8 CONTROL TOOLS

LEAN PRODUCTION SYSTEM

Topics Outline

- Introduction
- Lean Overview
- Process Control Tools
  1. Flow Chart / Diagram
  2. Check Sheet
  3. Histogram
  4. Pareto Chart / Diagram
  5. Cause-and-Effect Diagram
  6. Why-Why Diagram
  7. Scatter Diagram
  8. Control Chart

INTRODUCTION

Have you ever been lost? Being lost is different from not being able to find something. In one case, you're unable to locate an object or a place; in the other, you don't know where you are. When you find out where you are, you can figure out where you need to go.

Dealing with problems can be similar to being lost. Problem solvers need to know where they stand, what the problem really is and what the cause of the problem is before any solutions can be proposed.

INTRODUCTION

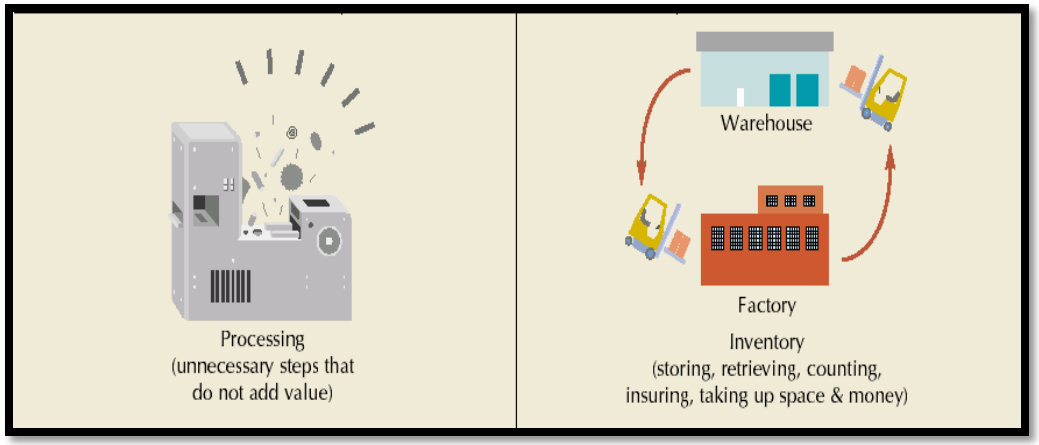
- A hit-or-miss type approach to tackling problems is not very effective.
- Problem solving is not an automatic process; people need to be trained in correct problem-solving procedures.
- Problem-solving efforts should be objective and focused on finding root causes.
- Proposed solutions should prevent a recurrence of the problem. Controls should be present to monitor the solution.
- Teamwork, motivation, coordinated and directed problem-solving, problem-solving techniques and statistical training are all part of ensuring that problems are isolated, analysed and corrected.

What is Lean?

- **Elimination of Waste**
  - Toyota Production System
- **Philosophy**
  - Produce only what is needed, when it is needed, with no waste
- **Methodology**
  - Determination of value added in the process
- **Tools**
  - 5S, Kaizen, Standardized Work, etc.

8W – Waste (Muda)

1. Over-production
2. Waiting
3. Transportation / Movement
4. Over-processing
5. Inventory
6. Motion
7. Defects



Common Causes of Waste

- Long setup time
- Lack of training
- Layout (distance)
- Poor maintenance
- Poor work methods
- Incapable processes
- Inconsistent performance measures
- Ineffective production planning
- Lack of workplace organization
- Poor supply quality / reliability

LPS TECHNIQUES

- Jidoka and Andon
- Poka-Yoke (Mistake Proofing)
- SMED
- Standardized Work
- Takt Time
- Throughput Time
- Spaghetti Diagram
- Value Stream Mapping
- Kanban
- Total Preventive Maintenance
- Cellular Manufacturing / Work Cells
- Heijunka

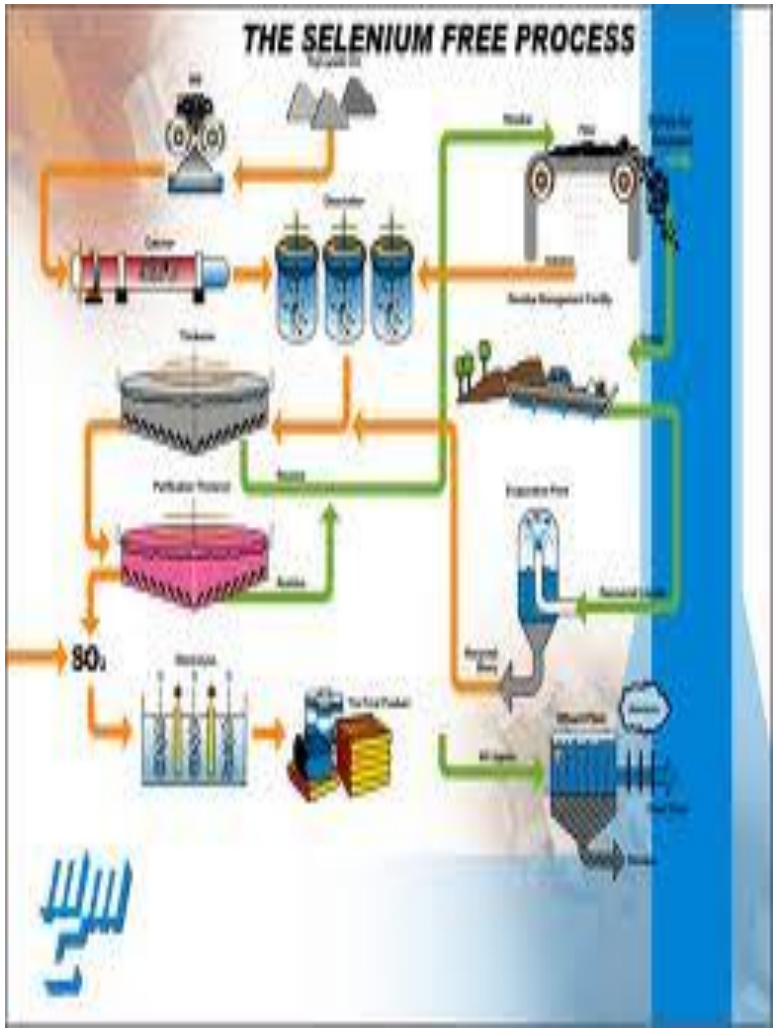
Process Flow Diagram

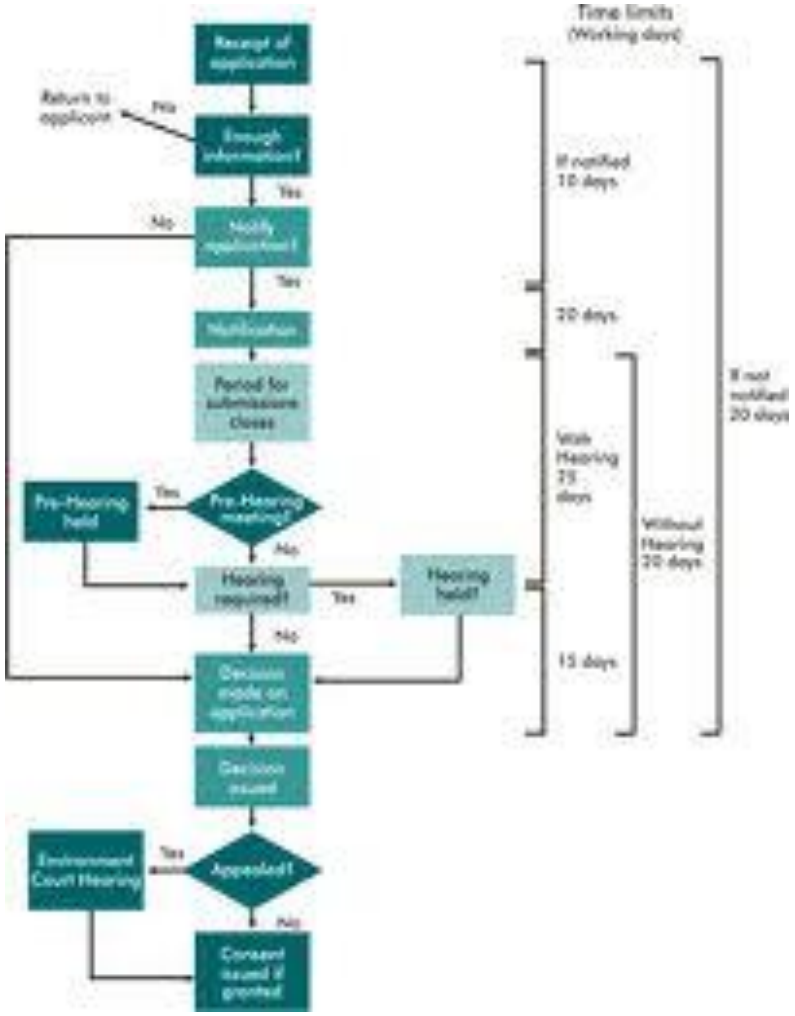
- A process map / flowcharts / process flow diagrams is a graphical representation of all the steps involved in an entire process or a particular segment of a process
- It is a schematic diagram that shows the flow of the product or service as it moves through the various processing stations or operations
- Effectively used in the first stages of problem solving because the charts enable those studying the process to quickly understand what is involved in a process from start to finish

Process Flow Diagram

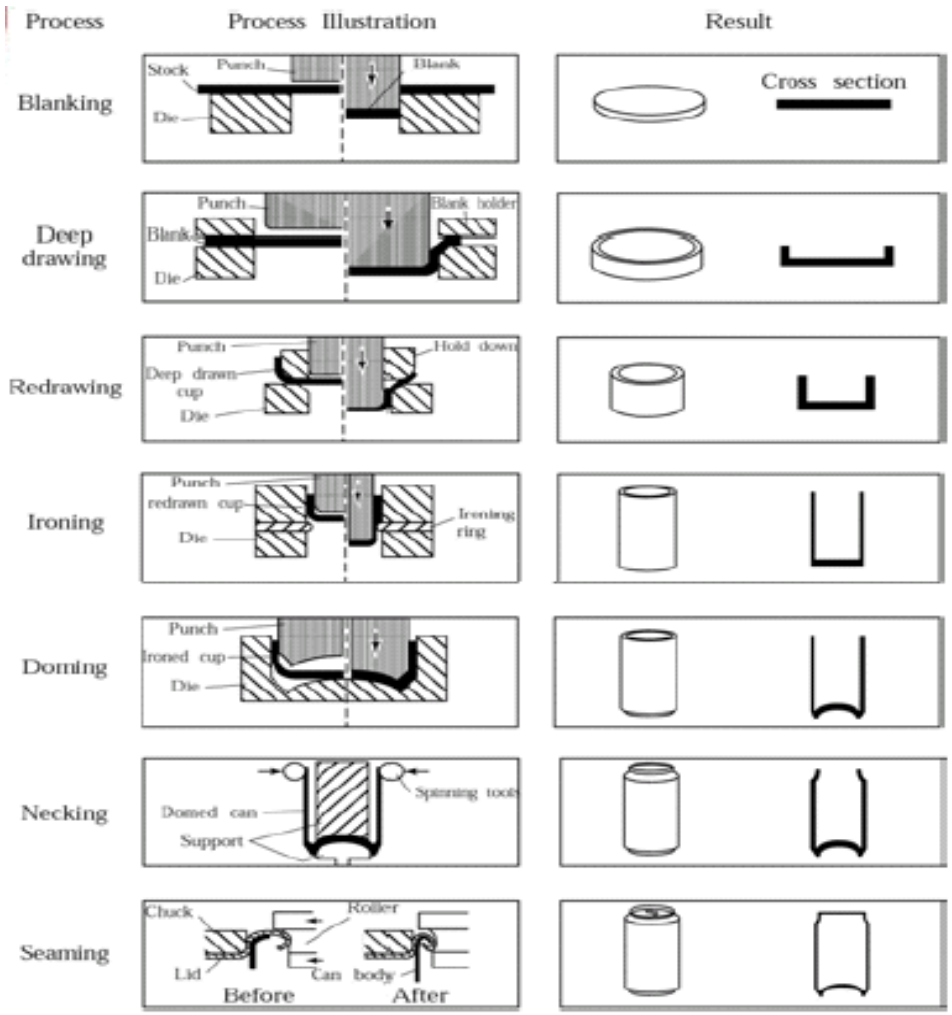
- **The diagram makes it easy to visualize the entire system, identify potential trouble spots and locate control activities**
- **Because processes and systems are often complex, there are various technique to create a chart - use standardized symbols, constructed with pictures or include additional details like process activities and specifications**

Process Flow Diagram





Process Flow Diagram



Steps in Manufacturing an Aluminum Can

Check Sheets

- Main purpose is to ensure that the data are collected carefully and accurately by operating personnel for process control and problem solving
- Data should be presented in such a form that it can be quickly and easily used and analyzed
- Creativity plays a major role in the design of a check sheet; it should be user friendly and whenever possible, include information on time and location

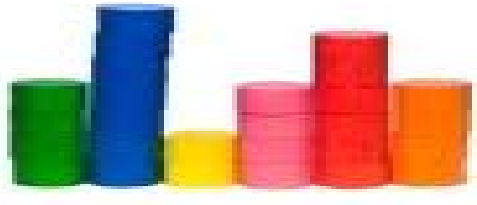
Check Sheets

- A data recording device, as events occur in categories, a check or mark is placed on the check sheet in the appropriate category
- Given a list of items or events, the user of a check sheet marks down the number of times a particular event or item occurs – the user checks off occurrences
- Checklist is differ where it lists all of the important steps or actions that need to take place or things that need to be remembered

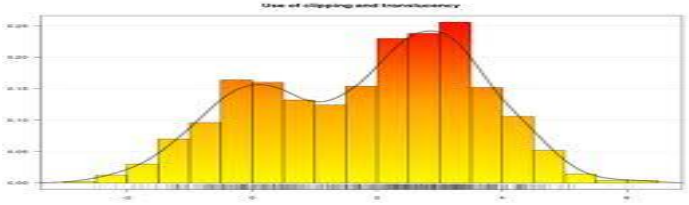
Not to confuse a check sheet with a checklist

Delay Category	Frequency of occurrence:
Prepress system problems	IIIII IIIII (10)
Press mechanical problems	IIIII III (9)
Late edit closes	IIII (4)
Page flow to plate room	III (3)
Late arriving ads	III (3)
Excessive web breaks	III (3)
Difficult press configuration	II (2)
Total	34

Histogram



- Data in a ‘form’ are difficult to use and not effective in describing the data’s characteristics
- Summarizing the data are needed to show what value the data tend to cluster about and how the data are dispersed or spread out
- Identifiable characteristics – variation, shape and location
- Can determine the process capability compare with specifications, suggest the shape of the population and indicate if there any gaps in the data



Histogram

The histogram describes the variation in the process. It is used to :

- **Solve problems**
- **Determine the process capability**
- **Compare with specifications**
- **Suggest the shape of the population**
- **Indicate discrepancies in data such as gaps**

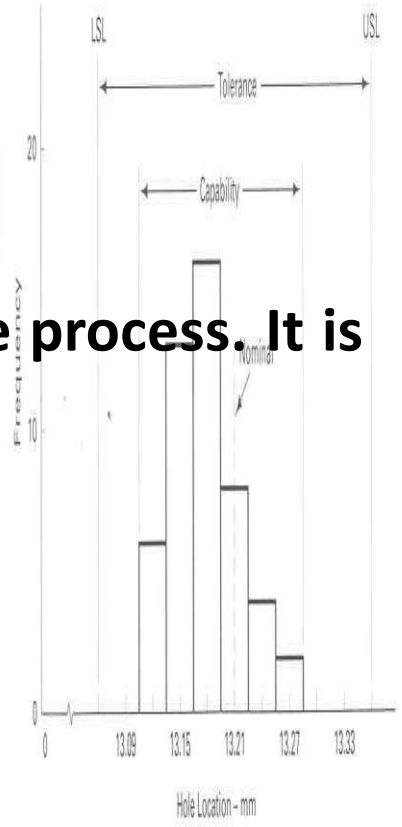
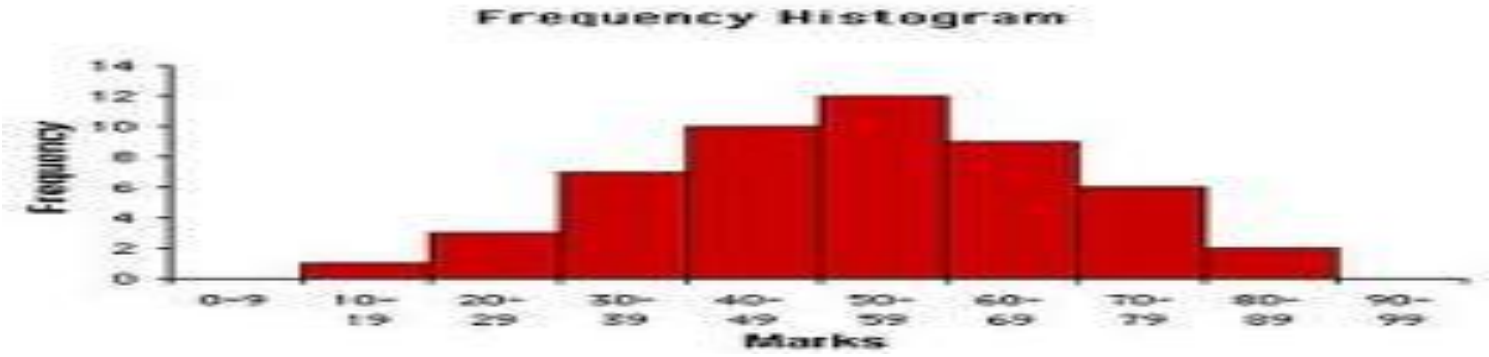


FIGURE 2-12 Histogram for hole location.



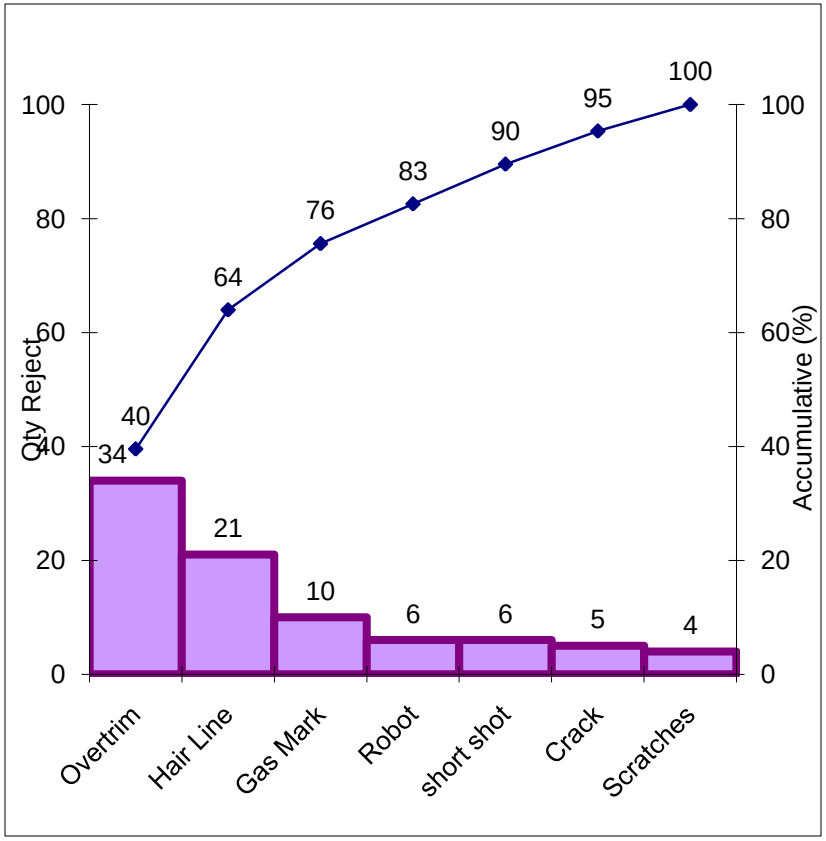
Pareto Diagram

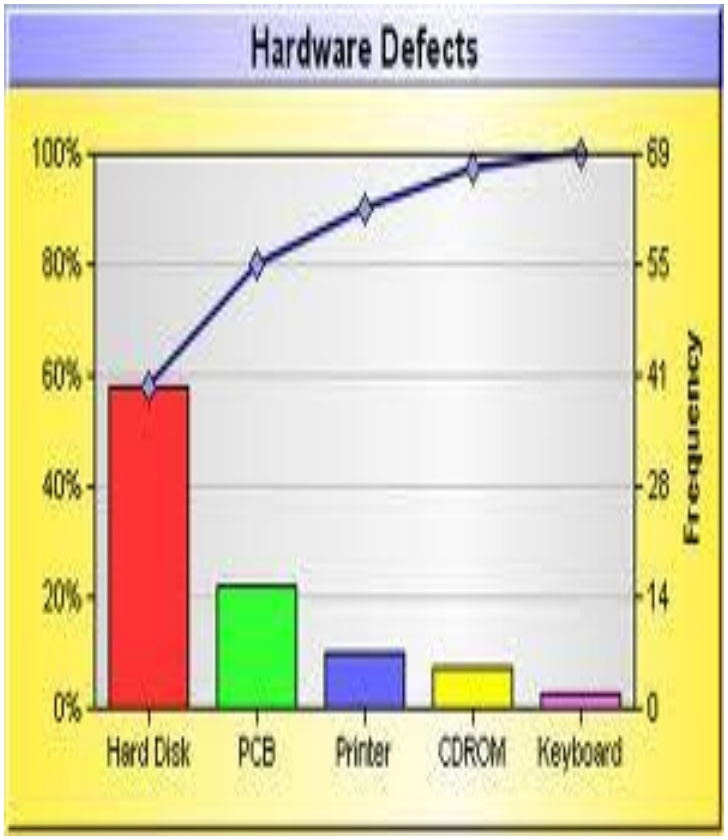
- Identified by Vilfredo Pareto (1848 to 1923), conducted studies of the distribution of wealth
- Dr. Juran recognized the concept as a universal - he coined the phrases vital few and useful many
- Examples of the vital few are:
  - A few problems account for the bulk of the process downtime
  - A few suppliers account for the majority of rejected parts
- A Pareto diagram is a graph that ranks data classifications in descending order from left to right

Pareto Diagram

- A graphical tool for ranking causes of problems from the most significant to the least significant (in descending order from left to right)
- A graphical display of the 80-20 rule : 80% of problems come from 20% of causes
- Applicable to any problem that can be separated into categories of occurrences – identifying which problems are most significant
- It is applicable to problem identification and the measurement of progress

Pareto Chart





- ☑ Normally, the vertical scale is dollars, frequency or percent

Pareto Diagram

Pareto chart is constructed using the following steps:

1. **Determine the method of classifying the data: by problem, cause, nonconformity and so forth**
2. **Determine what data to be gathered**
3. **Collect data for an appropriate time interval or use historical data**
4. **Determine the total number of nonconformities, calculate the percentage in each category and rank order categories from largest to smallest**
5. **Construct the diagram and find the vital few**

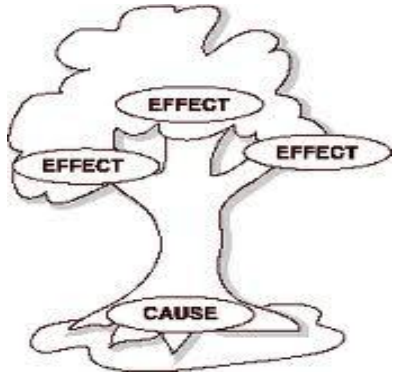
Cause-and-Effect

- Developed by Dr. Kaoru Ishikawa (1943) – sometimes referred to as Ishikawa diagram / fish-bone diagram because of its shape
- Diagram is a picture composed of lines and symbols designed to represent a meaningful relationship between an effect and its causes
- Are used to investigate either a "bad" effect and to take action to correct the causes or a "good" effect and to learn those causes responsible; for every effect, there are likely to be numerous causes

Cause-and-Effect

- Causes are usually broken down into the major causes of work methods, materials, machine, man / people and the environment - each major cause is further subdivided into numerous minor causes
- Diagram are useful in:
  - Analyzing actual conditions for improvement, more efficient use of resources and reduced costs
  - Elimination conditions causing nonconformities and customer complaint
  - Educate and train personnel in decision making and corrective action activities
  - Standardization of existing and proposed operations

Cause-and-Effect



To construct a cause-and-effect diagram:

1. **Clearly identify the effect or the problem. Problem statement is placed in a box at the end of a line**
2. **Identify the causes. Brainstorming is the usual method for identifying these causes.**
3. **Build the diagram. Organize the causes and sub-causes in diagram format.**
4. **Draw the effect box and the center line. Connect the potential causes boxes to the center line.**
5. **Analyze the diagram and take corrective action**

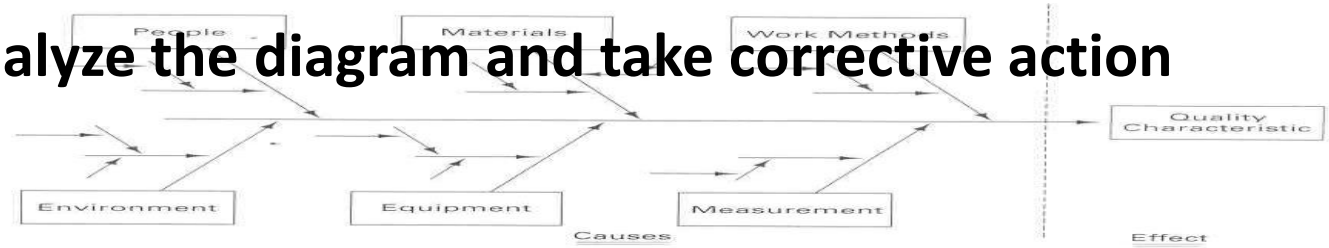
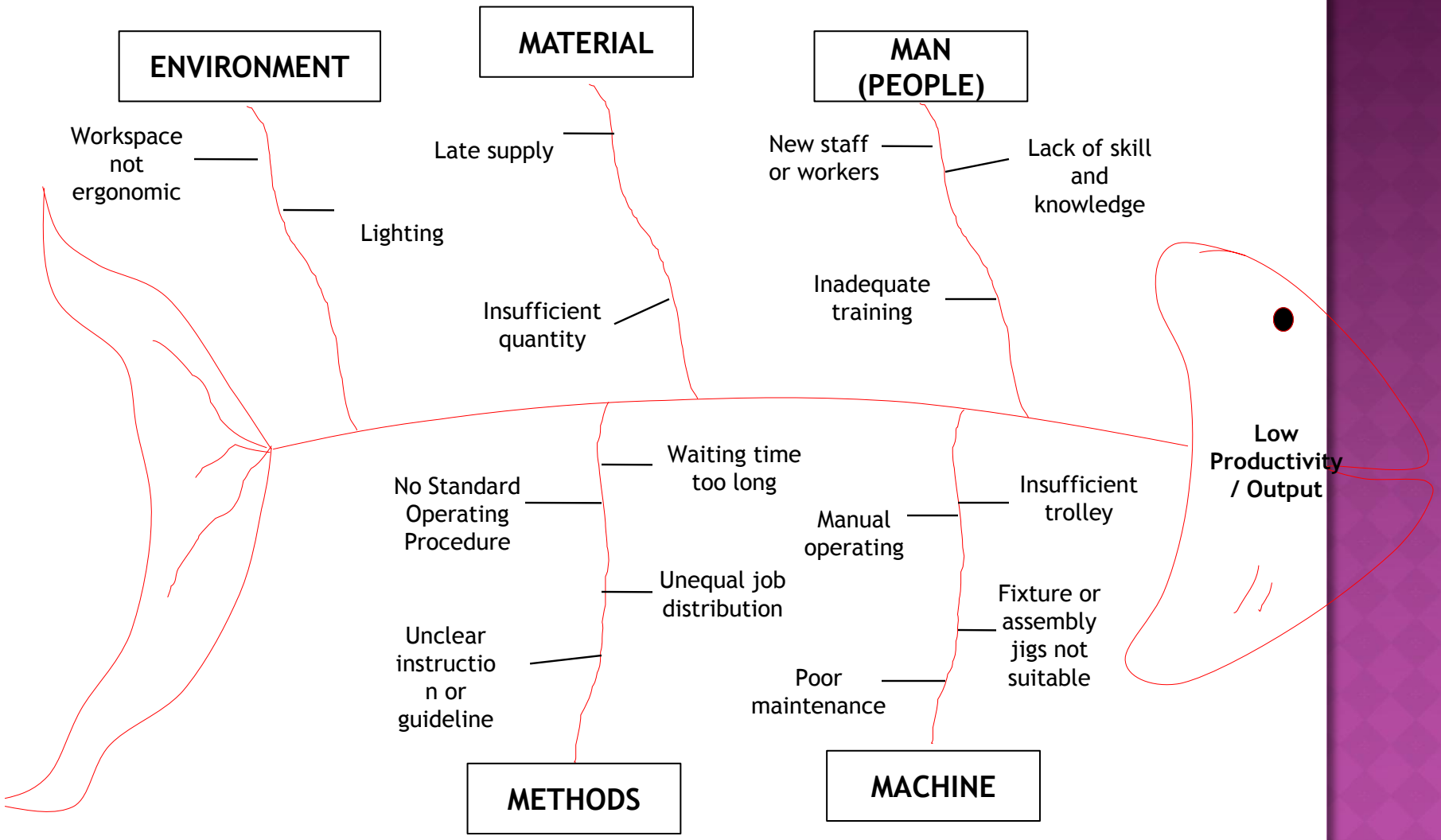


FIGURE 2-6 Cause-and-effect diagram.

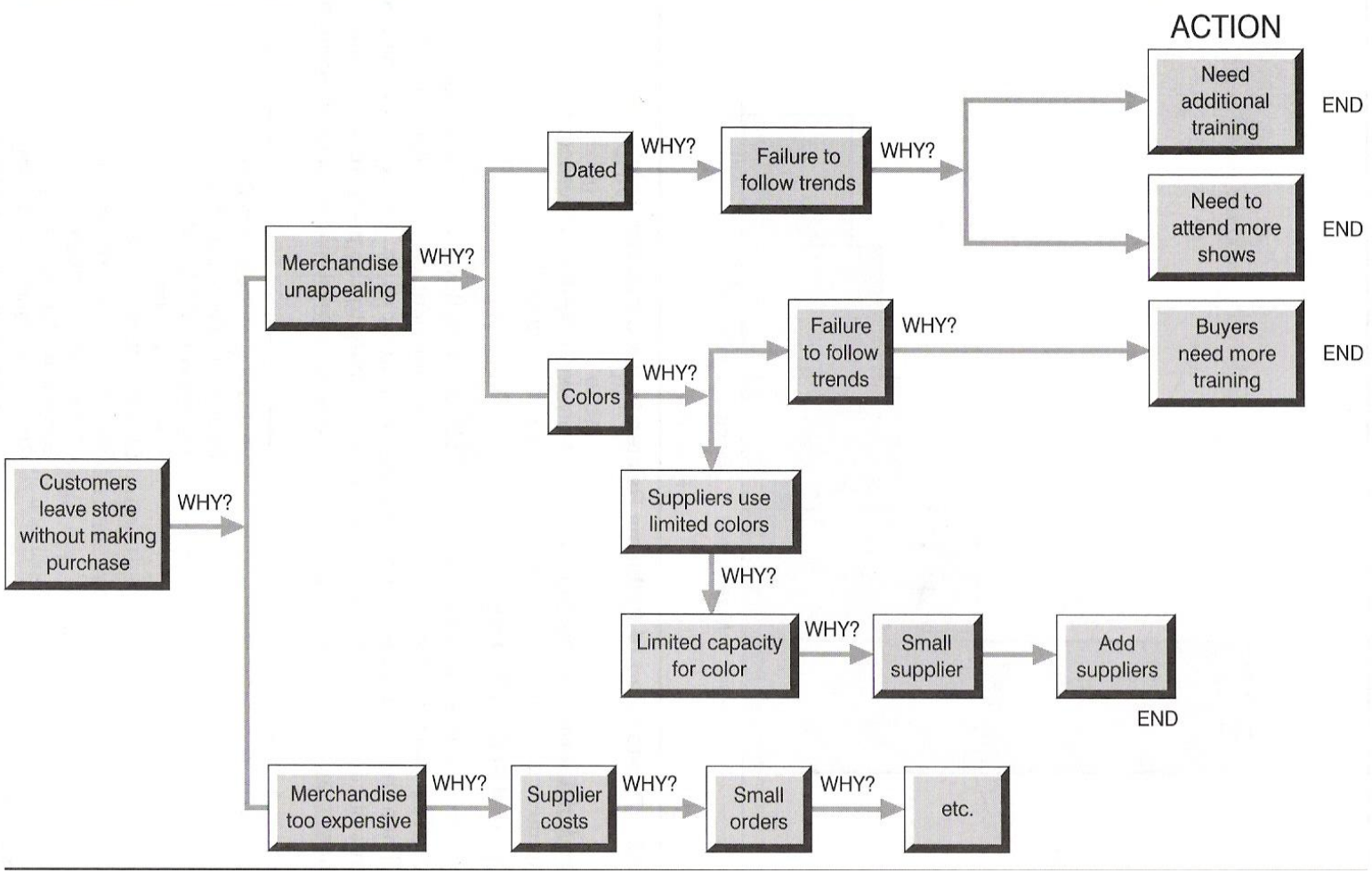
Fish-Bone Diagram



Why-Why Diagram

- Diagrams are organize the thinking of a problem-solving group and illustrate a chain of symptoms leading to the true cause of a problem
- An excellent technique for finding the root cause(s) of a problem and a method for determining what factors have to be in place in order to respond to an opportunity
- By asking “why” five times, the problem solvers are stripping away the symptom surrounding the problem and getting to the true cause of the problem
- At the end of a session it should be possible to make a positively worded, straightforward statement defining the true problem to be investigated.

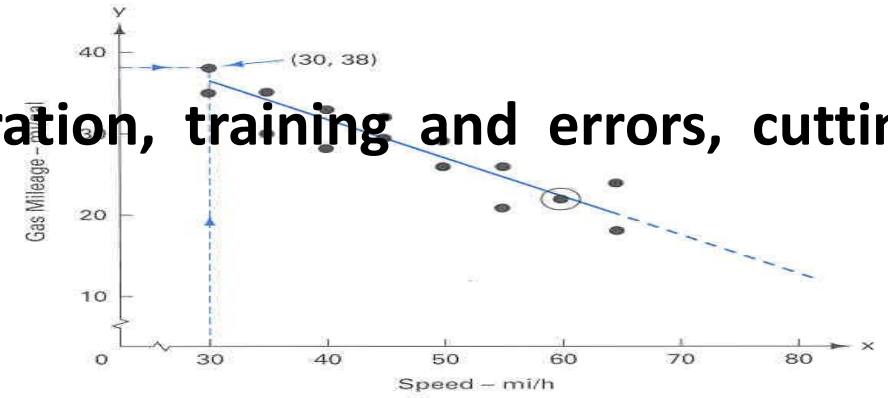
Why-Why Diagram



Scatter Diagram

- A graphical technique that is used to analyze the relationship between two different variables
- The independent variable (can be manipulated) is recorded on the x-axis and the dependent variable, the one being predicted is displayed on the y-axis
- User can determine if a connection or relationship exists between two variables being compared
- Examples:

  yield and concentration, training and errors, cutting speed and tool life



Scatter diagram.

Scatter Diagram

- Two sets of data are plotted on a graph
  - The independent variable – the variable that can be manipulated is recorded on the x axis
  - The dependent variable – the one being predicted, is displayed on the y axis
- When all the plotted points fall on a straight line, there is perfect correlation
- In order to fit a straight line to the data mathematically, need to determine slope and its intercept with the y axis

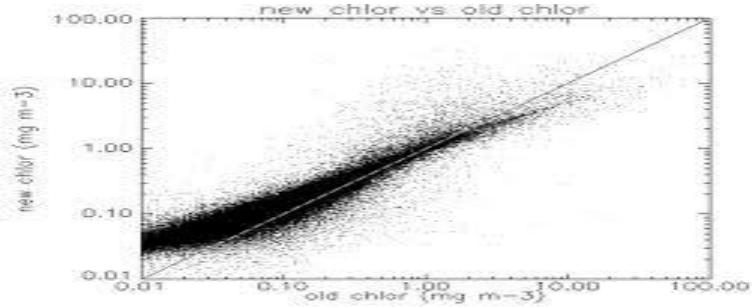
$$m = \frac{\Sigma xy - [(\Sigma x)(\Sigma y)/n]}{\Sigma x^2 - [(\Sigma x)^2/n]}$$

$$a = \Sigma\frac{y}{n} - m(\Sigma\frac{x}{n})$$

$$y = a + mx$$

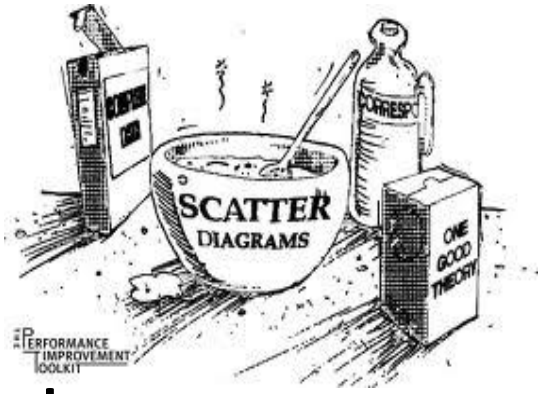
Scatter Diagram

- Another useful statistic is the coefficient of correlation which describes the goodness of fit of the linear model
- It is a dimensionless number, r, that lies between +1 and -1
- Positive and negative signs tell whether there is a positive / negative correlation
- The closer the value is to 1.00, the better is the fit, with a value of one meaning that all points fall on the line



$$r = \frac{\Sigma xy - [(\Sigma x)(\Sigma y)/n]}{(\Sigma x^2 - [(\Sigma x)^2/n])\ (\Sigma y^2 - [(\Sigma y)^2/n])}$$

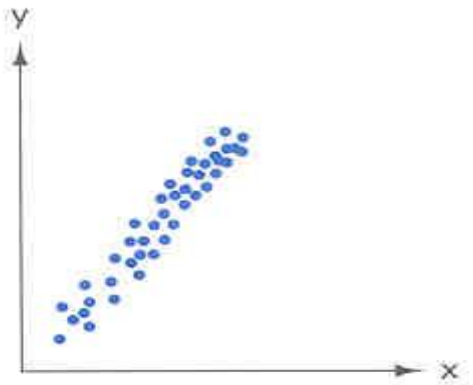
Scatter Diagram



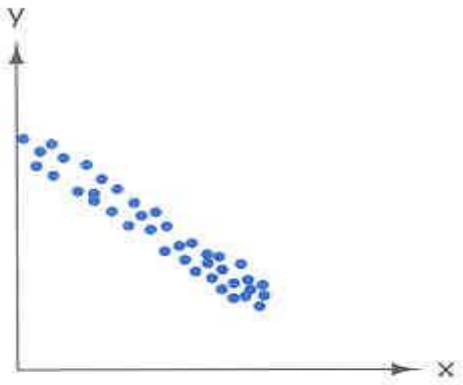
To construct scatter diagram, use these steps:

1. **Select the characteristic, the independent variable that wish to study**
2. **Select the characteristic, the dependent variable that suspect affects the independent variable**
3. **Gather the data about the two characteristics**
4. **Draw, scale and label the horizontal and vertical axes**
5. **Plot the points**
6. **Interpret the scatter diagram to see if there is a relationship between the two characteristics**

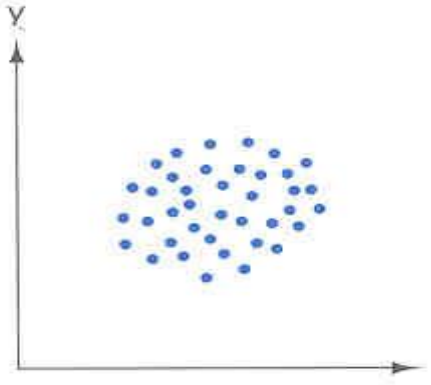
Scatter Diagram Patterns



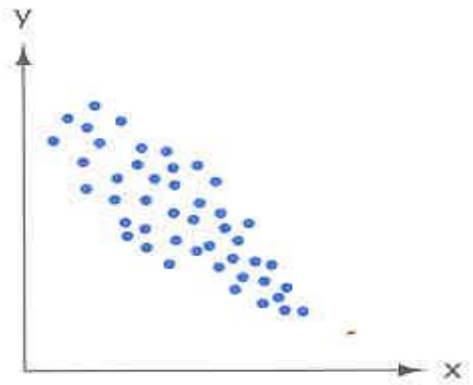
(a) Positive Correlation



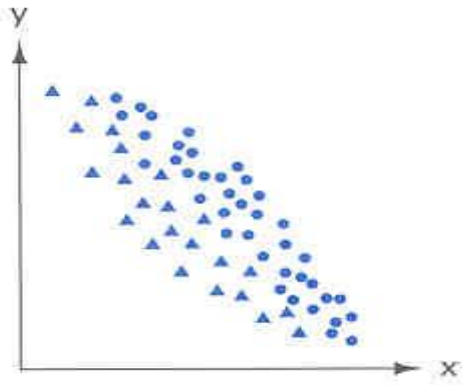
(b) Negative Correlation



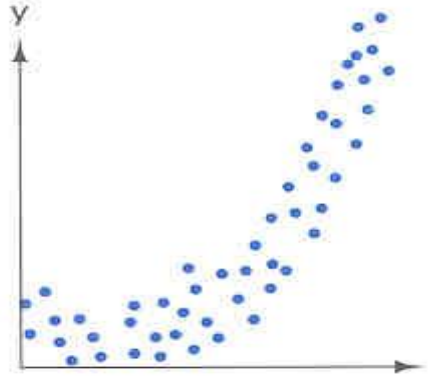
(c) No Correlation



(d) Negative Correlation May Exist



(e) Correlation by Stratification

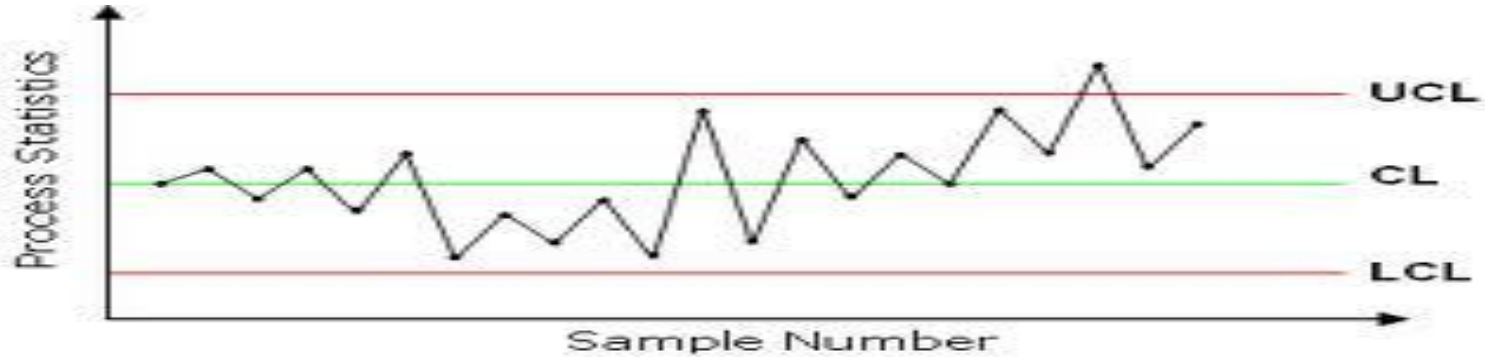


(f) Curvilinear Relationshi

Control Charts

The Chart contains:

- **Center line that represents the average value of the quality characteristics corresponding to the in-control state**
- **Two other horizontal lines, called the upper control limit (UCL) and the lower control limit (LCL)**
- **All the sample points on the control chart are connected with straight-line segments, so that it's easier to visualize how the sequence of points has evolved over time**



Control Charts

- If the process is in control, nearly all of the sample points will fall between chosen control limits and no action is necessary
- However, a point that plots outside of the control limits is interpreted as evidence that the process is out of control, investigation and corrective action are required to find and eliminate the causes
- Even if all the points plot inside the control limits, if they behave in a systematic or non random manner, then this could be an indication that the process is out of control
- If the process is in control, all the plotted points should have an essentially random pattern


Q
A