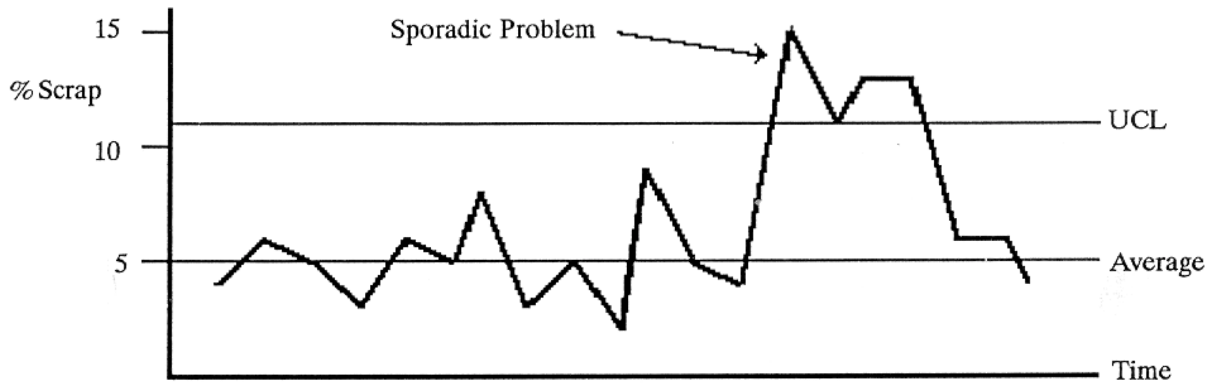
SIX SIGMA BREAKTHROUGH METHODOLOGY

TYPES OF PROBLEMS

The word **problem** usually means a deviation from expected performance or result. Something is not as it should be. However, in order that problem solving be effective, we must clearly understand the difference between two different types of problems. Properly understood, problems are opportunities for improvement.

Sporadic Problems

A **Sporadic Problem** is one where the deviation from performance is a result of a **specific, assignable cause.** Something has changed, and this specific, assignable change has directly resulted in deviation from expected performance. If we investigate, we must simply identify what has changed, what the cause was, and eliminate the cause. The process performance will then return to normal (see below).



An example of a sporadic problem is a process that has historically been averaging 5% scrap per day (100 units sampled). Statistical limits are calculated such that the upper control limit is 11%. As long as the process is centred around 5% and no one day exceeds 11%, the process is said to be "in statistical control" or "stable". However, one day the process generates 15% scrap. This is clearly beyond the upper control limit and signals that there has been a statistically significant change in the process. This change is called a **Sporadic Problem** because statistically it has been shown that it is much more probable that something has changed than that this could happen naturally, and hence this change has a specific, assignable cause.

Note, two principles that apply:

1. Sporadic Problems can only be identified statistically. It is not possible to "guess" at what level of increase might be considered statistically significant.

2. Once a problem has been proven to be sporadic, a thorough search for an assignable Cause is justified **and not before.**

In order to identify and resolve Sporadic Problems, it is necessary to find out what has changed. Because there is an assignable cause, this cause can be identified and steps taken to correct it. This can normally be done locally by the process operator. Identification of sporadic problems is the goal of **Control Activity** which is the typically the last phase of the Six Sigma Breakthrough Process.

Note that eliminating assignable causes and solving sporadic problems **is not improvement**. It is troubleshooting or fire-fighting. It is very important to understand the difference. For example, suppose that someone ran into my car while it was parked and destroyed the rear end. I then take it to the body shop and have it returned to its original state. Has the car been improved? Of course not. The sporadic problem with the rear end has been corrected, but that has not improved the vehicle. Most of us spend much of our time "putting out fires". While this is exciting business, it is not improvement. And improvement **is** where the money is.

Chronic System Problems

A Chronic system problem is one where the historical level of the problem has not changed significantly, but this very level represents unsatisfactory performance. Returning to the example above regarding the process which has been running 5% scrap, suppose that the process has been running well within the statistical limits and that everything is stable, are we satisfied? Probably not. Someone points out that 5% scrap costs us $2,000,000.00 per year, not to mention the marginal product that was shipped to the customer. Suddenly, the new knowledge sparks a sense of urgency toward improvement. How do we proceed?

The first step is to recognize that this is not a sporadic problem. Nothing has changed. There is no assignable cause. Blaming the foreman or the operator will be counterproductive. The process is stable. So, what we have here is a **chronic system problem**. Because the process is stable, the level of scrap is attributable to the system. Here two points need to be made:

1. In order to improve a stable process, the process will have to be changed. If nothing is changed the problem will stay at current levels
2. The process of changing a process to bring about a process improvement is known as **the Deming Cycle** or **Six Sigma Breakthrough.**

By Breakthrough, we mean a significant change in process performance that is a result of determined human effort and not luck. It is possible that processes can improve just due to a chance change in the system, but if we do not understand what exactly has changed, it is likely that process performance will deteriorate again and we will be no better off. In order to bring about an improvement, the system will have to be changed. This means that the process must be studied and an intelligent theory for improvement will have to be proposed. This theory will then have to be tested, verified and, if valid, implemented. Only then will breakthrough occur.

THE DEMING CYCLE

The **Deming Cycle** was named after Dr. W.E. Deming who first described to Japanese Engineers in 1950. Although Dr. Deming himself attributes it to Dr. Shewhart, he himself has been responsible for its widespread application. The Cycle consists of four general steps as shown below.

PLAN (TARGET)

1.0 Recognise the Opportunity
1.a. Define the Opportunity
1.b. Study Symptoms or Facts
1.c. Develop theory on Improvement

DO (ANALYZE)

2. Test the Theory
2.a Design test
to verify theory
2. b. Conduct the test

CHECK

3.0 Observe the results
3.a. Does the result
verify the theory?
3.b. Postulate solutions
3.c. Select best solution

ACTION

4. Act on the Opportunity
4.a Implement the changes necessary
4.b Standardise to hold the gains

This improvement process has also been described by Dr. Juran as the **Universal Sequence for Breakthrough**. A comparison table of these two methodologies is shown:

Comparison

THE DEMING CYCLE - UNIVERSAL SEQUENCE FOR BREAKTHROUGH

THE DEMING CYCLE	UNIVERSAL SEQUENCE FOR BREAKTHROUGH
1.0 RECOGNIZE THE OPPORTUNITY	1.0 IDENTIFY PROBLEM:
1.a.Define the Opportunity (Problem) 1.b.Study symptoms or facts 1.c.Develop theory on improvement	1.a Brainstorm for Problems 1.b Select & Define Problem
	2.0 COLLECT DATA & STUDY SYMPTOMS
2.0 TEST THEORY:	3.0 THEORIZE ON POSSIBLE CAUSES
2.a.Design Test to verify Theory 2.b.Conduct the test	4.0 EXPERIMENT TO DISCOVER TRUE CAUSES
3.0 OBSERVE THE RESULTS:	5.0 POSTULATE SOLUTIONS
3.a.Does the result verify the theory 3.b.Postulate solutions	
4.0 ACT ON THE OPPORTUNITY	6.0 IMPLEMENT SOLUTIONS
4.a.Implement the changes necessary. 4.b.Standardize the gains made.	7.0 INSTALL CONTROLS TO HOLD GAINS

The Deming Cycle provides a model for process improvement that is particularly effective when applied by a Six Sigma Team. The dynamics of the group, when properly channelled by a series of techniques releases the group synergy in a way that maximises the creative and analytical aspects of problem solving. These techniques, when mastered, provide a team with the **tools** necessary to sequence through the Deming Cycle and to achieve real progress on virtually any type of process improvement effort.

PROCESS IMPROVEMENT TECHNIQUES

A great number of process improvement techniques have been developed over the years in various parts of the world. The ones listed overleaf are the most common and certainly would account for 95% of the use by most process improvement teams.

Problem Solving/Process Improvement Techniques:

1. Brainstorming
2. Nominal Group Techniques
3. Process Mapping - Flowcharts
4. Checklists
5. Checksheets
6. Bar, line & pie charts
7. Pareto Charts
8. Histograms
9. Scatter Diagrams
10. Control Charts
11. Cause & Effect (CEDAC) Diagrams
12. Force Field Analysis
13. Process Analysis Technique
14. Action Plans

These techniques, when thoroughly mastered, provide motivated people with the ability to solve almost any problem and to make progress in the improvement process. However, just as with any set of techniques, the key to success is in knowing when and where to apply which technique and in what sequence. To aid in this, a step by step process flow is described below.

SIX SIGMA BREAKTHROUGH PROCESS

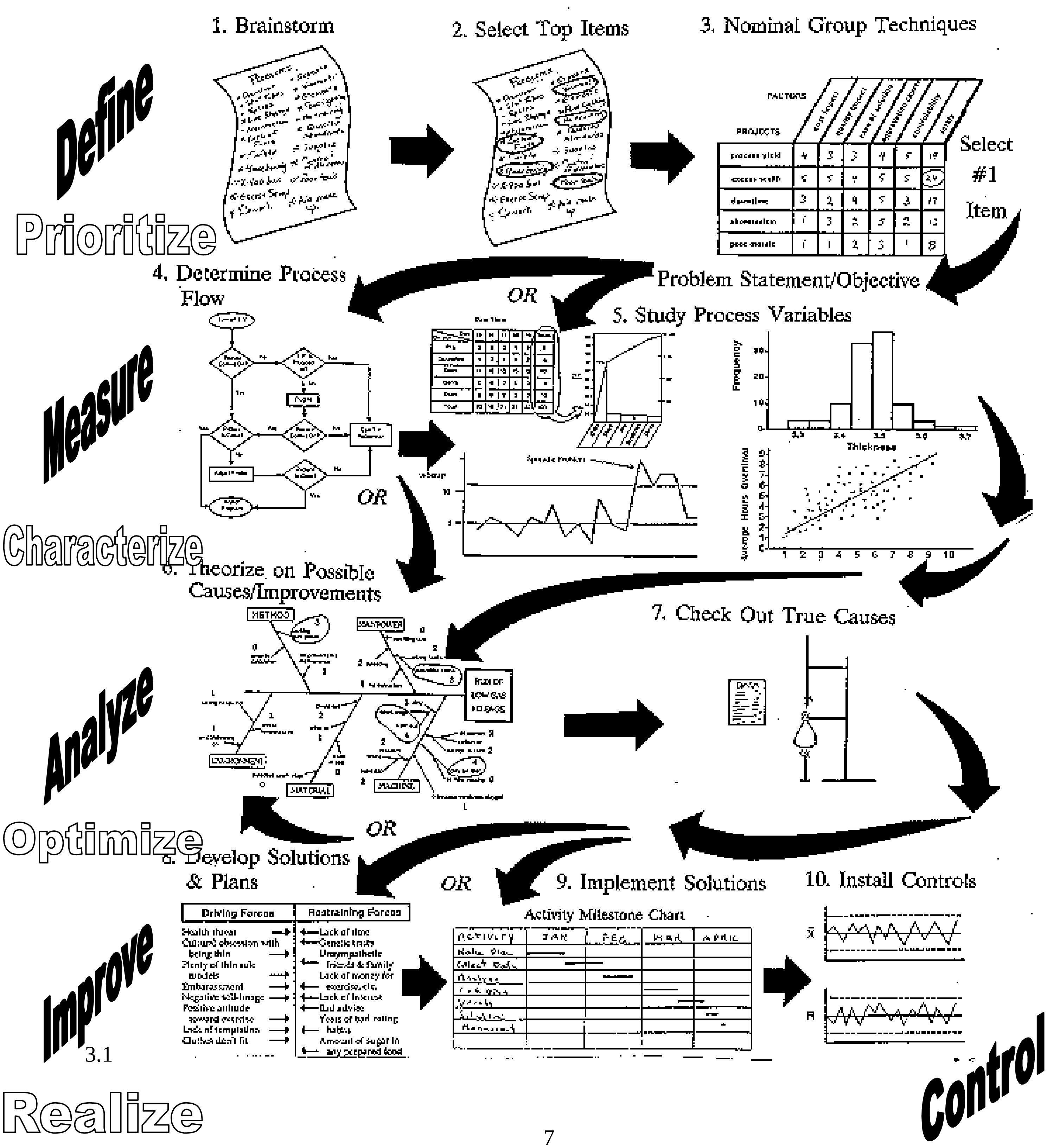
The Six Sigma Breakthrough Process has 5 major steps, each of which has sub steps. The process is a restatement of the Deming Cycle and the Universal sequence for breakthrough and is easily remembered. In addition there are four terms that are used to describe the objectives of the activities in each step of the process. They are given below

STEP	OBJECTIVE
1. DEFINE	*PRIORITIZE*
2. MEASURE	*CHARACTERIZE*
3. ANALYZE	
4. IMPROVE	*OPTIMIZE*
5. CONTROL	*REALIZE*

The problem solving (process improvement sequence) is shown schematically on the opposite page. The sub-steps are numbered and summarized below. Listed opposite are the techniques that apply.

Define	1. Develop a list of Potential Improvement Projects (Problems)	Brainstorming	Prioritize
	2. Select the top candidates from the list	Group Voting, Nominal Group	
	3. Identify the #1 Project & Develop Project Objective	Nominal Group Techniques Problem Statements, Project Objectives	
Measure	4. Map Process Flow	Process Mapping Flowcharts Process Analysis Technique	Characterize
	5. Characterize CTQ's (Critical to Quality) Characteristics and Process Variables	Checksheets, Pareto Charts Histograms, Scatter Diagrams Bar, Line & Pie Charts Control Charts, Measurement System Analysis (MSA)	
Analyze	6.Theorize on Possible Improvements or Causes, Identify Metrics, Objectives & Improvement Theories.	Cause & Effect Analysis CEDAC Diagram	Optimize
Improve	7. Experiment to Prove out Improvement Theories	Checksheets, Pareto Charts Histograms, Scatter Diagrams Bar, Line & Pie Charts Control Charts Designed Experiments (DOE)	
	8. Develop Solutions, Predict Obstacles and Develop a Plan for Change	Force Field Analysis	
Control	9. Execute Implementation Plan	Action Plans	Realize
	10. Install Controls to hold gains	Control Charts, Checklists	

SIX SIGMA PROCESS SCHEMATIC



STEP 1: LIST POTENTIAL IMPROVEMENT PROJECTS OR PROBLEMS

Step 1 assumes that a process improvement team has been formed. The team should have a leader, who may be appointed or elected by the group. The team should also elect a secretary or scribe to keep point-form minutes of what is discussed at each meeting.

This team could be a department team consisting of people who work in the same area, or could be a cross functional team made up of people from other areas. In the latter case, a team may have been formed for a specific purpose to work on a specific project. In this case, step 1 is not necessary as the project is already clear, so the team should move onto step 3.

If, however, the team does not have a specific project assigned, it should begin by conducting a **Brainstorming Session** to identify potential projects. Projects which impact directly on customer satisfaction should receive priority. Two types of Brainstorming can be used:

1) **Structured** Brainstorming requires that each person be given an opportunity to suggest an idea in turn, in rotation around the table or to say "Pass". Once a person has given an idea, he/she must keep silent until the next round. This type of brainstorming gives each member the same opportunity to suggest ideas and keeps vocal members from dominating the group. It allows shy people to contribute, but may become somewhat formal.

2) **Unstructured** Brainstorming allows people to contribute ideas as they come to mind. It tends to create a more relaxed atmosphere, but can lead to domination by vocal members.

First, the group should be clear on who their customer is. Projects that impact directly on the customer should be given priority.

Whichever type of brainstorming is used, the leader must make it clear to everyone what the rules are. Several key rules should be followed.

Brainstorming Rules: (Memory Jogger ref: page 69)

1. Write down the Brainstorming Topic: **e.g. Possible Improvement Projects**
2. Everyone participates in turn around the group.
3. "Pass" rule allows people to pass their turn relieving pressure to contribute.
4. Every idea must be recorded as suggested. Use a flip chart or overhead projector.
5. Never criticize ideas, this only dampens participation.
6. Keep process moving (i.e. freewheeling). 5-15 minutes works best.
7. Don't allow discussion early on. This bogs down the session.
8. Keep going until ideas are exhausted. Post the Brainstorming record so that people can add to it.

Note: rules 2 & 3 do not apply to unstructured brainstorming.

The objective in Brainstorming is to develop a large number of ideas or issues. It is often helpful to post the Brainstorming record where people can add to it as ides come to mind later on. The concept of "sleeping on it" often pays dividends as key ideas may come to light later on.

An example of a brainstorming session is given below for the topic "Possible Improvement Projects" in a cafeteria.

Possible Improvement Projects	
* *long lines*	* *staff turnover*
* *absenteeism*	* *bad tasting coffee*
* *too hot*	* *freshness of salads*
* *dishwasher breakdowns*	* *poor pastry*
* *flies*	* *slow cash line*
* *people getting free food*	* *juice machine leaks*

STEP 2: SELECT TOP CANDIDATES FROM LIST

Once brainstorming is complete, the group can then begin the task of critically examining each item in order to focus attention on the top items. This is necessary as the group will get bogged down if it attempts to work on too many problems at the same time. There are two generally accepted methods for doing this: **Voting** and **Nominal Group Techniques**.

Voting to Narrow Down List

In this method, the leader points to each item in turn and asks "How many would like to vote for this item?" Group members are instructed that they may vote for as many items as they wish, but should only vote for those that they would like to see the group tackle. Voting is usually by a show of hands. The number of votes is recorded beside each item. The leader then circles the items with the most votes which may be 3 to 5 items. These are then the ones that the group will focus on.

It should be noted that before voting takes place, it is important to engage in a general discussion of the ideas listed. It is a good practice to go over each item and ask for clarification. This will ensure that everyone understands the rationale behind each idea and can then vote intelligently. It is also important that the leader clarifies the criteria for voting. (i.e. most costly problem, the one we would like to work on, the one we feel is most important to customer satisfaction, etc.) It may be necessary to develop a matrix and rank the ideas according to a number of criteria (see below). The list after voting might look like this:

Possible Improvement Projects	
** long lines 8*	** staff turnover 3*
** absenteeism 6*	** bad tasting coffee 8*
** too hot 5*	** freshness of salads 9*
** dishwasher breakdowns 3*	** poor pastry 4*
** flies 9*	** slow cash line 5*
** people getting free food 8*	** juice machine leaks 2*

STEP 3: IDENTIFY THE #1 PROJECT AND DEVELOP PROJECT OBJECTIVE

At this point the group must select a project or projects to work on. Normally, groups will select only one project at a time, however it is possible to work on several concurrently, especially if the group needs to wait for some action to take place before it can move on with a project. During such "dead time", the group may wish to start another project. The top project candidates as selected in step 2 can now be examined more closely. Two techniques can be used to do this. These are: **1. Nominal Group Techniques** and **2. Matrix Criteria Ranking**.

Nominal Group Techniques (Memory Jogger ref: Pages 70-71)

When selecting which problems to work on and in which order, frequently the most vocal members are able to sway the group vote such that their personal views are adopted. This may lead to the feeling by some members that the project selected is not **their** project but one put forth by someone else. One way to avoid this is to use a ballot type voting process known as nominal group techniques. This works especially well in narrowing the list from the top 5 to one project.

The steps in **Nominal Group Techniques** are as follows:

1. Write down the top 5 problems (potential projects) and assign letter designations such as A.B.C.D. & E. In our cafeteria, these might be:

   A. long lines
   B. bad tasting coffee
   C. flies (flying insects)
   D. freshness of salads
   E. People getting food for free

2. Each member is given a piece of paper and asked to write down the 5 letters A to E. Opposite each letter each member writes a number from 5 to 1, giving the most points to the problem that they would like to see selected as the group project 5 points. The next most important would be assigned 4, then 3, 2 and the least important 1 point.

E.g. Sally: A. 5 John: A. 4 Sue: A. 5 Pete: A. 5

B. 3	B. 3	B. 2	B. 1
C. 4	C. 5	C. 1	C. 2
D. 1	D. 2	D. 4	D. 4
E. 2	E. 1	E. 3	E. 3

3. The next step is to summarize all the points on one sheet, and to add these across for each letter. The project with the highest number of points is selected as the one the group will work on. The other projects can be ranked in descending order.

E.g. A. 5+4+5+5 = 19 ***** #1 Project selected
B. 3+3+2+1 = 9
C. 4+5+1+2 = 12
D. 1+2+4+4 = 11
E. 2+1+3+3 = 9

Matrix Criteria Ranking

In this method, members are given an opportunity to identify the criteria by which the top 5 projects will be assessed. This is helpful in giving the group a chance to "think through" what a particular project might entail. Often, members may select a project without having given the implications of the project enough forethought. This method allows the group to rank each project candidate according to predetermined criteria. The idea is to assess the voice of the customer and to work on truly important projects. The steps in this method are as follows:

1. Members make a list of the criteria by which projects will be assessed (by brainstorming) and select the top 5 (by voting).

E.g. 1. Impact on Customer satisfaction
2. Impact on health & safety
3. Ease of solution
4. Our ability to control this
5. Amount of Aggravation to staff

2. A Matrix is created where the projects are listed down the left side and the criteria across the top.

Criteria

	1.	2.	3.	4.	5.	Totals
A. long lines						
B. bad tasting coffee						
C. flies (flying insects)						
D. freshness of salads						
E. people getting food for free						

3. Then each group member assigns points to each project according to the 5,4,3,2,1 point scale described in Nominal Group Technique, except that the member does so **for each criterion**. In other words, Sally would rank each project based on criteria 1, Impact on customer satisfaction, then again for 2. Impact on health and safety and so on.

Then the totals for all members by criteria would be placed in the matrix diagram and the points totalled across. The project with the most points would be the choice for the team project. The completed diagram would look like this:

Criteria

	1.	2.	3.	4.	5.	Totals
A. Long lines	20	9	12	16	16	73
B. Bad tasting coffee	10	9	13	9	6	47
C. flies (flying insects)	18	20	14	10	15	77
D. freshness of salads	10	15	10	10	7	52
E. people getting food for free	2	7	11	15	16	51

Note that this time, "flies" became the number 1 project.

Criteria Cross Ranking

Another refinement of this technique is to weight the criteria against each other. For example, "customer satisfaction" should carry more weight in our project selection than "ease of solution". It is considered 5 times as important, so it is given a 5 and "ease of solution a .2 (inverse of 5 is .2 or 1/5) . The rankings are then added horizontally and totalled vertically. Each row total is then divided by the grand total to give a fractional ranking in brackets. These fractional ranks are then multiplied by the point rankings in the original matrix.

Criteria Criteria	1	2	3	4	5	Total
1. Customer Satisfaction		2	5	5	5	17 (.43)
2. Health and safety	.5		5	3	4	12.5 (.32)
3. Easy to Solve	.2	.2		3	2	5.4 (.14)
4. In our control	.2	.33	.33		2	2.86 (.07)
5. Aggravation to staff	.2	.25	.5	.5		1.45 (.04)
					Total	39.21(1.0)

STEP 3B: DEVELOP PROJECT (PROBLEM) STATEMENT, OBJECTIVES & CTQ'S

Once the project has been identified, an important step is to define the project (or problem) as specifically as possible. A one-word project i.e. "flies" is much too ambiguous. The problem (hence project) must be defined. "The presence of flies in the cafeteria" is an improvement, however it could still be improved.

For example:

> "Our problem is that the presence of flies in and around the food creates a risk of disease transmittal, leaving our customers with an uneasy feeling about the sanitation level, thus leading to a potential loss of business and health risk to our customers."

A good problem statement should contain as many of the following elements as possible:

1. What exactly is the problem?
2. Why is it a problem?
3. When did it start?
4. Where is the problem?
5. Who is involved?
6. How large is the problem?

5W's & H

These are sometimes referred to as the 5 W's and an H (What, Why, When, Where, Who & How). Taking the time to wrestle with these issues, will force the group to consider what it knows about the problem and, more importantly, what it doesn't know and needs to find out.

Project Objectives & Critical To Quality Characteristics (CTQ's)

Closely related to the development of a problem statement is the definition of the Project Objectives. Here the group should attempt to define exactly what the project is about and what it is not about. Project objectives are important because they:

Goals

* provide direction
* crystallize thinking
* provide for a challenge
* allow for measurement of progress
* define constraints
* allow for success
* enhance commitment
* enhance team spirit

The project objectives might be several or may be summarized in one succinct statement. For the problem of "flies" described above the Project Objective statement might read:

"Our objective is to completely eliminate the presence of all flies in the cafeteria and to do so in a manner that is environmentally safe."

A time frame may be added to the project statement, however, it is often difficult to predetermine exactly how long the project should take. One difficulty in setting a time objective is that, if not met, can be demoralizing, and if set too far ahead can lead to foot dragging. The important thing is to make progress.

An important aspect of developing the project objectives is to determine how progress will be **measured from the viewpoint of the customer**. This is called a **CRITICAL TO QUALITY CHARACTERISTIC or CTQ.** Without a method of measurement, the results may be difficult to gage. " Are we making progress?" is an important question that cannot be answered if no measurement method is determined. Here the issues are:

1. What variables are important to the customer? These are the CTQ's
2. How can they be measured?
3. How will this be recorded? By whom? When? When? How Often?
4. What type of chart will be used?
5. How will improvement be gauged? Is this statistically valid?

In the "flies" example, the group will have to devise a measurement system for the number of flies present. The group might come up with something like this:

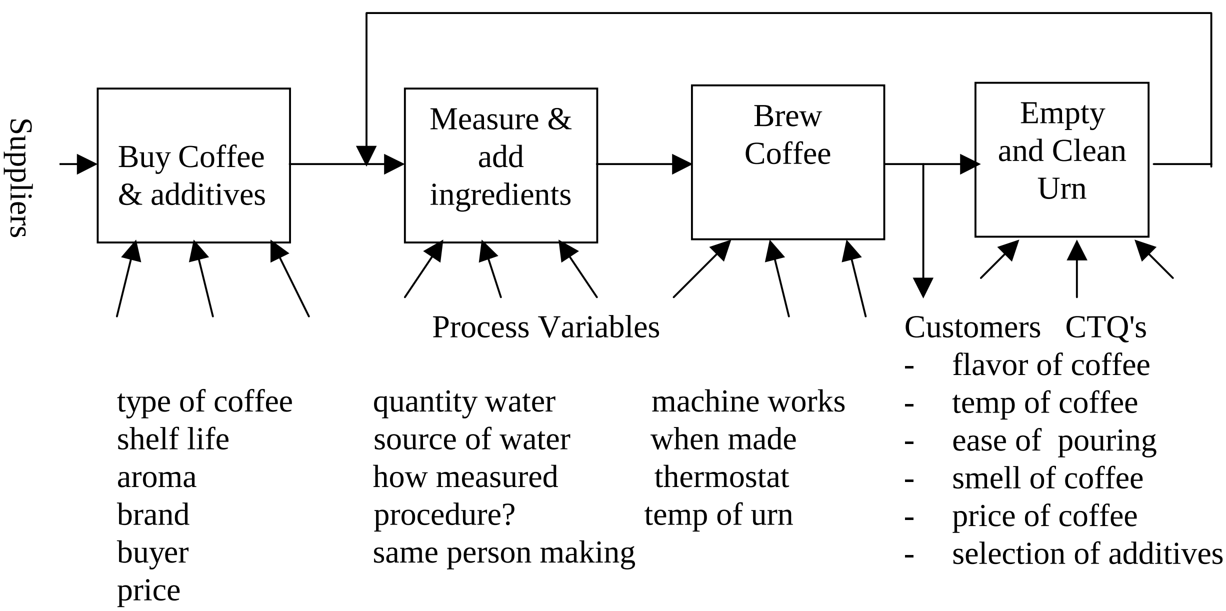
1. With a stopwatch, take a random walk through the area measured scanning counters, tables etc. for flies. Start the stop watch when you begin, stop the watch after 3 minutes.
2. Divide the number of flies spotted by the time in minutes to obtain a fly count of x flies per minute.
3. Chart the number of flies per minute on a c chart.
4. Do one fly count every two hours.

The development of a measurement system will naturally lead the next step in the sequence which is to study symptoms and then develop theories for improvement. Its importance cannot be over stressed.

Map the Process

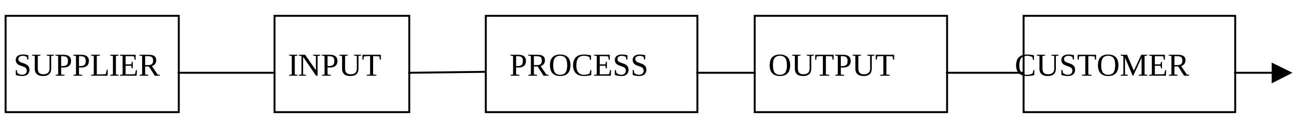
STEP 4: MAP THE PROCESS FLOW

Once Critical to Quality Characteristics (CTQ's) have been identified, the next step is to map the process. Process mapping means looking at the process as a series of inter related steps. The output of one step is the input to the next. The input for any given step comes from a SUPPLIER and the output goes to a CUSTOMER. In addition each process step is subject to operating variables such as methods, machines, manpower, materials and environment (5 M's and an E). The goal of the process is to produce product or service that meets the CTQ's. An example of a process map for the making of coffee in our cafeteria is shown below.



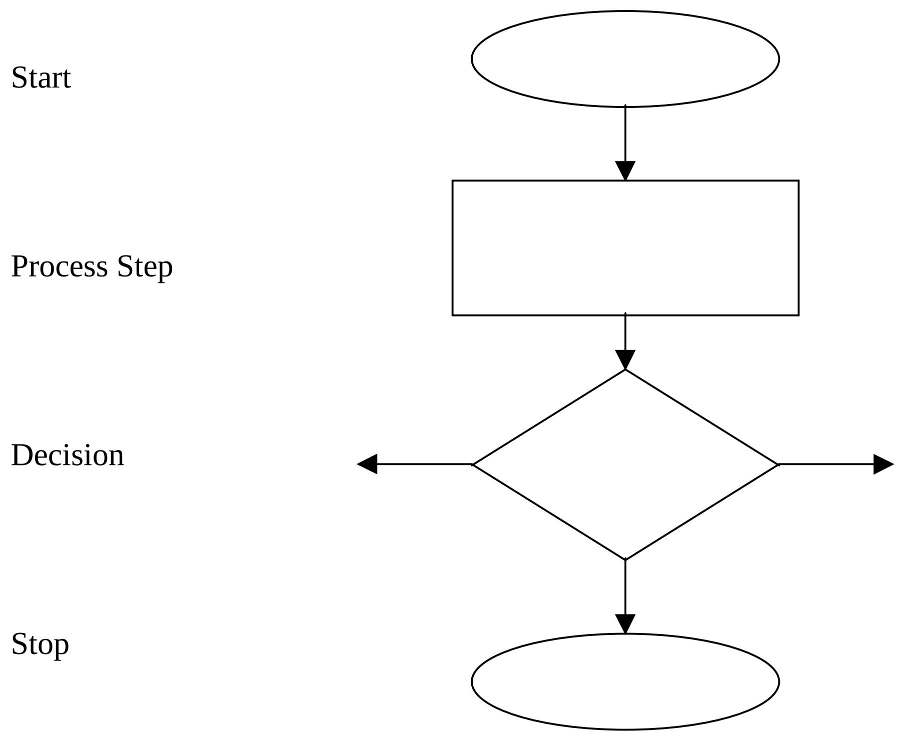
Once the CTQ's are measured and charted, then the team can begin to assess the impact of the process variables on the CTQ's. a data collection plan can then be devised to study the process further. This leads naturally to the next step of the Six Sigma process which is MEASURE. Not only do CTQ's need to be measured, but so also do process variables. As this is done information and data is gathered on the existing process. This data then serves as a launching pad for changes to the process that will bring about breakthrough.

Complex processes can be broken down into a series of steps. For each step, the SIPOC formula is identified. SIPOC stands for:



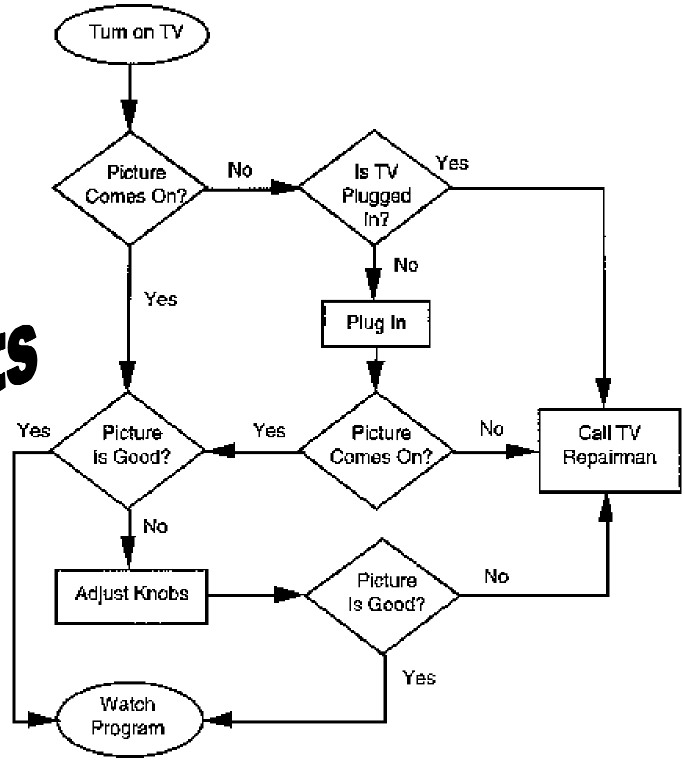
Flow Charts (Memory Jogger ref: pages 9-13)

Flow Charts are pictorial representations of the steps in a process and how they are interconnected. Flow Charts make use of easily recognizable symbols to represent the type of process step. These symbols are:



For example, the process of turning on a television could be represented as follows:

Flowcharts



The flow chart is useful in a problem analysis technique called **IMAGINEERING**. In this process, the people with first hand knowledge of the process meet to:

1. Draw a Flow Chart of the process as it actually flows.
2. Draw a second Flow Chart of the process flow as it should be.
3. Compare the two charts to find where they are different because that is where the improvement opportunity is.

Other questions that are useful in analyzing a process Flow Chart are:

1. Does each step add sufficient value?
2. Can this step be eliminated?
3. Can this step be completed in less time?
4. Can this step be completed at less cost?
5. Can another person/area better perform this step?
6. Can the step be simplified, reduced or changed?
7. Are appropriate customer requirements in place?
8. What are the key variables in this step?
9. Are appropriate controls in place?

STEP 5: CHARACTERIZE CTQ's AND PROCESS VARIABLES

In this step of the improvement process, members engage in analytical work that is designed to gather **factual data** about the process or problem. Critical to Quality (CTQ) characteristics must be identified and along with a way of measuring them (metric). Without a metrics, there is no way of knowing if our improvement efforts are having an effect. Process Variables should have been identified as part of the Process Mapping step. These variables must also be measured and characterized using statistical measures. This is an extremely important step, for if the group is to steer clear of opinions and myths, it must base its analysis on supportable factual evidence. Gathering data is the objective of this step, in order to shred light on the exact nature on the process or the problem being studied.

3.3.5.1 Types of Data

In studying a process, it is important to recognize that there are two distinct types of data. These are **Variables** data and **Attributes** data. **Variables data** is data which results from **measurements** and hence can vary over a continuous scale. Examples are: length, size, weight, volume, speed, time, viscosity, concentration and so on. **Attributes data** is data that is the result of Go/No Go decisions, i.e. **counted** data. Examples are; the number of defects in a lot, the number of defective units in a sample, etc.

	Variables Data	Attributes Data
	Measured	**Counted**
Examples:	Weight, temperature, size voltage, pressure, viscosity speed, volume, resistance, concentration, etc.	No. of defective units Percent defective units No. of defects Defects per unit
Distributions:	Normal Exponential Weibul	Binomial & Neg. Binomial Poisson Hypergeometric

Note that it is very important to clearly differentiate between these two types of data because the mathematical distributions that describe them are entirely different (see page 3-16). This will impact us when we attempt to calculate Statistical Control Limits for Control charts.

Essentially, variables data is measured data that is **qualitative** telling us how big or how much of something we have. Attribute data is **quantitative** or **defect type** data that tells us how many, what percentage of defects or parts per million defective we have.

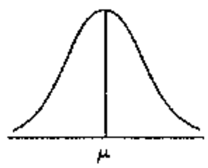
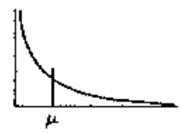
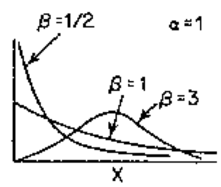
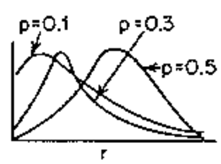
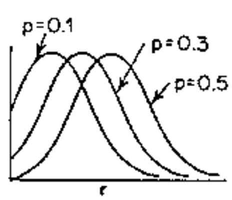
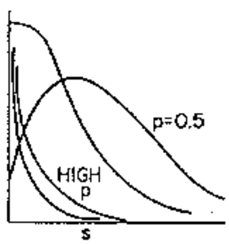
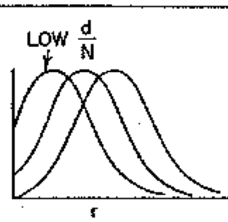
DISTRIBUTION	FORM	PROBABILITY FUNCTION	COMMENTS ON APPLICATION
NORMAL		$y = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(X-\mu)^2}{2\sigma^2}}$ μ = Mean σ = Standard deviation	Applicable when there is a concentration of observations about the average and it is equally likely that observations will occur above and below the average. Variation in observations is usually the result of many small causes.
EXPONENTIAL		$y = \frac{1}{\mu} e^{-\frac{x}{\mu}}$	Applicable when it is likely that more observations will occur below the average than above.
WEIBULL		$y = \alpha\beta(X-\gamma)^{\beta-1}e^{-\alpha(x-\gamma)^{\beta}}$ α = Scale parameter β = Shape parameter γ = Location parameter	Applicable in describing a wide variety of patterns of variation, including departures from the normal and exponential.
POISSON*		$y = \frac{(np)^r e^{-np}}{r!}$ n = Number of trials r = Number of occurrences p = Probability of occurrence	Same as binomial but particularly applicable when there are many opportunities for occurrence of an event, but a low probability (less than 0.10) on each trial.
BINOMIAL*		$y = \frac{n!}{r!(n-r)!} p^r q^{n-r}$ n Number of trials r = Number of occurrences p = Probability of occurrence q = 1−p	Applicable in defining the probability of r occurrences in n trials of an event which has a probability of occurrence of p on each trial.
NEGATIVE BINOMIAL*		$y = \frac{(r+s-1)!}{(r-1)!(s!)} p^r q^s$ r = Number of occurrences s = Difference between number of trials and number of occurrences p = probability of occurrence q = 1−p	Applicable in defining the probability that r occurrences will require a total of r + s trials of an event which has a probability of occurrence of p on each trial. (Note that the total number of trials n is r + s.)
HYPERGEOMETRIC*		$y = \frac{\binom{d}{r}\binom{N-d}{n-r}}{\binom{N}{n}}$	Applicable in defining the probability of r occurrences in n trials of an event when there are a total of d occurrences in a population of N.

Fig. 22-3 Summary of common probability distributions. Asterisks indicate that these are discrete distributions, but the curves are shown as continuous for ease of comparison with the continuous distributions.

Variables Data Analysis Techniques

There are a number of basic variable data analysis techniques that we will look at in this section. These are:

1. Measurement Checklists
2. Histograms
3. Run Charts
4. Bar Charts
5. Pie Charts
6. Scatter Diagrams

Other advanced variable analysis techniques are Process Capability Analysis and Statistical Control Charts for variables. These are statistical techniques that are covered in the section entitled Statistical Process Control.

Measurement Checksheets (Memory Jogger ref: page 40)

Measurement Checksheets or Tally Sheets are designed to collect data from a process where the same measurement is being repeated. They are also referred to as Frequency Tables. For example, in a toaster assembly operation, the final test of toaster timings gives data on how long it took each toaster to trip measured in seconds. The operators take this data and fill out a tally sheet as shown. Experience tells them that the timings can range from 60 to 130 seconds so they divide the tally sheet into 10 second intervals. The raw data from the process and the checksheet are shown below.
Data (seconds)

Data (seconds)

95	87	110	113	85
78	92	101	115	78
81	81	61	109	103
73	74	122	60	102
101	66	109	77	93
91	84	116	87	107
93	74	123	100	80
102	95	115	81	94
99	124	93	60	93
93	108	90	95	64

	TALLY	Totals
60 - 69	/////	5
70 - 79	//////	6
80 - 89	////////	8
90 - 99	/////////////	13
100 - 109	//////////	10
110 - 119	/////	5
120 - 129	///	3

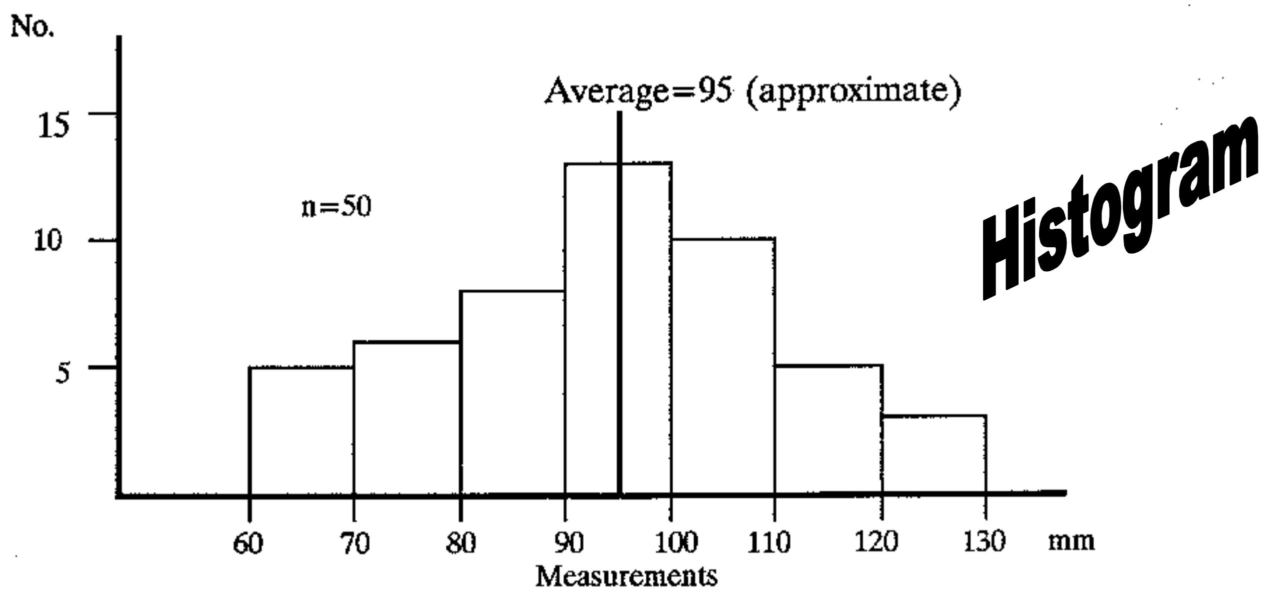
Range = Largest - Smallest = 124 - 60 = 64, 7 classes, class interval = 10

Histograms (Memory Jogger ref: pages 36-43)

A Histogram is a bar chart which graphically represents the distribution of **repeat measurements** over a continuous scale. The histogram gives us insight into the amount of variation that a process has and typically is the first step in determining the capability of a process.

To construct a Histogram, the following steps apply:

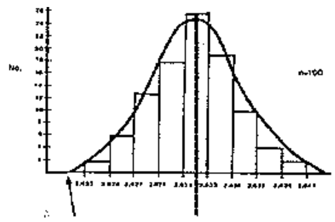
1. Collect a random sample from a process that is stable (i.e. not changing).
2. Measure each sample for the characteristic being studied. (i.e. trip time in seconds). Show this data on a data sheet (as per Page 3-17).
3. Find the range, R, of the measurements by taking the largest reading and subtracting the smallest. (i.e. Range = Largest - Smallest.) In the example on Page 3-17, R=124-60 or 64.
4. Determine the number of classes, K, to be used in the tally sheet by taking the square root of the sample size and rounding to the nearest whole number (i.e. if sample size = 50, the number of classes, K is the square root of 50 or 7.
5. Determine the class interval by dividing the range by the number of classes (i.e. 64 divided by 7 or 9.1). This is then rounded to the nearest whole number and may be adjusted to give logical increments (i.e. 5, 10, 15, 20 etc.). In this case we will use a class interval of 10.
6. Construct the tally sheet (checksheet) and post the data to it (see Page 3-17).
7. Construct a Histogram based on the checksheet. Here the number of measurements in each class are plotted up the left side and the measurement classes are plotted along the bottom. Once a scale has been determined, the bars of the histogram are drawn in so that they but up against each other.



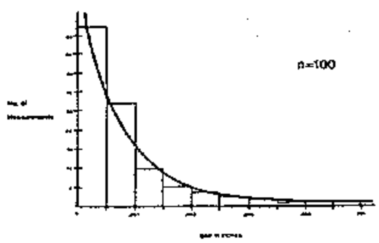
Interpreting Histograms (Memory Jogger ref: pages 36-37, 64-68)

Once the histogram has been drawn, it can then be studied to determine the nature of the process. Note that the Histogram will have a certain **Shape, Centre, and Spread.**

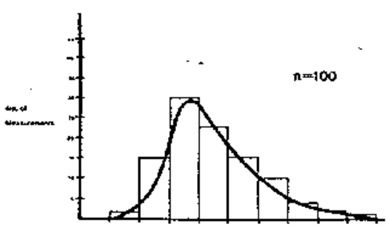
It should be noted that the exact shape of the Histogram may vary from sample to sample due to the randomness of **Sampling Variation**. This does not necessarily mean that the process has changed but that the randomness of sampling is being observed. If the histogram is based on a very large sample (i.e. 200), then the shape becomes more meaningful as sampling variation is reduced. The shape of the histogram gives clues as to the process that it represents.



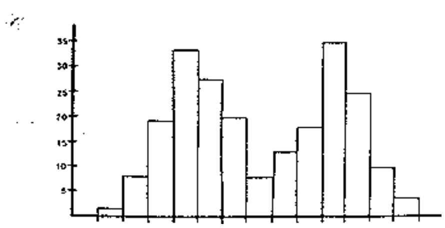
Normal Distribution: This shape is caused by many small random causes of variation that are equally likely to give variation on both sides of but close to a central value. It is the most common distribution.



Exponential Distribution: This distribution occurs when some natural barrier creates a greater likelihood that the process will be dispersed only to one side of the peak.



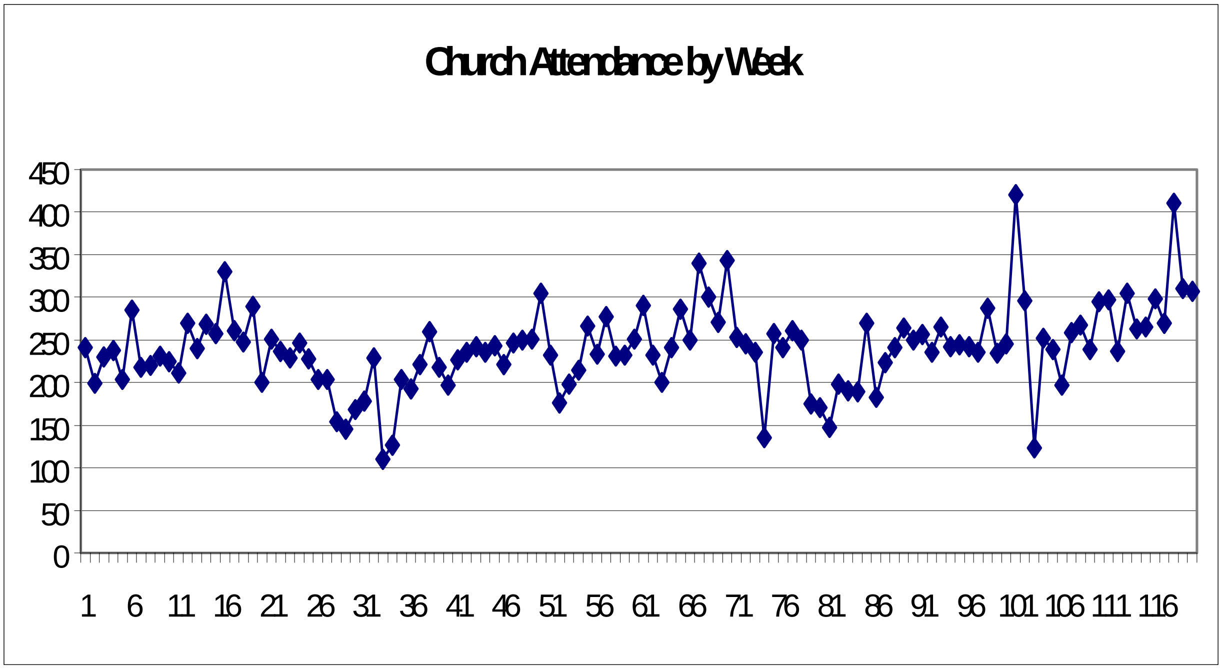
Skewed Distribution: This distribution is caused random causes of variation that are more likely to cause greater dispersion on one side of the peak than the other. It may also be the result of a normal distribution that has recently shifted.



Bimodal Distribution: This is the result of two primary sources of variation centred in two different places.

Run Charts (Memory Jogger ref: pages 30-31)

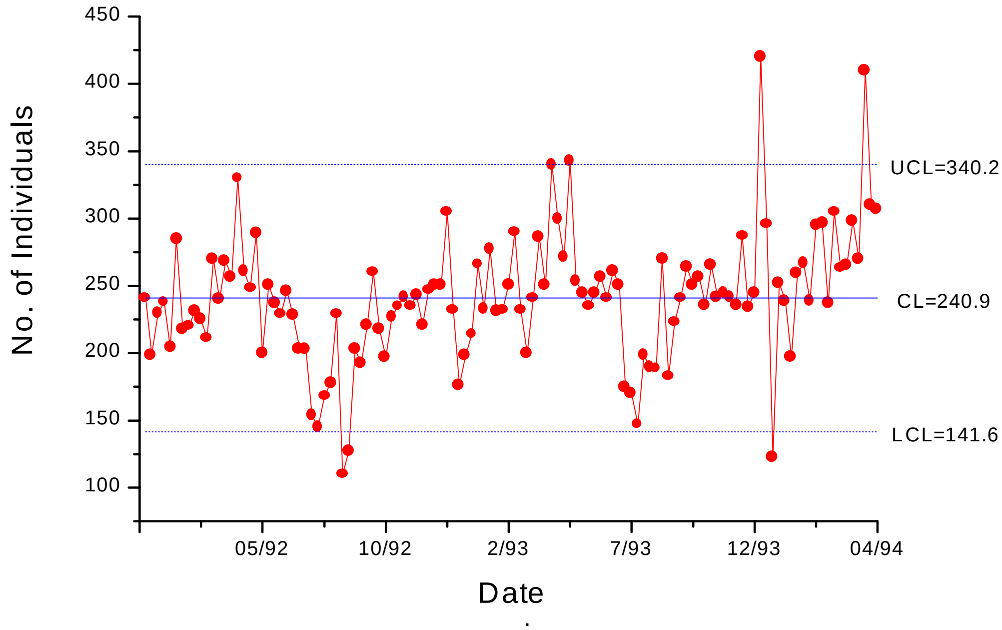
A run chart is simply a line graph that depicts the value of a variable measurement over a sequential period of time. Normally the variable measurement is recorded up the left side and the time across the bottom. The variable plotted could represent temperature, humidity, length, voltage, pressure, sales volume etc.



The scale on the left side is normally selected so that the total extent of variation is displayed. A Central Line is often drawn which might represent the average of all plot points or the target value that is sought.

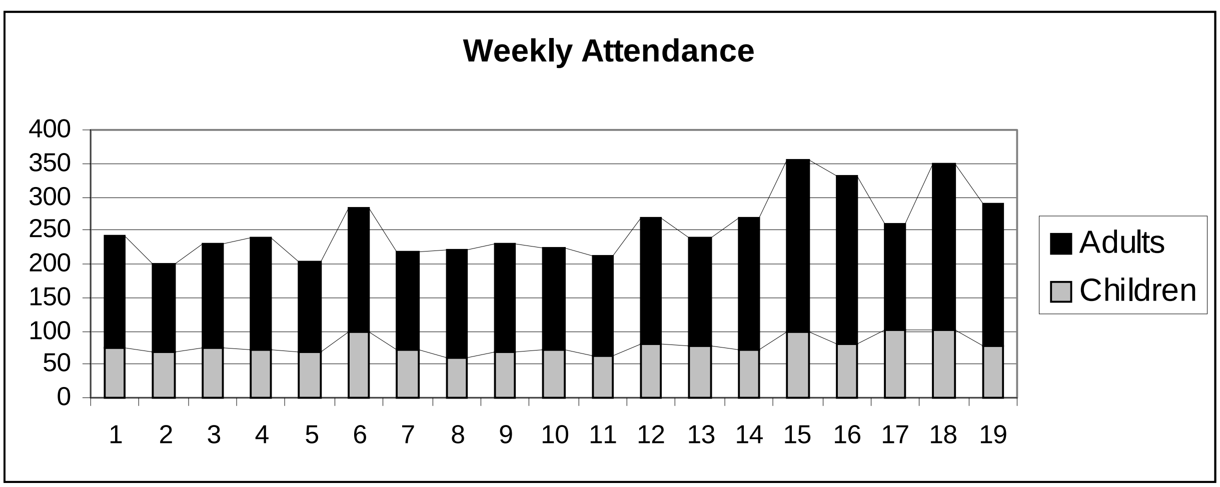
One difficulty with a run chart is that it is impossible to tell how much of the variation is "natural", i.e. part of the system, and how much is "unnatural" or the result of specific causes. In order to do so, we must calculate statistical control limits for the chart. This is covered in more detail in the section on Statistical Process Control. However, simple runs (i.e. 7 or more points on the same side of a historical average, are significant and indicate that something has changed on a run chart. The same chart above plotted with a central line and Statistical Control lines is shown below. Notice how much easier it is to identify special causes once Control lines have been established.

Church Attendance by Week



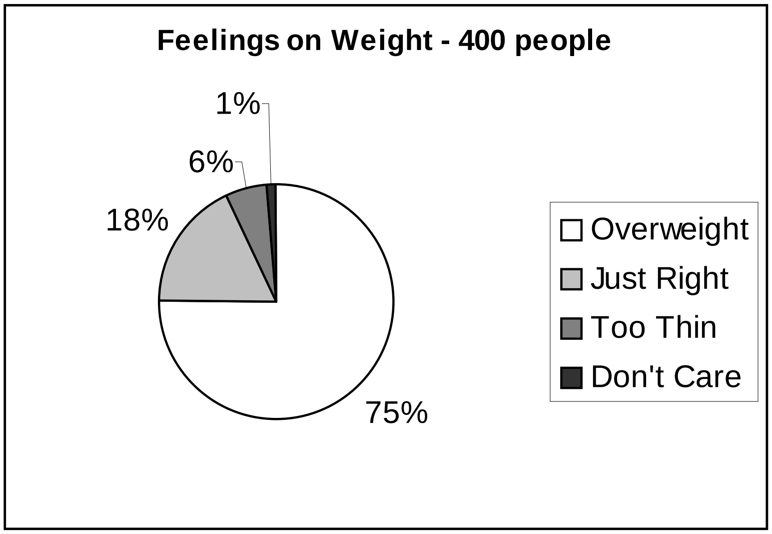
<u>Bar Charts:</u> (Memory Jogger ref: page 77)

Bar charts can be used for either variables or attributes data and are particularly useful in comparing several categories or sources of information. For example, the bar chart below shows the weekly church attendance for the first 19 weeks of the year showing number of children as well as adults. Bars can be shown adjacent to each other or stacked to display how several categories make up the total.



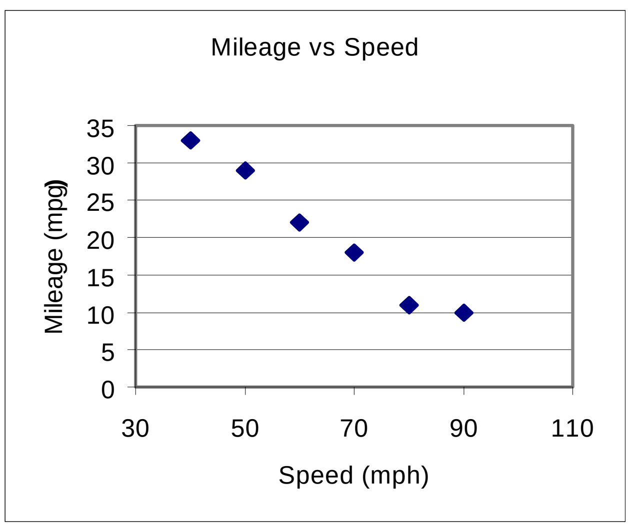
Pie Charts: (Memory Jogger Ref: page 75)

Pie charts are useful in displaying what portion of the whole is represented by various categories. Here the angle sector occupied by a particular category is obtained by multiplying the fraction proportion by 360 to get the degrees of angle sector. For example, in the pie chart shown, the angle for "Just Right" is calculated by multiplying the fraction 72/400 times 360 to get 64.8 degrees. This can then be drawn on the pie using a protractor.



Scatter Diagrams: (Memory Jogger ref: pages 44 - 50)

A scatter diagram is used to study the possible relationship between one variable and another. Although the scatter diagram cannot prove that one variable causes another, it can show that a relationship does or does not exist and can show the nature and strength of the relationship.



To construct a scatter diagram, the following steps apply:

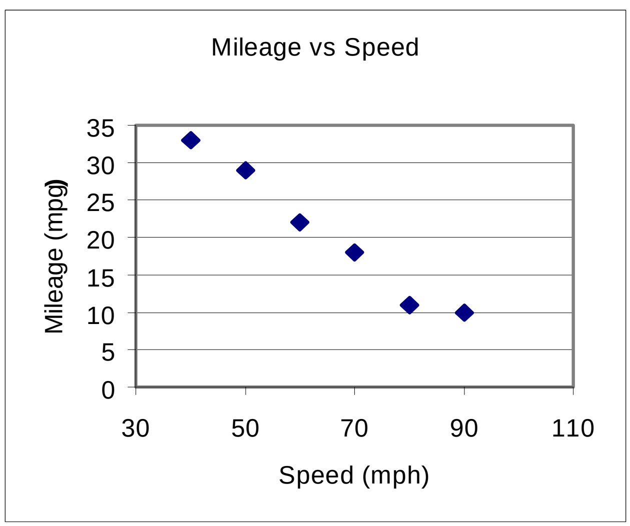
1. Collect pairs of data by measuring the two variables that you suspect may be related at the same time.

Trial	Speed	Mileage
1	40	33
2	50	29
3	60	22
4	70	18
5	80	11
6	90	10

2. Draw the horizontal and vertical axis of the scatter diagram. Normally the independent variable is plotted along the bottom and the dependent variable up the left side. Here, we suspect that Gas Mileage depends on Vehicle Speed so we plot Gas Mileage up the left side. The scales are selected such that the full range of values for each variable can be accommodated.

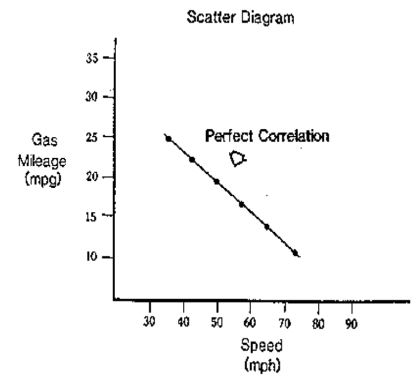
3. Plot the data on the scatter diagram. Each dot corresponds to one data pair. If two data points coincide, the can be shown as a concentric circle or simply as two points nestled together.

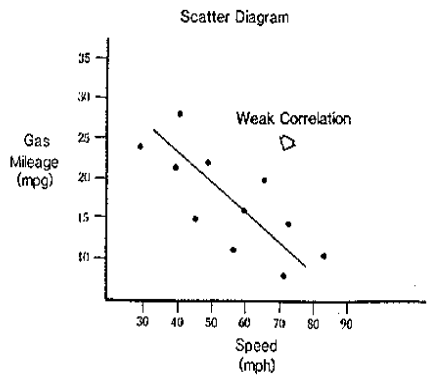
Scatter Diagrams

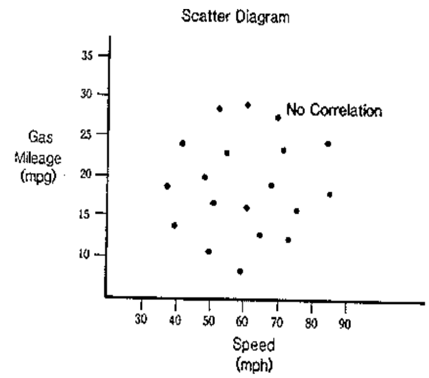


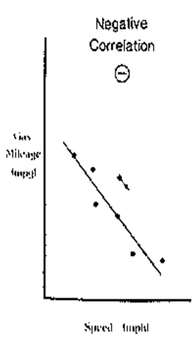
Interpreting Scatter Diagrams:

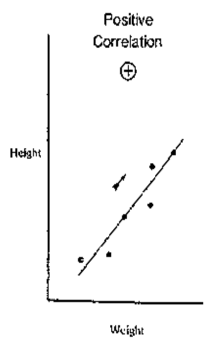
The pattern formed by the data points gives us clues about the relationship. If one variable increases as the other increases, this is called **positive correlation**. If one variable decreases while the other increases, this is called **negative correlation**. If the pattern formed by the dots is a straight line, it is called a **linear correlation**. If the pattern has a definite curve, it is called **non-linear**. If the dots are clustered close together, the correlation is said to be **strong**. If the points show a great deal of scatter, the correlation is said to be **weak**. The scatter diagrams below show examples of these.

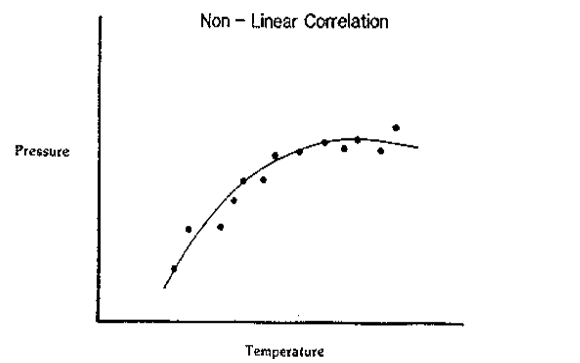












Attribute Data Analysis Techniques:

Defect-Type Checksheets (Memory Jogger ref: pages 14-16)

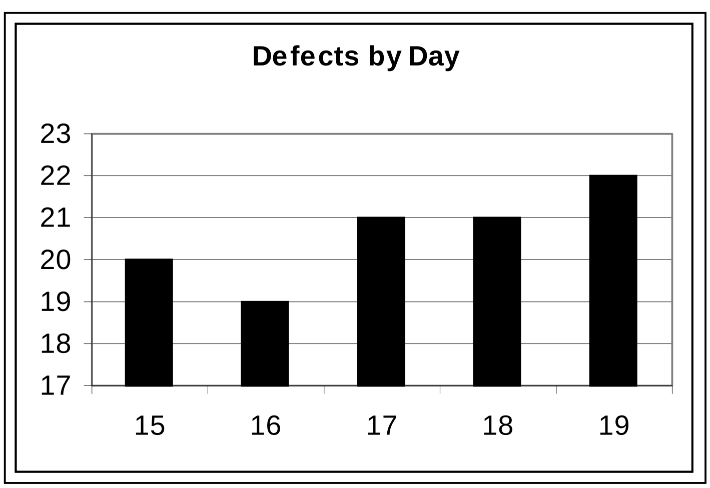
Defect type checksheets are used for attribute or counted data where the occurrence of certain types of defects is being counted. Here the object is to record the type of defect and when it occurred.

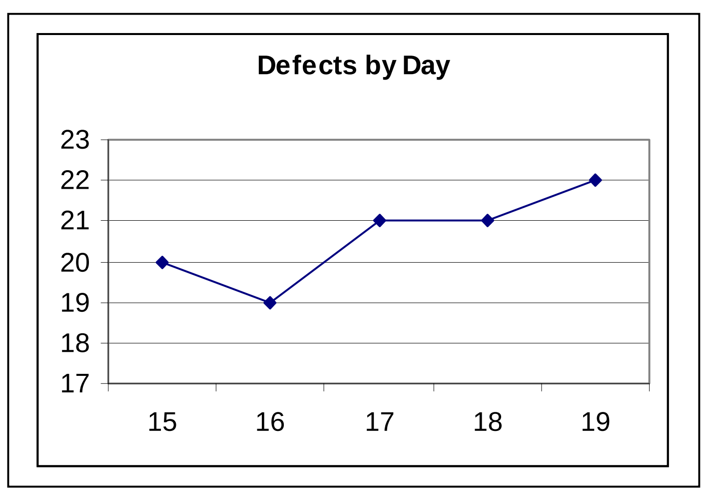
The steps in constructing a defect-type checksheet are as follows:

1. Agree exactly of the defect categories being observed and what constitutes each type of defect.
2. Decide on the time period to be studied. This could be days, weeks, or months. Also the time intervals will have to be defined.
3. Design a form that will allow you to collect the data. Label the columns and rows clearly.
4. Collect the data and post it to the checksheet.
5. When the checksheet is complete, total the columns and rows.

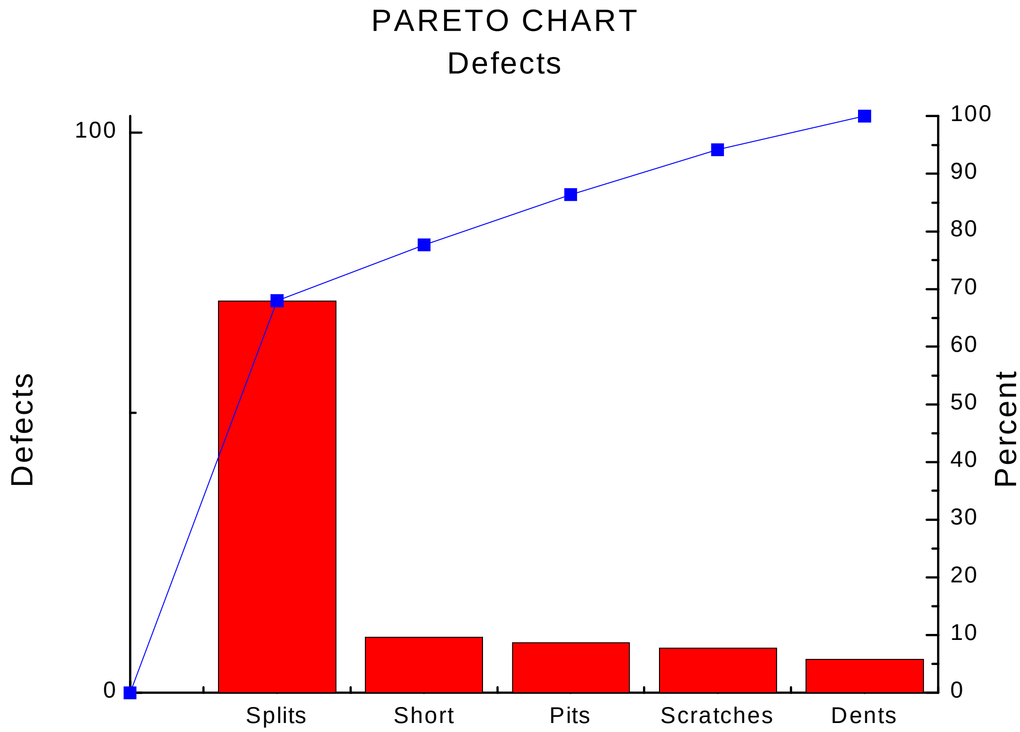
Defect/Day	15	16	17	18	19	Totals
Pits	3	0	3	1	2	9
Scratches	1	3	1	1	2	8
Splits	14	16	13	15	12	70
Dents	0	0	2	1	3	6
Short	2	0	2	3	3	10
Total	29	19	21	21	22	103

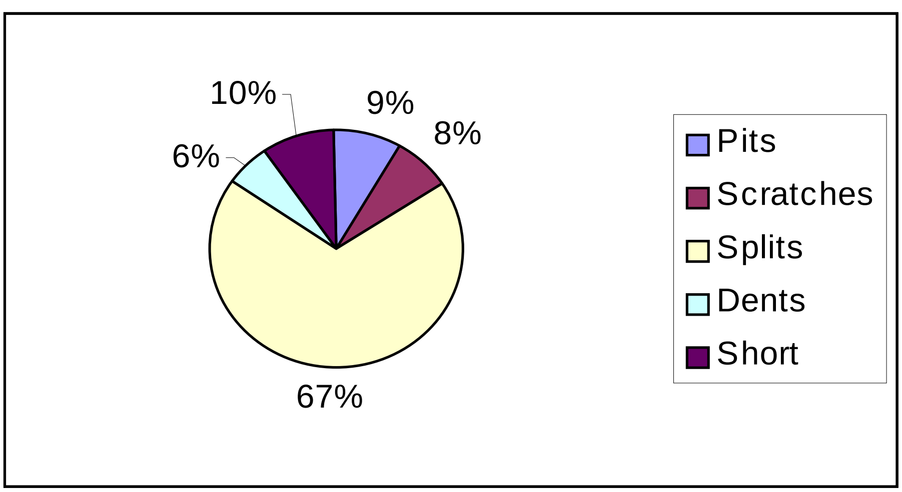
The completed checksheet becomes the basis for data analysis. It will be necessary to display this data on a graphical chart to make interpretation more meaningful. The defect data can be shown over time for each category on a bar chart or a line chart.





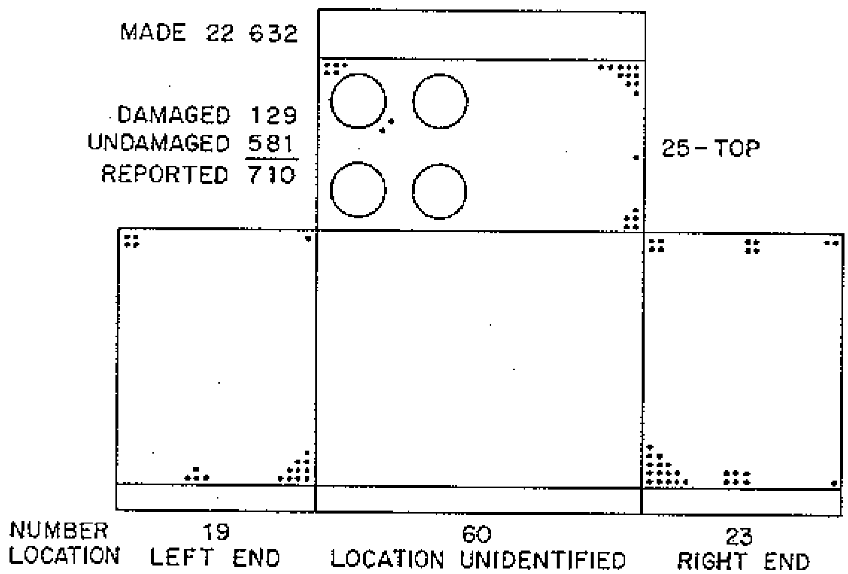
The defect category data can be shown on a specialized type of bar chart called a Pareto Chart. It could also be displayed on a Pie Chart.





Defect Location Checksheets:

Another type of checksheet that is useful for attribute data is the Defect Location Checksheet. Here data is collected on a diagram or drawing of the component or area being studied and symbols are placed on the diagram to indicate the exact location of defects as they occur. The example below shows the location of pits in the surface of a kitchen stove.



Pareto Charts: (Memory Jogger ref: pages 17 - 23)

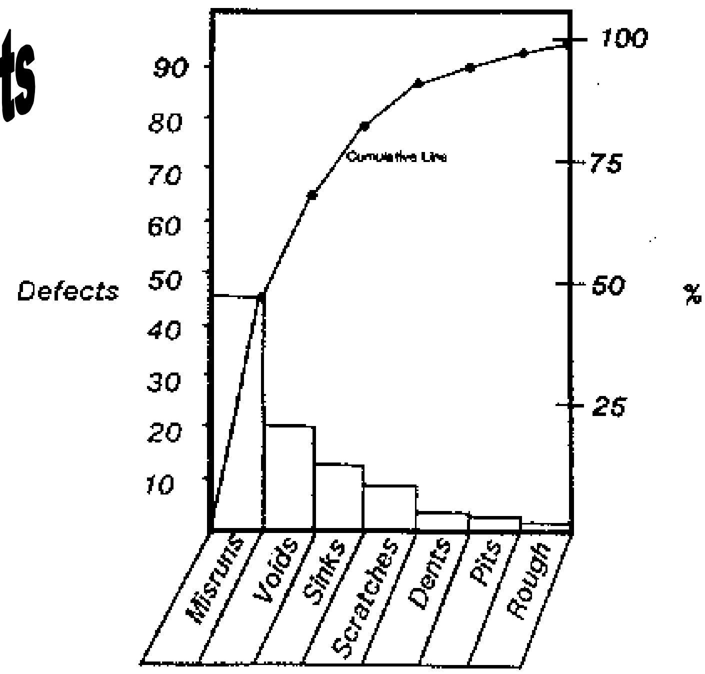
A Pareto chart is a specialized type of Bar Graph that focuses attention on the **Vital Few** Contributors to a problem. It is named after Wilfredo Pareto, an Italian scholar who lived in the 19th century. Pareto observed that the distribution of wealth in Italy was such that 90% of the wealth was held by 2% of the people. He called these the **Vital Few** because they accounted for most of the total wealth. The remaining 98% of the people were the **Trivial Many** because they represented very little of the total wealth. Since then, other scholars have observed that in any breakdown of data, a **Vital Few** categories tend to account for most of the total.

Other examples of the Pareto Principle are:

1. 90% of the absenteeism is caused by 5% of the people.
2. 75% of the defects are concentrated in 2 or 3 items.
3. 90% of the orders are for hamburgers and French fries.
4. 90% of the population of all creatures is concentrated in 10% of species.
5. 85% of the cost of components is concentrated in 10% of the items.

A Pareto Chart is simply a bar graph that depicts the items from left to right in descending order. Often a cumulative line is added to show how the items accumulate as a percentage of total items.

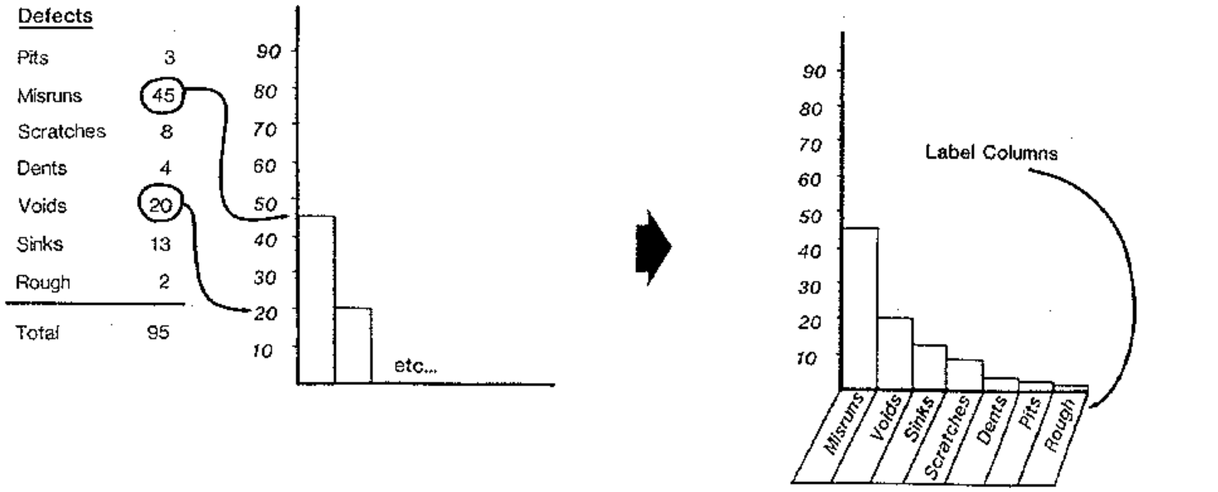
Pareto Charts



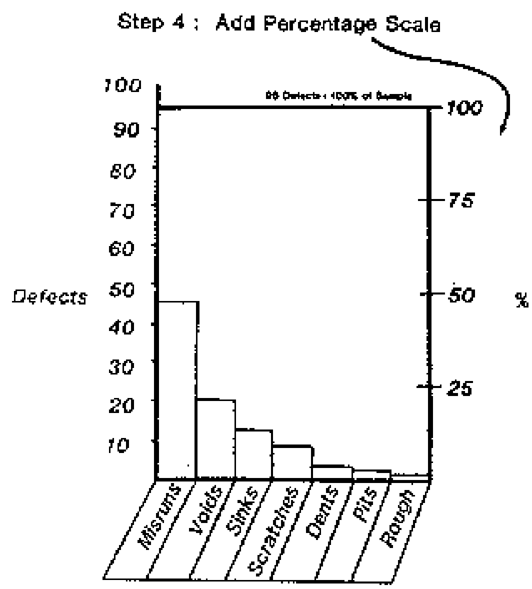
Constructing a Pareto Chart:

The steps in constructing a Pareto Chart are as follows:

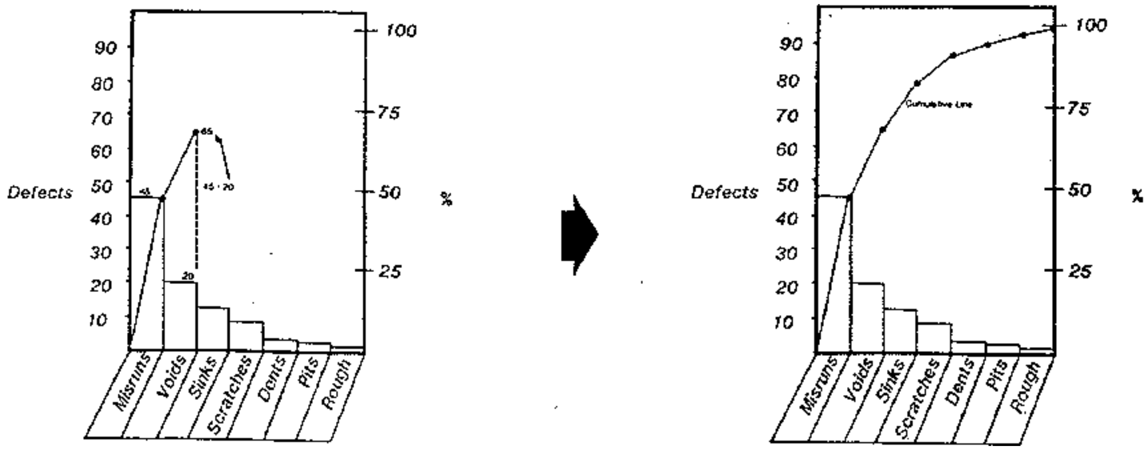
1. Select a sample and categorize the items.
2. Total the items to determine the vertical scale. The top of the scale is the total of the items.
3. Draw in the columns starting from left to right, beginning with the largest item and proceeding to the smallest.
4. Label each column.



5. Create a percentage scale on the right hand side so that the total number of items is equal to 100%



6. Draw in the cumulative line starting at the lower left corner and proceeding to the upper right corner of the first column. Continue the line so that it is x units above the second column because the second column is x units high. Continue until the line reaches the upper right corner of the chart, which is 100%.



Interpreting the Pareto Chart is simply a matter of looking at the first few tallest columns. These are the **Vital Few** items because they account for most of the total. Obviously, if we are going to make an impact on our problem, we must address the **Vital Few**. If we cut each of these by one half, we will have a major impact on the total.

Often one Pareto Chart will lead to another. An analysis of "Splits" might cause us to develop another Pareto Chart on the cause of the splits. Also, often costs or percentages are used as the categories for a Pareto Chart. Pareto charts are useful because they cause us to focus on the **Vital Contributors** to any problem.

STEP 6: THEORIZE ON POSSIBLE CAUSES, DEVELOP MEASUREMENT SYSTEMS, OBJECTIVES AND IMPROVEMENT THEORIES

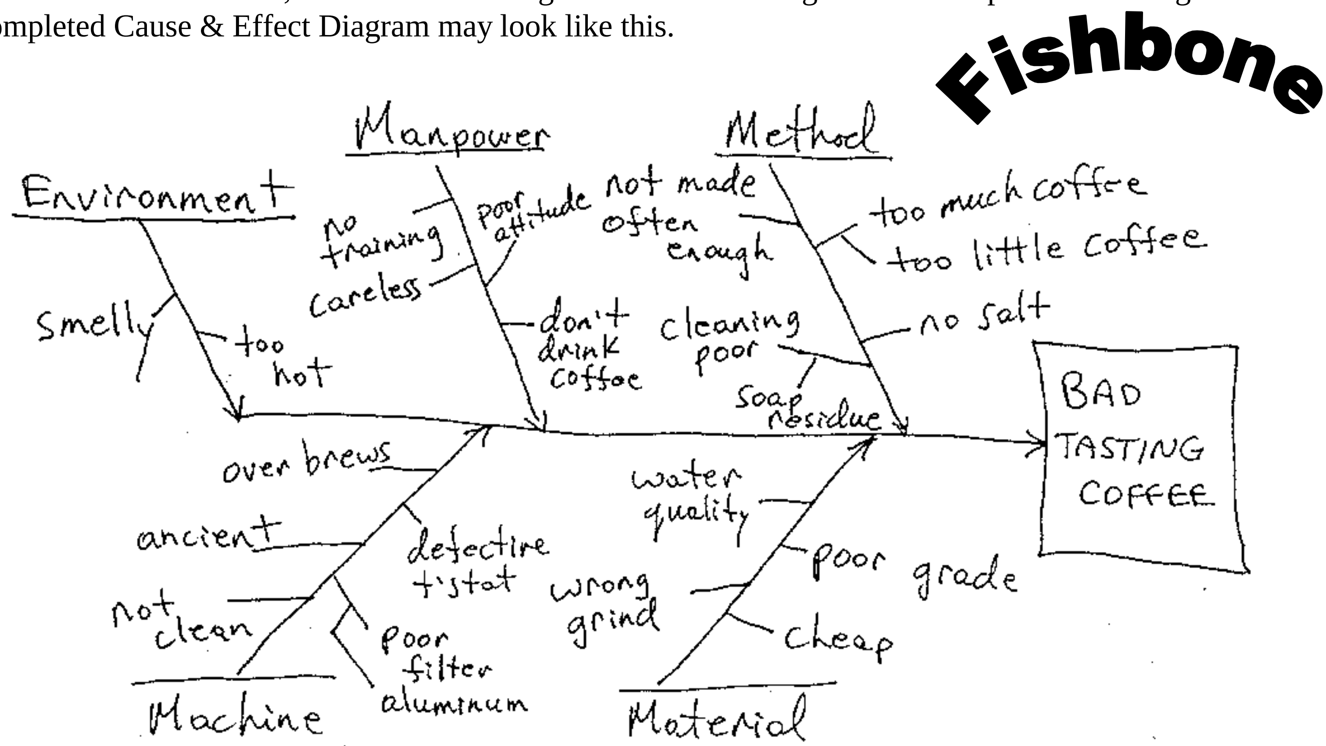
Once data has been gathered and process variables have been studied, the opportunities for process improvement of problem solving should be focused on certain **Vital** areas. For example, a general project statement such as "Improving Customer Satisfaction", in a cafeteria, may be focused on "Improving the taste of coffee", once the data gathered has been analyzed and the vital contributors to "customer satisfaction" have been narrowed down. This, of course is the point of Pareto Analysis studied above. The next step is to take these specific areas or problems and begin to **theorize** on possible causes or areas of improvement. Three excellent and related tools for this step are:

1. Cause & Effect Diagram (Fishbone) 2. Structure Tree 3. CEDAC Diagram

The purpose of each is to help a group or team (or an individual) organize their thinking as to what the possible causes or opportunities for improvement are, and then to develop a plan to test and verify these.

The Cause and Effect Diagram: (Memory Jogger ref: Pages 24-29)

The Cause & Effect Diagram was first developed by Dr. Ishikawa in Japan. It is used to theorize on all the possible causes of an **effect**. The effect to be studied is placed in a box to the right of the diagram. This effect could be a problem (i.e. Bad Tasting Coffee) or could be a desirable effect (Great Tasting Coffee). If the effect is a problem, then all the possible causes of the problem are developed to the left. If the effect is desirable, then all those things that need to be right are developed on the diagram. A completed Cause & Effect Diagram may look like this.



Note that the possible causes are listed under some major headings. These are the generic cause categories and usually consist of the 4 M 's (Method, Manpower, Material, Machines) in manufacturing or the 4 P's (Policies, Procedures, People, Plant) in administrative problems. An E (for Environment) is often added. Once the diagram is developed, then the group can begin to narrow down the "most likely" causes or "vital areas" by a group voting process or by collecting data and investigating to rule out non contributors. These top items are then subject to verification by designing a test or trial run to prove out their impact.

The steps in constructing a Cause and Effect Diagram are as follows:

1. Develop a clear statement of the effect to be studied. This should be as specific as possible. For example, "Scrap" would be a poor effect to use because it is much to general. A better approach would be to focus on one particular type of scrap such as "Porous Castings". This will lead to more specific causes emerging. The effect is placed in the box to the right.

2. Develop the generic cause categories. These could be the 4M's or 4P's and an E. (Methods, Materials, Manpower, Machine; Policies, Procedures, People, Plant and

Environment). These are placed on the Mainframe of the diagram.

3. Conduct a **structured brainstorming** session, where members of the group suggest possible causes or issues in turn around the table. The leader then places these on the diagram under the appropriate heading. Related ideas that are linked should be placed together as sub branches of others under which they fall.

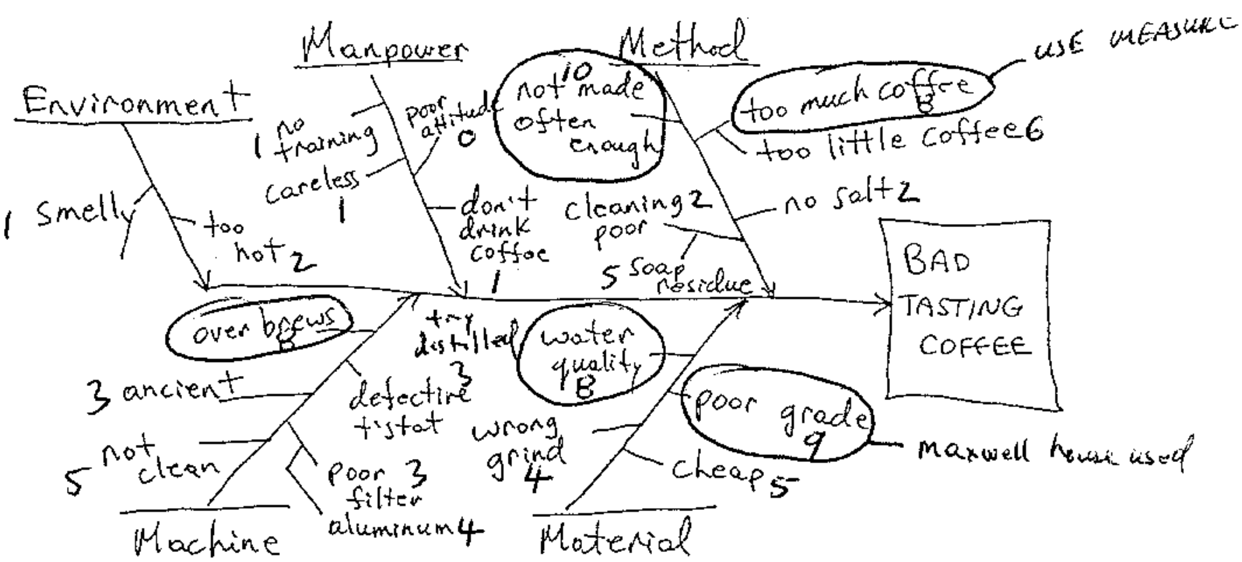
4. For each possible cause, ask "Why does this happen?" This will generate additional branches to the diagram as it grows outwards.

5. Once the brainstorming is complete, then the most probable causes need to be identified. This is done by the voting. The leader points to each cause and asks "How many wish to vote for this?" Members are instructed that they may vote for as many causes as they wish, but should vote only on those they consider to be truly important. Here it is essential that members have a first hand knowledge of the problem or process. The number of votes is recorded next to each cause. The top 5 or 6 vote-getters are circled.

   Another approach is to weed out the improbable causes by gathering data and studying facts. Someone in the group may know that a certain suggested cause can be ruled out because of some specialized knowledge or some check that has been done. In addition, the group can design a scheme to do their own checking to weed out some causes.

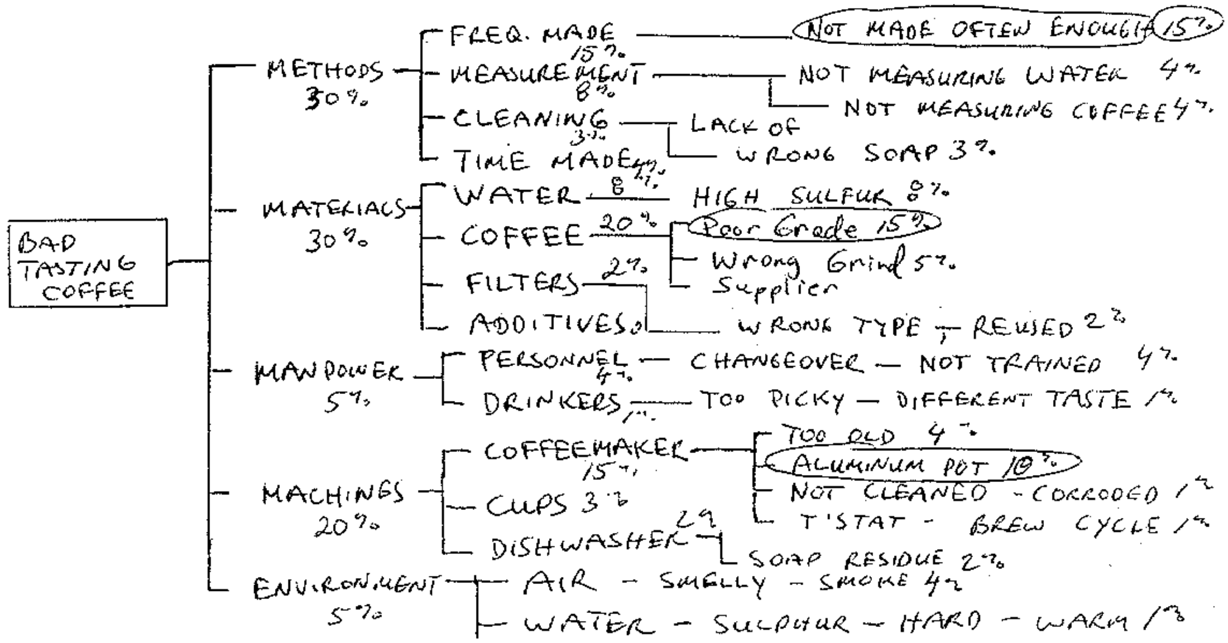
6. Once the most likely causes have been identified, then the group must **Verify** these.

   This is an important step because, up to now, the group only has theories. These theories must be tested. This is the next step of the problem solving process. As theories are tested, the results can be marked on the diagram. The final diagram may look like this:



The Structure Tree:

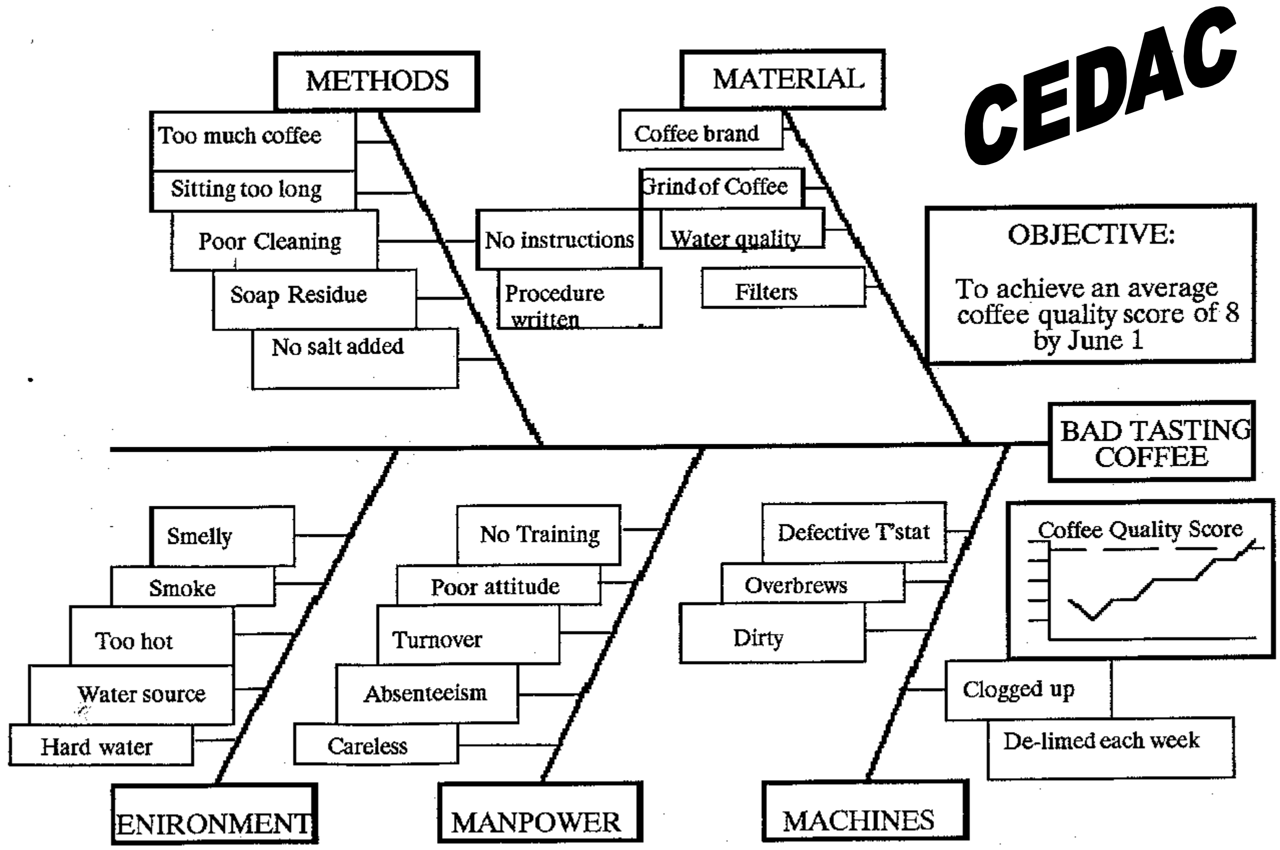
The structure tree is a specialized type of Cause and effect diagram where the **Effect** is placed in a box to the **left**, and the tree is developed to the right. Here brainstorming focuses on each cause category. The leader would point to "Methods" and ask "What are the methods that might affect "Bad Tasting Coffee". For each suggested method he/she would ask "Why does this happen. The Structure tree thus develops by focusing on each category and working into the details. An example is shown below.



Some people prefer the structure tree because it is easier to document problem solving logic. It also works well in a small group (2 or 3) where structured brainstorming does not work well. Once the tree is developed, members can narrow down most likely causes by assigning a % probability to each branch and then assigning further % probabilities as the branches detail out to the right.

The CEDAC Diagram

CEDAC stand for **C**ause and **E**ffect **D**iagram with the **A**ddition of **C**ards. This is essentially the same idea as the Cause and Effect Diagram, but has a number of additional features which greatly enhance the effectiveness of the process. A large outline of a Cause & Effect Diagram is created and brainstorming is done by writing possible causes on Cards or adhesive "Post It" notes. This allows the cards to be moved around on the diagram or disposed of. In addition, different colour cards can be used to note various actions that have been taken to prove out causes. Another distinct feature of this technique is to develop a measurement system for progress as well as an objective statement. These are posted above and below the diagram and serve to keep the group focused on the objective and how to get there. A completed CEDAC diagram is shown below.



The steps in constructing a CEDAC Diagram are as follows:

1. Develop a clear statement of the effect to be studied. This should be as specific as possible. For example, "Scrap" would be a poor effect to use because it is much to general. A better approach would be to focus on one particular type of scrap such as "Porous Castings". This will lead to more specific cause emerging. The effect is placed in the box to the right.

2. Develop the generic cause categories. These could be the 4M's or 4P's and an E. (Methods, Materials, Manpower, Machine; Policies, Procedures, People, Plant and Environment). These are placed on the Mainframe of the diagram.

3. Conduct a **structured brainstorming** session, where members of the group toss out possible causes or issues and write them on **Cause Cards** which are then passed to the leader. The leader then places these on the diagram under the appropriate heading. Related ideas that are linked should be placed together as sub branches of others under which they fall. The possible cause cards are placed to the **left** of the main branches.

4. For each possible cause, ask "Why does this happen?" This will generate additional cards that can be attached to their main cards.

5. Decide on a Measurement System that will track whether improvement is occurring.

Here the group will have to put some thought into how to quantify the effect. In the example of "Bad Tasting Coffee", the team will need to decide how coffee taste can be measured. They will then devise a scheme to survey customers and develop a coffee quality score that they can track. This chart is the hung on a clipboard below the effect. It is then necessary to collect data to establish a starting point for "Coffee Quality Score".

6. Decide on an Objective for Improvement. Based on the measurement system devised in step 5, the group should develop an objective. This is a simple statement that focuses the group's attention on the task at hand. For example, "Increase Coffee Quality Score to an average of 8.5 by June 1991."

7. To begin the improvement process, the most probable causes need to be identified. This is done by the voting. The leader points to each cause and asks "How many wish to vote for this?" Members are instructed that they may vote for as many causes as they wish, but should vote only on those they consider to be truly important. Here it is essential that members have a first hand knowledge of the problem or process. The number of votes is recorded next to each cause. The top 5 or 6 cards are set apart. Another approach is to weed out the improbable causes by gathering data and studying facts. Someone in the group may know that a certain suggested cause can be ruled out because of some specialized knowledge or some check that has been done. In addition, the group can design a scheme to do their own checking to weed out some cards. These cards are then moved to the right side of the branches and different, coloured **verification cards** are attached to them that explain what has been done.

8. Once the most likely causes have been identified, then the group must **Verify** these. This is an important step because, up to now, the group only has theories. These theories must be tested. To do this, members select a card and suggest ways of testing this card. The test is written on a **Verification card** which is a different colour. The verification card is attached to the **Cause Card** and is placed on the left of the branch until the result of the test is obtained. If the test shows that the cause is not significant, the cards are moved to the right side of the branch. In this way, the group can keep track of what has been done, what needs to be done and so on. Additional cards can be added at any time to keep the improvement process flowing. Progress is tracked on the measurement chart until the objective is reached.

STEP 7: EXPERIMENT TO PROVE OUT THEORIES

In this step, the group must take the most likely causes and subject them to experimental trial runs or tests. It is important to remember that a theory is only a theory until proven. Several general steps apply.

1. Decide on a method of measurement for the effect studied. How can this effect be quantified? How can we develop a numerical index that will quantify subjective effects. In the example of "Bad Tasting Coffee", the team will need to decide how coffee taste can be measured. They will then devise a scheme to survey customers and develop a coffee quality score (say on a scale of 1 to 10) that they can track.

2. Establish baseline measurements. Before any changes are made, the group must establish the "current situation". In the coffee example, several days of survey work may show an average coffee score of 6.5. This is then the baseline measurement.

3. Take the cause being verified and develop an improvement theory. For example if "Cheap Coffee used" is the cause being verified, then the group will develop a plan to use "Gourmet Coffee" on a trial basis.

4. Carry out the test, being sure to record and measure all variables and the effect measurements. The impact of the change in coffee type can then be evaluated.

5. Draw Conclusions. Here a note of caution is warranted. Sound statistical analysis will be necessary to draw conclusions that are valid. If you are not sure, get help. For complex processes with many variables and interactions, statistically designed experiments will need to be conducted (see section on Design of Experiments (DOE)

STEP 8: DEVELOP SOLUTIONS, PREDICT OBSTACLES AND DEVELOP A PLAN FOR CHANGE:

Once true cause has been identified, the group is then in a position to postulate solutions. Here the group will need to consider carefully the implications of each solution. A detailed analysis of the costs, benefits, potential problems, and impact on other areas will need to be developed. Often the group will have to make a formal presentation to Management to present its proposals. If their homework has been done properly, the proposal has a high chance of being accepted. Some issues to consider in designing a presentation to management are:

1. Has the cause been truly proven out? What data backs this up?
2. Is this the most logical solution? What other solutions have been contemplated and ruled out? Why?

3. What is the cost of this solution? What are the benefits? What are the risks? What is the impact on other areas? What is the payback time?
4. What intangible benefits are there? Are these consistent with our overall objectives?
5. How long will the solution take? Who will implement? What help will be needed?
6. What will be the roadblocks to change? How can these be overcome?
7. How will we ensure that the problem stays fixed? Who will follow up? How can we standardize and monitor performance in an ongoing way?

Here, it is important to recognize that the group is proposing change. Resistance to change is one of the greatest barriers to improvement. In order to help a group identify these barriers a technique called Force Field Analysis is useful.

<u>Force Field Analysis:</u> (Memory Jogger Ref: Pages 72-73)

Force Field Analysis is a technique devised by Kurt Lewin to help an organization or an individual facilitate change. How does change occur? It's a dynamic process that is driven by many forces and can be resisted by many forces. If the restraining forces predominate, no change will occur. Often an attempt to push driving forces causes restraining forces to increase in reaction. However, if restraining forces are reduced, then driving forces will predominate and accomplish the change.

In this technique, members identify the **Driving Forces** and the **Restraining Forces** that impact on the change desired. Then they plan a strategy for the removal of restraining forces and the subtle promotion of driving forces. A completed Force Field Analysis for the issue of Reducing Cholesterol is shown below:

REDUCING CHOLESTEROL

Driving Forces	Restraining Forces
Health threat →	← Society's high fat diet
Risk of Heart Attack →	← Use of animal fat in restaurants
Being overweight →	← Fast Foods
Public awareness →	← Lack of Awareness
Supportive Spouse →	← Eating habits
Need to feel fit →	← Lack of knowledge
Desire for longevity →	← Packaged Food Labelling
Doctors Advice →	← Lack of Exercise
	← Lack of Time
	← Easy access to junk food

STEP 9: IMPLEMENT SOLUTIONS:

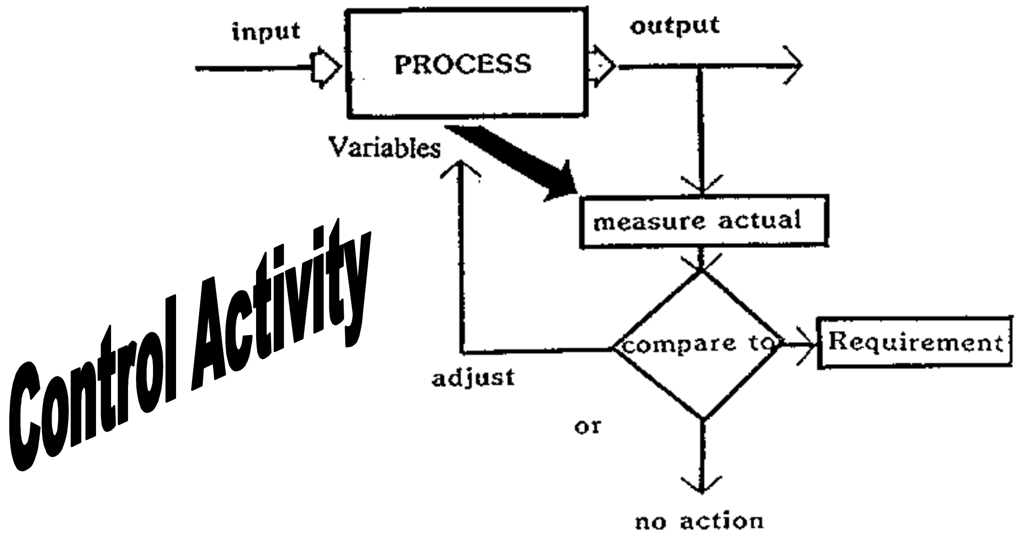
Developing Action Plans

One of the simplest, yet most effective tools for initiating change is the action plan. The action plan allows a group to identify general activities and break them down into specific actions that need to be taken. In addition, the plan allows assignment of who will do which action item and by when. This allows the group to follow the progress of the project and to keep it on track. An example is shown below.

No	ITEM	ACTION	WHO	Target	Actual
1	No Instructions	Write Procedure	John	Apr. 15	Apr.10
2	Clogged Up	De-liming procedure Get Descaler Descale both Coffeemakers	Pete	Apr. 15	Apr. 15
3	Sitting Too Long	Trial run, 6 times per day	Sally Pete	Apr. 25-30	
4	Poor Brand	Trial run with *Tasters Choice*	Joan	May1-5	

3.5.10 STEP 10: IMPLEMENT CONTROLS TO HOLD GAINS:

The purpose of Control Activity is to implement on line process control systems that are statistically based. Most organizations have developed some type of process control system for almost every type of activity or work. The purpose of these systems is to ensure that the process is operating adequately and to provide an alarm or a signal to the operators (those who run the activity) when the process deteriorates. Most process control systems are detection based, meaning that they consist of a series of inspections made on a checklist or data log sheet. Operators; supposedly “know” when the “number” goes too high or too low. Unfortunately, these systems do not take the principle of variation into account and in the absence of any statistical analysis, often result in under-control or over-control. The process operator is faced with the task of evaluating a possibly large number of variables on the basis of a log sheet with hundreds of numbers on it.



When faced with the prospect of malting adjustments to a process, the local operator can make two types of errors.

TYPE 1 ERROR: The operator fails to adjust the process when he should. Performance is sub optimal. Process really needs to be adjusted. Under-adjustment

TYPE 2 ERROR: The operator adjusts the process when he should not. The operator believes he is improving the process but in fact he is making it worse. Over-adjustment

One cannot blame the process operator in these instances. In most cases he is r trying to do his best. The problem is that he has no way of knowing when to adjust the process. He is like a man trying to drive a car blindfolded with someone yelling directions in his ear. He really can't see what the process is doing What the operator needs is a simple statistical tool, the Control Chart Once he has that tool, and understands how to use it he will avoid type 1 & 2 errors. For details on exactly how to choose and construct Statistical Control Charts, see the sections on Statistical Process Control .

Steps In Implementing Statistical Control Activity

Step 1: FLOWCHART THE PROCESS:

The first step is to develop a flowchart of the process showing each step. This flow chart should be detailed enough to expose all the variables that the process is influenced by. The use of commonly accepted flowcharting symbols will help the team stay consistent in its diagrams (see attachment).

Once the flowchart is made, it should be reviewed for completeness, and for logic. Often the team will realize that there are two or more flowcharts that exist, one for what the process is supposed to be, one for the process as it actually is, and perhaps others for different conditions (i.e. Saturday's, Night shift, etc.).   Once the improved flowchart has been finalized, the team can reassess the process variables.

Step 2: LIST & PRIORITIZE PROCESS VARIABLES:

For each step in the process, the team should construct a list of the process variables that affect this step or downstream steps. These may be: people, process characteristics (temperature, pressure, voltage, weight, etc.), methods, testing processes, materials, environmental factors, equipment variables, procedures, etc. Once this list is compiled for each step in the process, then the lists should be reviewed to identify the most critical variables. These are the variables that are subject to the most variability, and also have the most impact on the process. Critical customer requirements will also need to be identified. These are the variables that the team will make the focus of the initial statistical process control efforts.

Step 3: DESIGN STATISTICAL CHARTING SYSTEM:

Once the critical variables have been identified, then the group can look at each variable and ask the questions:

1. If this is a critical variable, how do we control it now?

2. How can we convert this to statistical controls (i.e. Control Charts)? Here the group will need to consider a number of issues that will have to be addressed in establishing control charts for the critical variables. These are addressed by the e questions below:

3. How can this variable be measured? (tests, readouts, surveys, etc.) These measurements should be on a continuous scale. (survey results on a scale of 1 to 10)

4. Is the measurement system sufficiently capable? Here the total measurement system variability should be no more than 20% of the tolerance. (see section on Measurement Capability Analysis)

5. What type of control chart should be used? Possible charts to choose from are for Variables: Average Range, Individual moving Range, Moving Average moving Range, Exponentially Weighted Moving Average, Average Standard Deviation; and for Attributes, np,p,c & u charts.

6. Here, the rule is to start simple. While the more sophisticated charts may be technically superior, simplicity will make the chart more easily accepted by the operators. -A chart selection matrix is attached.

7. How often should data be collected? Here the time of data collection and the frequency will have to be decided. Generally common sense will dictate where to start. Experience will then show if the frequency needs to be increased or reduced. There is no set rule. Some processes change very quickly. Others change very slowly. Another issue is continuity across different shifts and different operators.

8. Who will fill out the chart? Who will calculate control limits? How often should these be recalculated. Who will interpret & analyze the charts. Those closest to the process should perform these functions.

9. Where will the chart be located? Where will it be filed when complete? What forms will be used? Where will they be procured?

STEP 4: IMPLEMENT THE CONTROL PLAN

Once these issues have been addressed, the group must ensure that the plan is executed.

1. Measure and plot "important" variables over a period of time.

2. Establish optimum values for process parameters and statistically determined control limits.

3. If a variable falls outside its statistical boundary according to generally accepted rules of interpretation, then investigate to determine what has changed and apply corrective action. Mark this action on the chart.

4. If the process is centred about the target and is stable, leave it alone.

5. If a statistically significant change occurs, without a corresponding change in one or more of the process parameters being measured, then additional parameters will have to be monitored which may have caused the change.

Step 5: EVALUATE THE CONTROL SYSI'EM:

The statistical control system (i.e. the charts) will need to be itself subjected to continuous improvement. This means reviewing and evaluating the charts on a regular basis. Some key issues are:

1. Is the chart being filled in correctly?

2. Are control limits present and calculated correctly?

3. Does the operator use the chart to make decisions?

4. Is the sampling frequency adequate?

5. Are significant patterns & signals analyzed and assignable causes determined. Are these marked on the charts.

6. Is variability being continually reduced?

7. How can this the charting process be automated, simplified, improved?

The team should be continually working on improving and fine tuning the statistical control system that they have just designed. This is a never-ending process.