact of a problem or issue; you need to make some assumptions and verify them as you gather data.

B. **WHY IS IT USEFUL?**

So teams can determine the dollar impact of problems and countermeasures.

C. **HOW IS IT DONE?**

**Bottom-Up Approach** - Start with smaller units and build the estimate toward an overall amount.

1. Estimate how many times the problem occurs per unit of time. (Example: 12 uniforms/week)

2. Estimate cost per occurrence. (Example: $3/cleaning)

3. Estimate total time involved. (Example: 52 weeks)

4. Calculate total/annual cost by multiplying above factors. (Example: 12 x $3 x 52 = $1872)
Cost/Benefit Analysis Worksheet

TOOLS/TECHNIQUES

Top-Down Approach - Start with the overall cost of some budget item or other known variable and an estimate of the percentage of that total which represents the problem and calculate unit cost.

1. Estimate the percent of some expenditure on the problem area (e.g., percent of total labor devoted to problem, percent of total "down-time" attributed to the problem).

2. Multiply the percentage by the budgeted annual cost to get the estimated amount spent on the problem in one year. (Example: 10% x $185,000/year budgeted = $18,500/year.)

3. Divide by unit of time. (Example: $18,500/year ÷ 52 weeks/year = approx. $355/week.)

D. WHEN IS IT USED?

1. Cost estimation may aid in prioritizing and selecting counter-measures. Data gathered using cost estimation can be used to construct a Pareto Chart.

2. Cost estimation is used as the raw data in many decision-making processes.

E. WHO TO CONTACT FOR HELP?

Your local supervision or financial analyst should be contacted for general cost factors (such as the cost of supplies) and also to help interpret the cost information.
Barriers and Aids
TOOLS/TECHNIQUES

A. WHAT IS BARRIERS AND AIDS ANALYSIS?

1. *Barriers and Aids* is a technique for pinpointing and analyzing elements which resist change (barriers) or push for change (aids).

2. This technique helps a team to meet its objectives by planning to overcome barriers and to make the maximum use of available aids.

3. Consider the following categories when doing the Barriers and Aid Analysis:
   - People
   - Environment
   - Hardware or Equipment
   - Dollars

<table>
<thead>
<tr>
<th>COUNTERMEASURE</th>
<th>→ BARRIERS →</th>
<th>← AIDS ←</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B. WHY IS IT USEFUL?

Barriers and Aids helps teams to carefully analyze a situation when they are planning for change. Once barriers and aids are identified, the teams can make plans to use the available aids and/or to overcome the barriers which can prevent implementation of a solution.
C. HOW IS IT DONE?

1. Identify the countermeasure, task, change or concern.
2. Identify (through brainstorming) possible barriers; put them in a list.
3. Identify likely aids (again list them).
4. Rank all listed items as high, medium, or low.
5. Match aids which balance or overcome barriers.
   (Note: it is not necessary to come up with an aid for every barrier.)
8. Identify items needing team action using your rankings (High, Medium, Low).
9. Develop an action plan.

D. WHEN IS IT USED?

After a team has identified the most appropriate countermeasures, it can use Barriers and Aids analysis to assist in planning the trial implementation. The Barriers and Aids Analysis should be a part of the team's Action Plan.
A. WHAT IS AN ACTION PLAN?

1. The team's Action Plan is a technique that catalogues all the things that must be done to ensure a smooth and objective trial of the solution or improvement.

2. Although the Action Plan may have different formats, it should answer:
   - Who
   - What
   - When
   - Where
   - How

   and consider the Barriers and Aids necessary for success.

   An example is shown below:

<table>
<thead>
<tr>
<th>No.</th>
<th>Task/Project</th>
<th>Priority/ Due Date</th>
<th>Assigned To</th>
<th>Date Assigned</th>
<th>Status/Remarks</th>
</tr>
</thead>
</table>

   

   TASK ASSIGNMENT RECORD
   (Review Daily; File for Future Reference)

   Prepared By ___________ Date ___________ Page ___________ of ___________

   Loc'n/Proj. ___________ Period ___________
B. **WHY IS IT USEFUL?**

It allows us to explain our ideas to management and peers, and it ensures an organized, objective implementation of the selected countermeasures.

C. **HOW IS IT DONE?**

- The proposed improvement or solution is analyzed by the team and then broken down into steps.
- The hardware and numbers of people involved at each step should be considered.
- Brainstorm, if necessary, for other items of possible significance.
- Add to the list until the team feels it is complete.

D. **WHEN IS IT USED?**

We develop an Action Plan as part of the Countermeasures step. The plan will be one of the items that helps the team obtain cooperation and approvals, and effectively implement its countermeasures.
**DATA SHEET #1**

The trouble department was investigating the increase in trouble calls.

It seemed to the dispatcher that calls got heavier as the day went on.

A QIP team collected data.

Prepare a scatter diagram and discuss the relationship.

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>No. of Calls</th>
<th>Time of Day</th>
<th>No. of Calls</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 P.M.</td>
<td>14</td>
<td>6 P.M.</td>
<td>18</td>
</tr>
<tr>
<td>1 P.M.</td>
<td>11</td>
<td>5 P.M.</td>
<td>20</td>
</tr>
<tr>
<td>10 P.M.</td>
<td>5</td>
<td>10 A.M.</td>
<td>3</td>
</tr>
<tr>
<td>NOON</td>
<td>9</td>
<td>11 A.M.</td>
<td>6</td>
</tr>
<tr>
<td>3 P.M.</td>
<td>6</td>
<td>NOON</td>
<td>6</td>
</tr>
<tr>
<td>6 P.M.</td>
<td>19</td>
<td>2 P.M.</td>
<td>9</td>
</tr>
<tr>
<td>5 P.M.</td>
<td>17</td>
<td>3 P.M.</td>
<td>12</td>
</tr>
<tr>
<td>1 P.M.</td>
<td>6</td>
<td>3 P.M.</td>
<td>13</td>
</tr>
<tr>
<td>9 A.M.</td>
<td>4</td>
<td>5 P.M.</td>
<td>13</td>
</tr>
<tr>
<td>2 P.M.</td>
<td>10</td>
<td>5 P.M.</td>
<td>16</td>
</tr>
</tbody>
</table>
DATA SHEET #2

An "Eastern City" was having an air pollution problem.

The solution was to add additional systems to eliminate air contamination.

The team tracked the level of air pollution as they added the systems.

Below are the pollution levels with regards to the number of additional systems on line.

Prepare a scatter diagram with this data.

<table>
<thead>
<tr>
<th>No. of Systems</th>
<th>Air Sample</th>
<th>No. of Systems</th>
<th>Air Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.98</td>
<td>7</td>
<td>.39</td>
</tr>
<tr>
<td>6</td>
<td>.45</td>
<td>3</td>
<td>.71</td>
</tr>
<tr>
<td>2</td>
<td>.87</td>
<td>2</td>
<td>.79</td>
</tr>
<tr>
<td>4</td>
<td>.42</td>
<td>8</td>
<td>.41</td>
</tr>
<tr>
<td>10</td>
<td>.35</td>
<td>7</td>
<td>.65</td>
</tr>
<tr>
<td>9</td>
<td>.17</td>
<td>6</td>
<td>.61</td>
</tr>
<tr>
<td>8</td>
<td>.29</td>
<td>5</td>
<td>.85</td>
</tr>
<tr>
<td>1</td>
<td>.86</td>
<td>3</td>
<td>.82</td>
</tr>
<tr>
<td>5</td>
<td>.70</td>
<td>2</td>
<td>1.10</td>
</tr>
<tr>
<td>9</td>
<td>.42</td>
<td>1</td>
<td>.77</td>
</tr>
</tbody>
</table>
DATA SHEET #3

A utility company was experiencing an outage problem.

The department manager was sure that the increased outages were a result of the warmer weather.

A QIP team was given this as a task to resolve.

Their first step was to collect data and determine if there was a relationship between temperature and outages.

Prepare a scatter diagram with this data collected.

<table>
<thead>
<tr>
<th>Temperature</th>
<th>No. of Outages</th>
<th>Temperature</th>
<th>No. of Outages</th>
</tr>
</thead>
<tbody>
<tr>
<td>81°</td>
<td>3</td>
<td>85°</td>
<td>11</td>
</tr>
<tr>
<td>89°</td>
<td>13</td>
<td>81°</td>
<td>18</td>
</tr>
<tr>
<td>84°</td>
<td>21</td>
<td>88°</td>
<td>8</td>
</tr>
<tr>
<td>92°</td>
<td>17</td>
<td>81°</td>
<td>12</td>
</tr>
<tr>
<td>80°</td>
<td>6</td>
<td>87°</td>
<td>21</td>
</tr>
<tr>
<td>92°</td>
<td>9</td>
<td>91°</td>
<td>22</td>
</tr>
<tr>
<td>84°</td>
<td>16</td>
<td>83°</td>
<td>2</td>
</tr>
<tr>
<td>89°</td>
<td>18</td>
<td>90°</td>
<td>4</td>
</tr>
<tr>
<td>84°</td>
<td>7</td>
<td>86°</td>
<td>15</td>
</tr>
</tbody>
</table>
OBJECTIVE:
Confirm that the problem & its root causes have been decreased & the target for improvement has been met.

KEY ACTIVITIES:
- Confirm the effects of the countermeasures by checking to see if the root causes have been reduced.
- Compare the problem before & after using the same indicator.
- Compare the results obtained to the target.
- Implement additional countermeasures, if results are not satisfactory.

HELPFUL TOOLS/TECHNIQUES:
- Histogram
- Pareto diagram
- Control chart
- Graph

CHECKPOINTS:
18. Root causes have been reduced.
19. Tracking indicator was the same one used in the Reason for Improvement.
20. Results met or exceeded target. (if not, cause was addressed.)
The objective of step five of the QI process is to confirm that the problem and its root causes have been decreased and the target for improvement has been met.

The key activities of this step are to:

1. Confirm the effects of the countermeasures, checking to see if the root causes have been reduced.
2. Compare the problem before and after, using the same indicator.
3. Compare the results obtained to the target.
4. Implement additional countermeasures, if results are not satisfactory.
HELPFUL TOOLS/TECHNIQUES INCLUDE:

- Histogram
- Pareto Chart
- Control Chart
- Graph
## STANDARDIZATION

### OBJECTIVE:

Prevent the problem & its' root causes from recurring.

### KEY ACTIVITIES:

- Assure countermeasures become part of daily work.
  - Create/revise the work process
  - Create/revise standards
- Train employees on revised process and/or standards and explain need.
- Establish periodic checks with assigned responsibilities to monitor countermeasures.
- Consider areas for replication.

### HELPFUL TOOLS/TECHNIQUES:

- Control system
- Control chart
- Graph
- Procedure
- Training

### CHECKPOINTS:

21. Method to assure countermeasures become part of daily work was developed. (include training).
22. Periodic checks were put in place with assigned responsibility to monitor the countermeasures.
23. Specific areas for replication were considered.
Step 6: Standardization

**OVERVIEW**

Step Six, "Standardization," has the objective of preventing the problem and its root cause from recurring. Once the data in the "Results" section of the story indicates that the countermeasures have been successful, the team begins to standardize its system for improvement.

### Quality Improvement Story

<table>
<thead>
<tr>
<th>Control System</th>
<th>Control Chart</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Control System Diagram" /></td>
<td><img src="image" alt="Control Chart" /></td>
</tr>
</tbody>
</table>

The key activities of this step are to:

1. Assure that countermeasures become part of daily work.
   - Create/revise the work process
   - Create/revise standards
2. Train employees on revised process and/or standards; and explain need.
3. Establish periodic checks with assigned responsibilities to monitor countermeasures.
4. Consider areas for replication.
Step 6: Standardization

QI STORY

HELPFUL TOOLS/TECHNIQUES INCLUDE:

• Control Systems
• Control Chart
• Graph
• Process Flow Chart
• Procedures/Standards
• Training
A. WHAT ARE CONTROL CHARTS?

- Control Charts are line graphs specifically used to track the trend or performance of an on-going process. This is accomplished by observing how the variability within the process causes the trend line to fluctuate within a pair of statistically calculated limits.

- When the fluctuations within the process occur in a non-random pattern or go outside a control limit, the process is indicating that a change is occurring. If action is not taken, the change may affect the overall reliability of the process.

- Control limits, which are statistically derived, are not to be confused with specification limits. Specification limits are determined by the customers' valid requirements, regardless of what the process is capable of achieving. Ideally, the control limits are well within the specifications so there is confidence in the reliability of the process. If the specifications are very close to or within the control limits, then the process is indicating that it may not be reliable in achieving the customers' needs. This indicates opportunities for improvement.
PURPOSE OF CONTROL CHARTS:

1. Control charts can be a helpful tool to identify and analyze processes for improvement.

2. All natural processes are subject to variation. Even identical twins are often slightly different in height, weight and looks. But how much variation is acceptable and what kinds of variation are controllable and therefore improvable?

3. A control chart is a special type of trend chart with limits specifically used to track an ongoing process and its variability. We use it to see if a process is within limits or control, i.e., if the variation is natural and to be expected (chance variation) or if it is due to assignable causes. Control charts also serve to indicate when abnormal process situations and trends are developing. Recognizing these trends can help us respond before a major problem occurs.

4. Control charts vary slightly depending on what kind of data variation is being examined, i.e., whether it is a control chart for attribute or variables data. Below is an example of a control chart:

![Control Chart Diagram]

The X axis tracks time or sequential order, and the Y axis charts the factor being studied. The average of the process is indicated and control limits are added above and below the average. These control limits are derived through statistical calculations based on historical data from the process under observation. Control charts can be particularly helpful in identifying problem areas, analyzing the current situation, and in tracking results.
5. It is important here to note that when we are involved in processes that reliably and consistently produce according to plan, control charts can be a helpful tool to identify and analyze processes that can be improved. Control Charts will be studied in detail later.
Control Charts can be classified into two main application groups depending upon the type of data generated from the process. Below is a chart which summarizes the types of Control Charts which will be discussed on the following pages.

Types of Data

- Types of Charts for \textit{Variables Data}
  - $\overline{X}$, R Chart
  - $X$, Moving Range Chart

- Types of Charts for \textit{Attribute Data}
  - P Chart
  - NP Chart
  - C Chart
  - U Chart
1. VARIABLES CONTROL CHARTS

a. \( \bar{X}, R \) CHART

This is a two part Control Chart used to monitor processes with variables data. The data used on these charts is reported in small subgroups containing at least 2, or at most 10, individual data readings.

\[ 2 \leq n \leq 10 \]

**EXAMPLE:** Average time it takes to drive to work per day. Consider a work week of five days as a subgroup.

The \( \bar{X} \) chart tracks how the process average varies from one point to another. In this example, this shows how the average driving time varies from week to week. The \( R \) (or range) chart tracks the variation that occurs within each subgroup (i.e., the time difference between each daily drive to work).

b. \( X, MOVING\ RANGE\ CHART \)

This is another two-part chart used to monitor processes with variables data. This is similar to the \( \bar{X}, R \) Chart, except the number of items observed at each instance is equal to 1.

In other words, the \( X, \) Moving Range Chart tracks how each process data point varies from one another.

**EXAMPLE:** The total overtime hours reported per month for a department.
2. **ATTRIBUTE CONTROL CHARTS**

a. **p Chart:** This is only a one-part Control Chart which charts the progress that generates attribute data. It is applicable to problems which deal with the percentage that do not conform to specifications.

   **EXAMPLE:** Percentage of jobs reworked per month.

b. **np Chart:** This is a special type of the p chart where the number of nonconformances is tracked from a fixed sample size at each instance.

   **EXAMPLE:** Number of rejects found in a lot inspection with equal sample size at each inspection.

c. **c Chart:** This chart tracks the number of non-conformances per unit. In addition, this monitors attribute data where the probability of an occurrence is very small but the number of possible instances very large.

   **EXAMPLE:** Number of accidents reported per day at a service center.

d. **u Chart:** With the c chart, it is assumed that the probability of an occurrence (for example an accident) is the same for each day. But if we are considering the monthly number of bottle jams per finishing line, the number of finishing lines running changes from month to month. Therefore, the probability for an occurrence is not the same each time.

   The Control Chart used in this instance where the opportunity for an occurrence is not the same is called the u chart.

Due to the complexity in setting up these Control Charts, it is suggested you contact an SPC specialist for the necessary help.
**B. WHY ARE THEY USEFUL?**

They are helpful tools to monitor the performance of an ongoing process in determining the following:

1. If the process is in control; or if action needs to be taken to keep the process in control; or if action needs to be taken to bring it back to control.

2. If the process is capable of meeting the customers' valid requirements.

3. If an opportunity for process or system improvement exists.

4. If any countermeasures have improved the process.

**C. WHAT DO THEY LOOK LIKE?**

In general, Control Charts are line graphs in which the process is shown as a trend line drawn on a chart along with these three lines:

1. A mean ($\bar{X}$) or central line represents the average value of the process.

2. An upper control limit (UCL) drawn at a calculated distance above the central line which represents the maximum variation that could be expected if only normal causes of variation are present.

3. A lower control limit (LCL) drawn at a calculated distance below the central line which represents the minimum variation which could be expected only when normal causes of variation are present.
Below is an example of what a Control Chart may look like:

![Diagram of a Control Chart](image)

**D. HOW IS IT DONE?**

**Step 1:** Decide on a measure to use in monitoring your performance. Put this on the vertical axis.

**Step 2:** Choose a time interval for taking measurements. Put this on the horizontal axis.

**Step 3:** To calculate control limits, first find the average and standard deviation for the data that you have. The upper control limit (UCL) is at the average plus 3 standard deviations, while the lower control limit (LCL) is at the average minus 3 standard deviations. **Mark these “control limits” on the vertical axis and draw a line for each horizontally along the length of the chart.**
A. **WHAT IS STANDARD DEVIATION?**

The Standard Deviation is a measure of how tightly the data points cluster about the mean (average). It is represented by Sigma (σ).

B. **WHY IS IT USEFUL?**

The standard deviation is far less sensitive to the addition of another data point or the changing of a data point; therefore, it is a more reliable **MEASURE OF THE VARIABILITY** of a process.

C. **WHAT DOES IT LOOK LIKE?**

\[
\sigma = \sqrt{\frac{\sum (x-x)^2}{n-1}}
\]

D. **HOW IS IT DONE?**

1. Start with a group of data.
2. Take the different data points and subtract from each the value of the mean (\(\bar{x}\)).
3. Square each of these values.
4. Add all the squared numbers.
5. Divide by the number of data points in the group less one (n-1).
6. Take the square root of this result. This is the standard deviation for this group of data.

E. **WHEN IS IT USED?**

The standard deviation is used in summarizing and/or comparing certain characteristics of a group data set. In addition, it is used in the construction of a control chart in determining the upper and lower control limits of a process. It is also used as part of the checking stage in the P-D-C-A cycle after the data is already gathered.
QI STORY
FUTURE PLANS

OBJECTIVE:
Plan what to do about remaining problems and evaluate the team's effectiveness.

KEY ACTIVITIES:
- Analyze and evaluate any remaining problems.
- Plan further actions if necessary.
- Review lessons learned related to problem solving skills & group dynamics (team effectiveness):
  - What was done well
  - What could be improved
  - What could be done differently

HELPFUL TOOLS/TECHNIQUES:
- Action plan
- P D C A

CHECKPOINTS:
24. Any remaining problems of the theme will be addressed.
Step 7: Future Plans

QI STORY

OVERVIEW

The final step in the QI Story is “Future Plans.” This allows the team a chance to review its story and address any remaining issues. The team will plan what is to be done about any remaining problems and then evaluate the team's effectiveness.

Quality Improvement Story

<table>
<thead>
<tr>
<th>Future Plans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Action Plan</td>
</tr>
<tr>
<td>Plan, Do, Check, Act</td>
</tr>
</tbody>
</table>

The key activities of this step are to:

1. Analyze and evaluate any remaining problems.
2. Plan further actions, if necessary.
3. Review lessons learned relating to problem-solving skills and group dynamics. (Team effectiveness)
   - What was done well?
   - What could be improved?
   - What could be done differently?
HELPFUL TOOLS/TECHNIQUES INCLUDE:

- Control System
- Process Flow Chart
- Action Plans
- Evaluation Guides
QI STORY
# QI Story Review Form

**Team Name:**

<table>
<thead>
<tr>
<th>QI Story Steps</th>
<th>Tools/Techniques</th>
<th>Objective/Checkpoints</th>
<th>√</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1 Reason for Improvement</strong></td>
<td>Project Planning Sheet</td>
<td>To identify a theme (problem area) and the reason for working on it.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. The criteria for selection was customer oriented.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. The indicator correctly represented the theme.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. The need for improvement was demonstrated using data.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. A schedule for completing the QI Story steps was developed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2 Current Situation</strong></td>
<td>Control Chart</td>
<td>To select a problem and set a target for improvement.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. The situation was stratified to a component level specific enough to analyze.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>6. Customer valid requirements were identified.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>7. Problem statement addressed the gap between the current and targeted values.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>8. The methodology in establishing goals/target was identified.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>3 Analysis</strong></td>
<td>Cause &amp; Effect Analysis</td>
<td>To identify and verify the root causes of the problem.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>9. Cause &amp; Effect analysis was performed on the problem.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>10. Root Causes were taken to an actionable level.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>11. Root Causes with probable greatest impact were selected.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>12. Data was used to verify the problem.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>4 Countermeasures</strong></td>
<td>Cost Estimation</td>
<td>To plan and implement countermeasures that will correct the root causes of the problem.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>13. Selected countermeasures attacked verified root causes.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>14. Countermeasures were consistent with meeting customer valid requirements.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>15. Countermeasures were cost beneficial.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>16. Action plan answered who, what, when, where, &amp; how.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>17. Action plan reflected the barriers &amp; aids necessary for successful implementation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>5 Results</strong></td>
<td>Graph</td>
<td>To confirm that the problem and its root causes have been decreased and the target for improvement has been met.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>18. Root causes have been reduced.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>19. Tracking indicator was the same one used in the reason for improvement.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>20. Results met or exceeded target. (If not, cause was addressed.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>6 Standardization</strong></td>
<td>Control Chart</td>
<td>To prevent the problem and its root causes from recurring.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>21. Method to assure countermeasures become part of daily work was developed (include applicable training).</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>22. Periodic checks were put in place with assigned responsibility to monitor the countermeasures.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>23. Specific areas for replication were considered.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>7 Future Plans</strong></td>
<td>Action Plan</td>
<td>To plan what is to be done about any remaining problems, and to evaluate the team’s effectiveness.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>24. Any remaining problems of the theme will be addressed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>25. Applied PDCA to lessons learned.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>