QUALITY CONTROL: INSPECTION TECHNIQUES

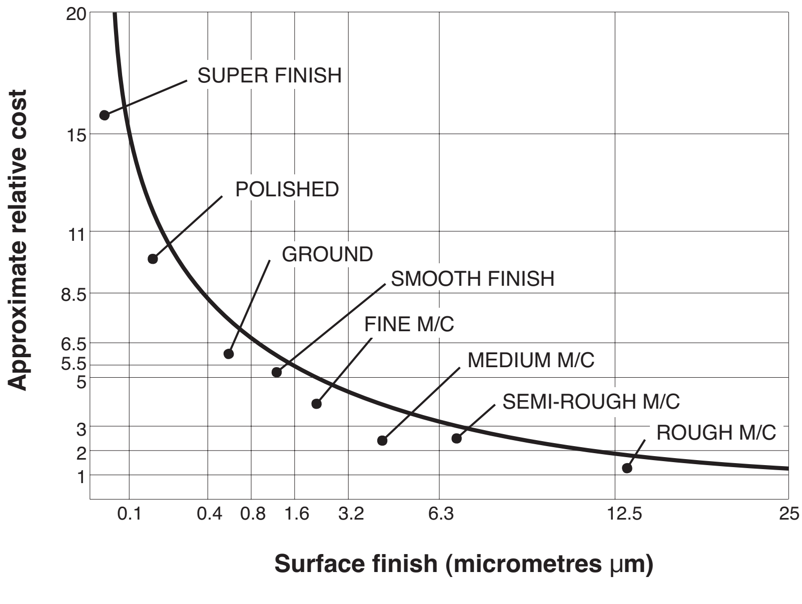
Individually manufactured parts and components are eventually assembled into products. We take it for granted that when, for example, a thousand lawnmowers are manufactured and assembled, each part of the product will fit properly with another component. For example, the wheels of the lawnmower will rotate smoothly on the axles, or the pistons will fit into the cylinders, being neither too tight or loose.

Likewise, when we replace a broken or worn bolt on a machine such as a bicycle, all we have to do is purchase an identical bolt. We are confident that, from similar experiences in the past, that the bolt will fit properly. The reason why we can feel confident is that the bolt is manufactured according to certain standards and that the dimensions of all similar bolts vary by only a specified amount. In other words, the bolts are manufactured within a certain range of **dimensional tolerances.** Thus all similar bolts are interchangeable.

Dimensional tolerance is defined as the permissible or acceptable variation in the dimensions (height, weight. depth, diameter, angles) of the part. The word is derived from the Latin *tolerare*, meaning to endure or to put up with.

Tolerances are unavoidable because it is virtually impossible and unnecessary to manufacture two parts that have exactly the same dimensions.

As a product is being manufactured there is a technological limit to the accuracy that can be achieved, and the nearer a process is used to that limit, the more it will costs. In general, for any particular manufacturing process there is a range of accuracy within which it is economic to use that process.



The output from any machine or process will vary in accuracy as a result of a number of causes. These might include:

- the tool, or die being subject to wear
- variations in the materials used. Although perhaps a particular non-ferrous alloy may be used for a certain component, the properties of that materials may vary from batch to batch.
- variations in the environmental conditions. For example, changes in temperature may result in the contraction or expansion of metals
- variations in the labour used - either in their levels of skill and training, or changes that may occur during the week due to tiredness or boredom

Although tolerancing is most frequently associated with dimensional and geometric tolerancing of parts, it can also apply to any specified parameter such as weight, temperature, time, current, voltage, strength, hardness, number of blemishes on a paint finish, and so on.

Quality Inspection

Quality must be built in during the manufacture of a product - it cannot be added during the inspection of a product.

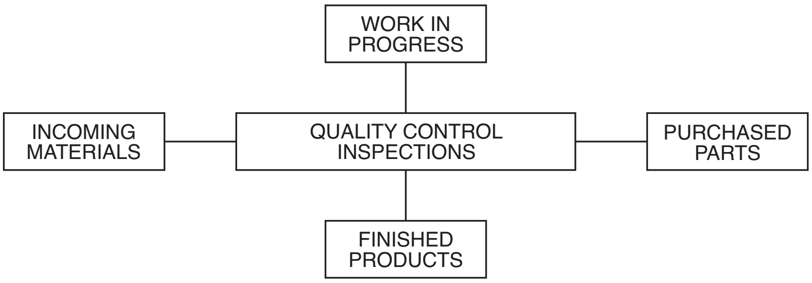
Inspections are not a substitute for accuracy when using machines and worker performance - rather, inspections are used to spot problems in order that they can be fixed.

Inspection involves measuring a part, comparing the measurement to specifications, and making a decision about the quality of the match.

There are three possible decisions:

1. *acceptable quality* - this means the component matches the tolerances specified in the working drawings.
2. *rework* - means that the part does not meet specifications, but it can be fixed.
3. *reject* - this part cannot be modified in order to meet specifications, and must therefore be scrapped.

There are four places where inspection occurs during manufacturing:



1. *incoming materials*
2. *purchased parts*

   If defects are found in incoming materials, or purchased parts, there is no cost to the company. The supplier of the defective material or component is responsible for its replacement.

3. *work in progress* - if a defect is found immediately after processing, that part can be reworked or rejected. This prevents a defective part from appearing in the final products, and costs very little in financial terms.

4. *finished products* - if defects are not identified under a product is finished, the entire product may have to be scrapped. Disassembling or reworking the defective part can be very costly, if not impossible.

   If a consumer finds a defect, costs are highest. The manufacturing company has already spent money for manufacturing, shipping and advertising. Depending upon the warranty, the entire product might have to replaced. In addition, the consumer may tell other potential customers not to buy the manufacturer’s products because of poor quality.

Inspection gauges

Quality inspection is made easier by using gauges. There are two main types:

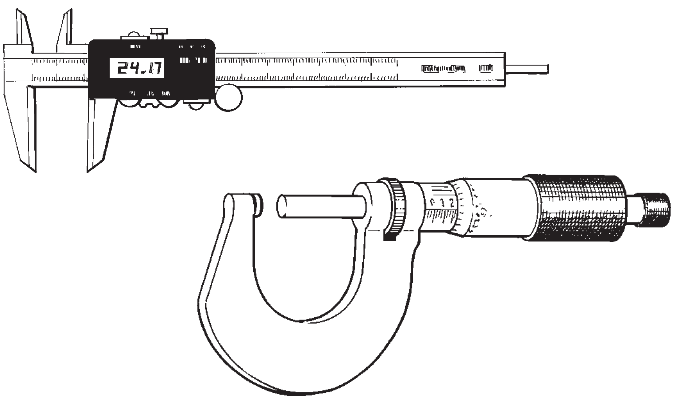
1. *indicating gauges*
2. *fixed gauges*

1. *Indicating gauges* - With an indicating gauge, an inspector measures a part; reads a numerical value (a measurement) of the gauge, and compares the value to the specification. On the basis of this, a decision is make to accept, rework or reject.

Indicating gauges include:

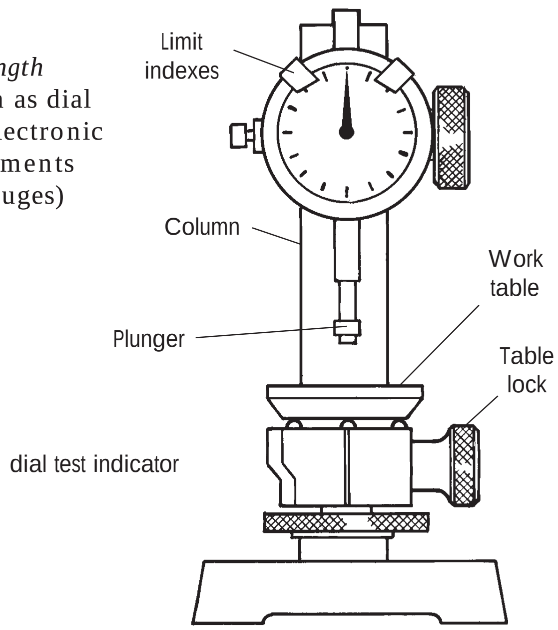
A. line graduated instruments

- direct reading - rules, vernier calipers and micrometers

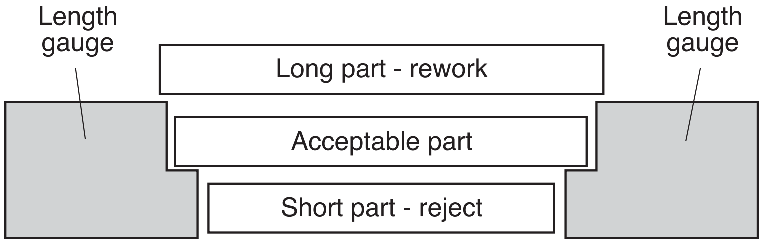


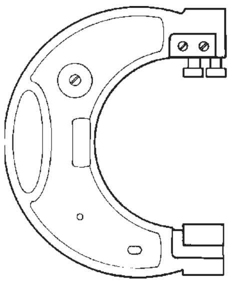
- indirect reading - protractors, sine bars and surface plates

B. comparative length instruments - such as dial indicators, and electronic measuring instruments (such as strain gauges)



2. ***Fixed gauges*** **-** When an inspector measures a part with a fixed gauge, it either matches specifications, or it does not. Fixed gauges have the minimum and maximum tolerance built in.





Adjustable limit
snap gauge set

Fixed gauges reduce the chance of human error in reading measurements. They also reduce the time needed for each inspection.

Fixed gauges must be precisely made to match the tolerances being measured.

Statistical Process Control (SPC)

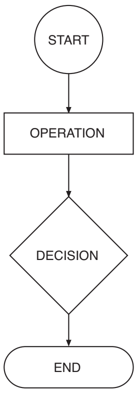
The best possible location for inspections would be after each and every operation. This is of course impractical and costly, because of the number of gauges and personnel involved. In practice:

a) accurate tooling will eliminate the need for excessive inspections - CAM technology with integrated automated inspection contributes to this significantly now.

b) where high volumes of the same items are to be checked, **samples** of the items are taken as representative of the whole batch

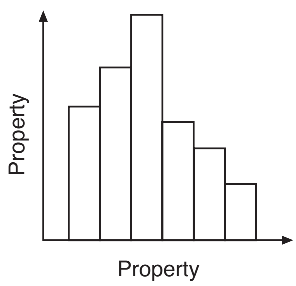
Statistical process control techniques are used in a set of statistically-based tools used to evaluate manufacturing processes. Processes can only be monitored and brought 'under control' by gathering and using data that relates to the measurements of the performance of the process, and the feedback required for corrective action where necessary.

The following 'tools' may be used to interpret fully and derive the maximum amount of information from data. (Source: 'The Enterprise Initiative : Statistical Process Control', published DTI)

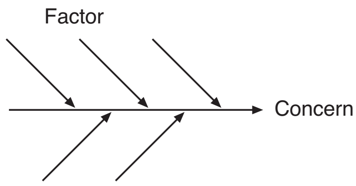


Process flow chart
A process flow chart is a picture, using symbols, of what is actually done. It records the series of events and activities, stages and decisions in a form which can be easily understood and communicated to all. It helps understanding the process and in making improvements.

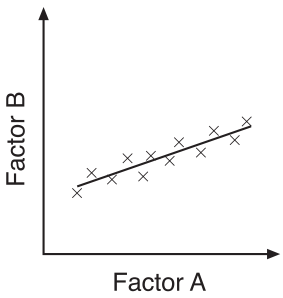
Check or tally chart
A check sheet or tally chart is a simple device on which data is collected or ordered, by adding tally marks against predetermined categories of items or measurements. It also helps to structure data



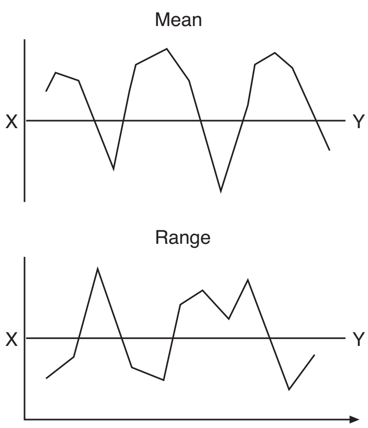
Histogram
A histogram is a picture of variation or distribution, on which data has been grouped into cells and their frequencies represented as bars. It helps people to see the extent of variation.



Cause and effect analysis
Cause and effect analysis and brainstorming involves the use of the expert knowledge of a group of people at work to 'brainstorm' a problem and present their ideas on a picture that is the shape of a fishbone, the head of which is the 'effect' or problem and the ribs of which carry the listed possible causes. It helps to open up thinking in problem solving



Scatter diagram
Scatter diagrams are pictures of possible relationships between factors. If dependence of one factor on another can be shown as simple graph plots, it may be possible to control the 'dependent' factor by controlling the 'independent'. They help to confirm or reject hypothesis about possible correlations.



Control charts
Control charts are pictures of variation over time. Data is plotted on graphs against time, preferable at the 'point of operation' where the process is actually carried out. Decisions are then made about the state of the process and whether any action should be taken. They help to monitor and control quality by acting as a set of process traffic lights, and are valuable in all types of activity.

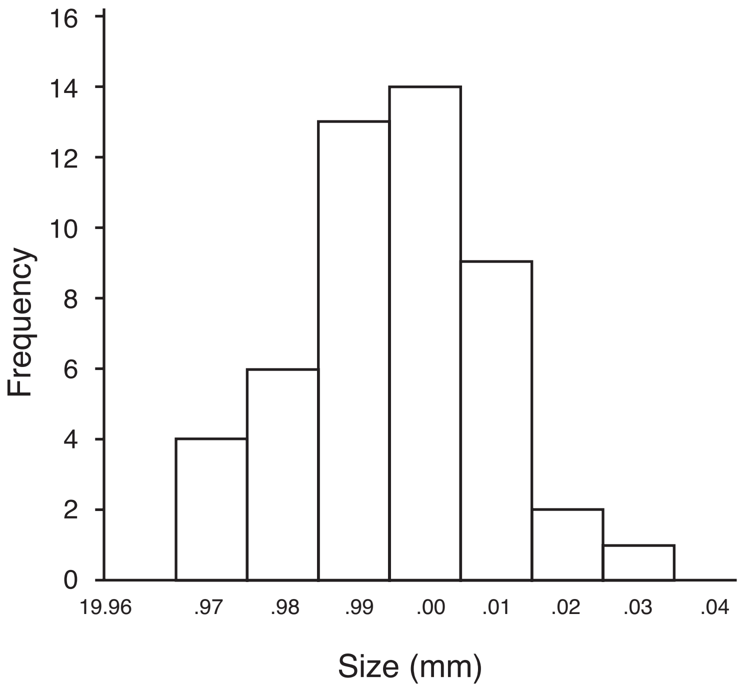
SPC procedures exist because there is variation in the characteristics of all materials, processes, articles and people. Variability makes it difficult to predict the value of any single product or process at any point in time.

SPC techniques allow data from samples to be translated into information about the whole population (or batch) from which the samples are taken.

For example, a component from a lawnmower requires a shaft to be turned on a lathe of diameter 20.00 mm. If 50 successive components produced by the machine are taken and measured, the following data might take the following form:

20.01	20.00	19.99	19.97	20.01	20.00	19.99	19.98	20.01	20.00
20.00	19.97	19.99	19.98	19.99	20.00	20.01	20.00	20.01	19.99
19.98	20.01	20.00	20.00	19.99	19.97	20.03	20.02	19.98	19.99
20.00	20.01	20.02	19.99	19.97	19.98	19.99	20.00	20.01	20.02
20.00	19.99	19.98	19.99	20.01	20.00	19.99	20.00	20.00	19.99

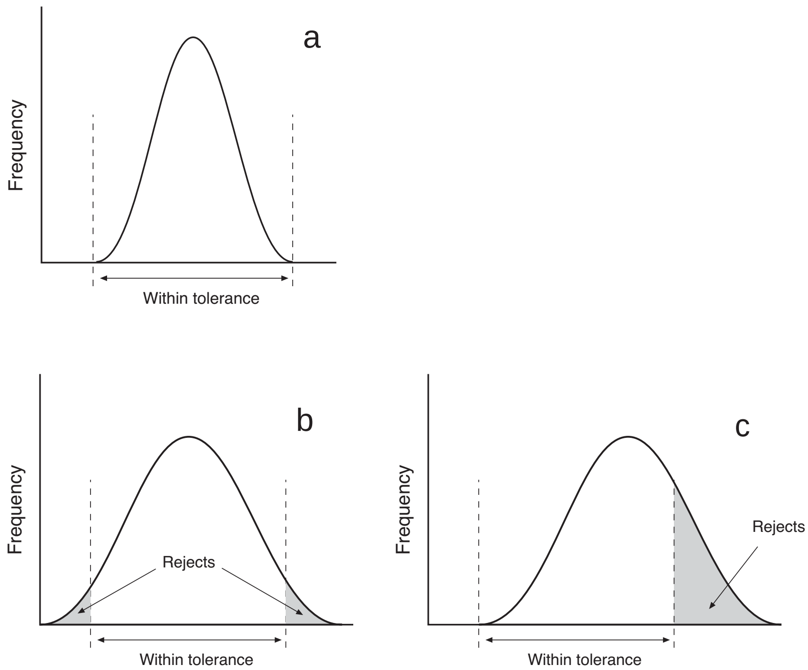
One way to look at the type of variation that is occurring in the turning process is to plot a **frequency distribution curve**. This means grouping the data and counting the number of readings that occur in each group, hence the frequency of occurrence. For example, there are 14 readings of 20.00m; 13 of 19.99.



The pattern that can be seen from the histogram is that most of the components have measurements of 19.99mm or 20.00mm.

If the tolerance for this particular component was +/- 0.03mm , it means that the range of acceptable dimensions lie between 19.97mm and 20.03mm. The histogram indicates that there are no components falling outside these limits - and so all are acceptable.

If more components had been measured and the readings taken to more decimal places, then the histogram would have approximated to a smooth curve - known as the frequency distribution curve.



In diagram (a) all the components are within the tolerance band and so there are no rejects - the variability of the process being acceptable. In diagram (b) some of the components are outside the tolerance band and so are rejected.

The reasons for this excessive variability where there as many components above the upper tolerance limit as below the lower tolerance limit is not due to a factor that would consistently incorrect, such as an incorrect adjustment, because that would produce a curve as in diagram (c). In this case, the reason may be excessive movement (‘play’) in a bearing, or the material being machined being of variable quality.

The distribution curve in diagram (c), where there are a large number of rejects above the upper tolerance limit and none below the lower tolerance limit, could be explained by either a tool being out of alignment, or the machine was incorrectly set, or a new operator was using the machine.