CHAPTER ONE

Inspection

1.1 INTRODUCTION

The term Inspection has been defined in different ways by different authors :

"**Inspection** is the art of comparing materials, products, or perfomances with established standards" –KIMBALL

"**Inspection** is the art of applying tests preferably by the aid of measuring appliances to observe whether a given item of product is within the specified limits of variability" –ALFORD AND BEATTY

"**Inspection** is the process of measuring the qualities of a product or services in terms of established standards"–SPIGEL AND LANSBURG

In simple words,"**Inspection** is the act of comparing a product with accepted specifications or other recognized standards".

Thus inspection means checking the acceptability of the manufactured product.

Inspection measures the qualities of a product or service in terms of predecided standards. Product quality may be specified by the strength, shape, hardness, surface finish, dimensions or by other Parameters.

1.2 PHYSICAL QUANTITY

All quantities in terms of which laws of Physics can be expressed and which can be measured directly or indirectly are called **Physical quantities**. In other words, "Any quantity which can be measured is called a Physical quantity." For example, force, work, time, mass, length, electric current are all Physical quantities as they can be measured in terms of base units.

1.3 MEASUREMENT

Measurement is the process of comparison of an unknown quantity with a known fixed unit quantity of the similar nature.

Every type of measurement, whether it is related with time, length, weight or other related quantities, requires two things.

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(i) Unit or standard

(ii) A number of Numerical factor.

(i) Unit or standard : The quantity which can be used as a standard of measurement is called a '**UNIT**'. A Physical quantity can be completely specified by both the numerical value as well as the unit of the system. These are inter-related with each othe. If 'N' is numerical value of the Physical quantity for a given unit 'U'. Then mathematically it can be given by the relation

$$N.U = \text{Constant}$$

$$N \propto \frac{1}{U}$$

∴ Unit of a physical quantity and its numerical value are inversely proportional to each other and product is equal to constant.

(ii) A number of numerical factor : It is the number, indicating, how many units are there in the quantity to be measured. This number is also known as measure number e.g. to determine the height of any person, we have to compare the known quantity (height) with a known and fixed unit quantity i.e. (metre rod)

"The number which shows that how many times a unit is repeating in a Physical quantity is called **numerical factor or numerical value** of Physical quantity."

Example : If we measure length of an object as 5m. This indicates that 1m units of length is repeating 5 times in the Physical quantity etc.

∴ Measurement of a Physical quantity = Numerical value of the Physical quantity (n)× unit (4)

Physical Quantity $= n \times 4$

1.3.1 Properties of a unit/standard :

A unit selected for measuring a Physical quantity should have the following properties:

(i) It should be well defined.

(ii) It should be convenient in size i.e. neither too large nor too small.

(iii) It should be easy to reproduce.

(iv) It should not change with time and from place to place.

(v) It should be easily accesible.

(vi) It should be possible to multiply or divide each one of the standard.

(vii) It should not be effected by conditions like temprature, pressure, humidity etc.

(viii) It should be commonly acceptable.

1.4 BASIC METHODS OF MEASUREMENTS

Depending upon the requirement and based upon the standards, employed, there are two basic methods of measurement :

(i) Direct comparison

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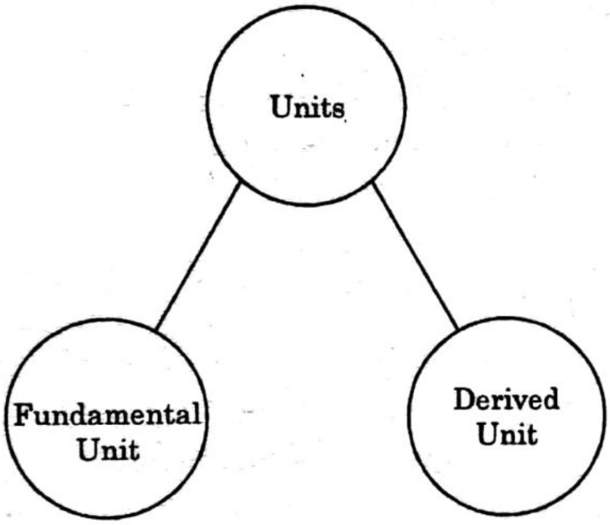
(ii) Indirect comparison

(i) Direct comparison : This method involves direct comparison of unknown quantity with a standard, usually a secondary standard, and to find out as to how many units of the standard are contained in the unknown.

(ii) Indirect comparison : Measurements are made more generally by indirect comparison with secondary standards through calibration. That saves the primary or secondary standards from a frequent and direct handling. It is a relatively much more reliable and accurate method because there is no appreciable involvement of the human factor in making the judgements. The accuracy of each approach is apparently traceable to the Primary standard via the secondary standard and the calibration.

1.5 CLASSIFICATION OF UNITS

Unit can be classified into two categories



(i) Fundamental units : Before study of fundamental units, it is necessary to know about the fundamental quantity.

Fundamental quantity : A fundamental quantity is a quantity which cannot be expressed in terms of any other physical quantity. The quantities like length, mass and time are chosen as fundamental quantities.

Fundamental units : The units selected for measuring the fundamental quantities (Mass, Length & time) are called fundamental units.

All the physical quantities can be expressed in terms of these fundamental units.

For measuring mass, length and time there are independent unity such as kilogram (kg), metre (m) and second (s). Hence kilogram (kg), metre (m) and second (s) are called fundamental units.

(ii) Derived units : "The units of all physical quantities which can be expressed in terms of fundamental units are called derived units."

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In other words "The units of all other quantities, which can be obtained from the fundamental units are called derived units. For example, unit of Area is a derived unit because it can be obtained from the unit of length.

$$\therefore \quad \text{Area} = \text{Length} \times \text{Length} = (\text{Length})^2$$

$$\text{Similarly, velocity} = \frac{\text{Distance}}{\text{Time}} = \frac{\text{Length}}{\text{Time}}$$

$$\text{Force} = \text{Mass} \times \text{Acceleration} = \frac{\text{Mass} \times \text{Length}}{(\text{Time})^2}$$

Thus the units of area, velocity and force are derived from the Fundamental units of mass, length and time etc.

1.6 SYSTEMS OF UNITS

There are following systems of fundamental units commonly in use :

(i) C.G.S SYSTEM (Also known as "French system") : In this system the unit of length is centimeter, the unit of mass is gram and the unit of time is second.

The centimeter is one-hundedth part of metre.

The Gram is one thousandth part of a kilogram.

The second is defined as $\frac{1}{86400}$th part of a mean solar day.

(ii) F.P.S system : It is also known as 'British system'. It uses Foot, Pound and second as the fundamental units of length, mass and time respectively. These units are defined on a poor Logic and it has two major problems.

(a) It is not based on decimal number system, therefore the calculations become lengthy. e.g to find area of a room measuring 5'7"× 12'8" one has to convert the length and breadth in inches and then divide by 144 to report the result in square feet.

(b) It is not a coherent system of units. This means that the derived units can not be obtained without introducing numerical factors.

(iii) M.K.S. SYSTEM : It is also known as 'Metric system'. It is a system of measurement in which the fundamental units of measurement of length, mass and time are metre, kilogram and second respectively.

(iv) S.I UNITS : French name of this system is "System international" units, abbreviated as S.I units. This system is an improved and extended version of M.K.S systems of units.

With the development of science and technology the three fundamental quantities like mass, length and time were not sufficient as many other Physical Phenomenon like light, heat, electricity etc. came up.

These Physical Phenomenon required more fundamental units in addition to

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the existing units of mass, length and time. Therefore, M.K.S system was modified with the addition of four other fundamental quantities. This gave rise to international system of units abbrivated on S.I for system International.

Thus S.I units are based on seven fundamental unit or base units. The seven base units selected are :

1. Metre (m) : It is unit of length. It is defined as 1650763.73 wavelengths in vacuum of the radiation emitted due to transition of the isotope of krypton-86 between the level $^2P_{10}$ and $^5d_5$.

2. Kilogram (kg) : It is a unit of mass. It is defined as mass of platinum–irridium alloy cylinder of diameter equal to its height. It is kept at the International Bureau of weights and measures at Severs near Paris.

3. Second (s) : It is unit of time. A second is the duration of 9,192,631,770 vibrations of the radiations emitted by ground state of the cesium – 133 atom.

4. Ampere (A) : It is a unit of electric current. It is defined as the strength of current which when flows through two parallel straight conductors, separated 1 metre apart, produces a force 2×10^{-7} N per metre length of the conductors.

5. Kelvin (K) : It is unit of temperature. It is defined as the fraction $\frac{1}{273.16}$ of the thermo-dynamic temperature of the triple point of water.

6. Candela (cd) : It is a unit of Luminous Intensity. It is defined as Luminous intensity of a black body, in the direction perpendicular to the surface, having a surface area of $\frac{1}{60,0000}$ m^2 at the temperature of freezing platinum and at a pressure of 101,325 N/m^2.

7. Mole (mol) : It is a unit of substance. It is defined as the amount of substance which contains as many elementary constiuents as there are atoms in 0.012kg of carbon – 12.

In addition to the above seven fundamental units, there are the two supplementary units.

8. Radian (rod) : It is a supplementary unit of plane-angle. A Radian is defined as the angle subtended at the centre of circle, by an arc whose length is equal to radius of the circle.

$$\pi \text{ radian} = 180°$$

9. Steradian (Sr) : It is a supplementary unit of solid angle. A steradian is a solid angle subtended at the centre of a sphere by an area of the surface of the sphere, equal to that of a square whose each side is equal to the radius of the sphere.

$$\text{Solid angle in steradian} = \frac{\text{Area cut out from the surface of sphere}}{(\text{radius})^2}$$

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Table 1.1

List of basic or fundamental units

S.No.	Name of Physical Quantity	Unit	Symbol
1.	Length	metre	m
2.	Mass	kilogram	kg
3.	Time	second	s
4.	Temperature	Kelvin	K
5.	Electric current	ampere	A
6.	Luminous Intensity	candela	cd
7.	Amount of substance	mole	mol.

List of supplementary units

S.No.	Name of Physical Quantity	Unit	Symbol
1.	Plane angle	radian	rad.
2.	Solid angle	steradian	Sr.

1.7 STANDARDS FOR MEASUREMENT

The accepted standards for the measurement of physical quantities are often classified as :

(i) Primary standards
(ii) Secondary standards
(iii) Tertiary standards
(iv) Working standards

(i) Primary standards : The highest standard of either a base unit or a derived unit is called a Primary standard. They are one material standards and are very carefully preserved under controlled conditions of atmosphere. The Primary standards have the highest possible accuracy but are very expensive. These standards are not put to frequent or common use. These are used for the purpose of verification and calibration of secondary standards. They can also be called master standards.

(ii) Secondary standards : These are the reference calibrated standards designed and calibrated from the primary standards. They are made as nearly as possible to the Primary Standard with which they are compared at intervals. But unlike primary standards, they are distributed to a number of places where they are kept under safe custody. They are compared with the Primary standards at regular intervals and a record of their deviations is maintained. They act as reference standards for the tertiary standards.

(iii) Tertiary standards : They are properly maintained in laboratories and workshops as reference for comparison of the working standards. They also are not

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used as frequently and commonly as the working standards, although more frequently than the secondary standards.

(iv) Working standards/Company standards : They are the normal standards used by the technicians and workers who are actually carrying out the operational measurements. In a factory or company, the production measuring instruments are checked against the working standards.

1.8 INTERCHANGEABILITY

"In large quantity production of the components of an assembly, when one component will assemble properly with any mating component, both being chosen at random, then this provision is known as '**interchangeability** of components of an assembly."

The principle of interchangeability is normally employed for the mass production of identical items within the prescribed limits of sizes. A little consideration will show that in order to maintain the sizes of the part within a close degree of accuracy, a lot of time is required. But even then there will be small variations. If the variations are within certain limits, all parts of equivalent size will equally fit for operating in machines and mechanisms. Therefore certain variations are recognised and allowed in the sizes of the mating parts to give the required fitting.

The advantage of applying this principle in the mass production system is that, because of the allowed error in workmanship, less skill is required of the operator, measurement and checking of the finished articles is easy and quicker and the rate of production is higher. Still the desired accuracy in the dimensions of mating parts is obtained to get the required fitting.

In order to control the size of finished part with due allowance for error in workmanship, **a limit system of dimensioning** for interchangeable parts is used. When an assembly is made of two mating parts, the one which enters into the other is known as the enveloped surface while the other is called the enveloping surface.

1.8.1 Types of Interchangeability : Three types of interchangeability systems are used. These are :

(i) Full or universal interchangeability : In this type of interchangeability, in an assembly any component can be replaced by a similar component without any further processing of the latter to obtain the desired fit.

(ii) Selective assembly : In this the parts of any one type are classified into different groups according to size. The parts which are to mate with these are also classified into the same number of groups according to size. Any one part from a particular group can be assembled with a part from the corresponding mating group and the resulting assembly is expected to facilitate the desired function.

(iii) Matched fits : This is suitable for only small assemblies. In this, the exact

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size of a finished part is accurately measured and then a mating part is made to match with it.

1.9 INTERNATIONL AND NATIONAL STANDARD

An important development in standardization of units took place in the year 1875 when representatives of seventeen nations met in Paris to establish an international system of units. They decided to use this system for all scientific work in their respective countries. They also formed organizations which would promote the adoption of this system all over the world. Representatives of these organizations were to meet from time to time to decide on any matter related to the units to be used by scientists internationally. These conferences, called Conférence Générale des Poids et Méasurés (CGPM) or 'General Conference on weights and Measures', are now held every four years.

The CGPM maintains the Bureau International des Poides etc. Measures (BIPM) at Sevres near Paris. At its meeting in 1954, the CGPM adopted a system of units based on metre (m), kilogram (kg), second (s), amphere (A), degree kelvin (k), and candela (cd). In 1960, the CGPM recommended the universal adoption of this system of units to cover the entire system of science and engineering and gave it the name "Systéme International d' unite's" abbreviated S.I.

In India too, a statutory decision was taken in 1956 by an act of Parliament to change over to metric system in conformity with S.I concept. The system of S.I units is based on seven base units and two supplimentary units, from which the host of derived units is obtained.

To maintain accuracy and interchangeability it is necessary that the standards be traceable to a single source, usually the National Standards of the country, which are further linked to International standards. The accuracy of National Standards is transferred to working standards through a chain of intermediate standards in a manner given below :

National Standards

↓

National Reference Standards

↓

Working Standards

↓

Plant Laboratory Reference Standards

↓

Plant Laboratory Working Standards

↓

Shop Floor Standards

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1.10 STANDARDS OF MEASUREMENTS

These days two standard systems of linear measurement, English (Yard) and Metric (metre) are in general use throughout the world.

The **'British System'** of linear measurement is based on one arbitrarily unit known as Yard.

The **'metric system'** was originated in France and is now being used in many countries in the world.

For linear measurements the various standards known are :

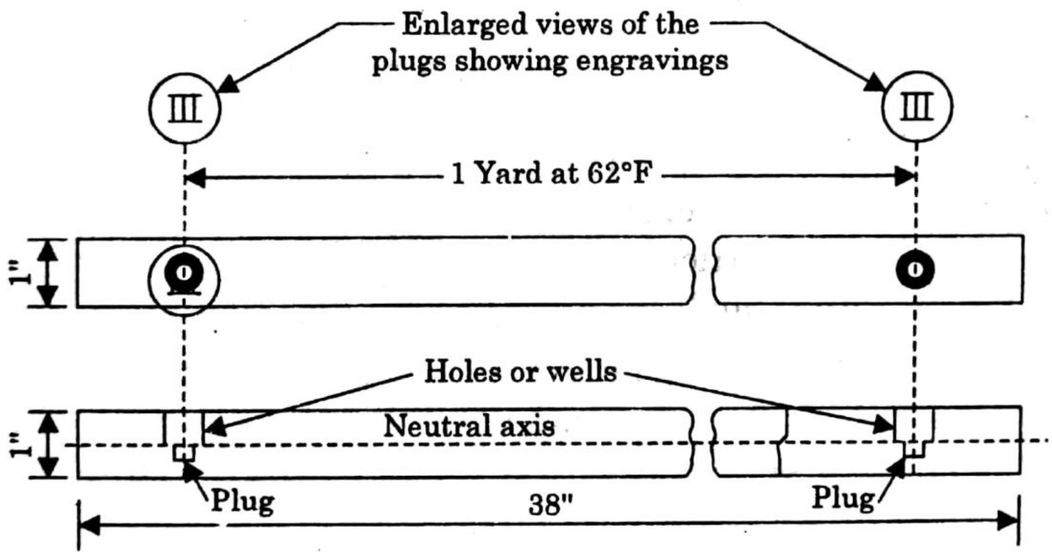
(i) Line Standards

(ii) End Standards

(iii) Wave Length Standards

(i) Line Standards :

(a) The Imperial Standard Yard : The yard in its current form was first set up in 1855 in England. It is made of 1 in × 1 in section bronze bar 38 inches long. The bar has two 0.5 inch diameter and 0.5 inch deep holes, **Fig. 1.1**. Each of these holes are fitted with two 0.10 inch in diameter gold plugs. The top surface of these plugs lie on the neutral axis of the bronze bar. The upper most surface of each plug is highly polished and contrain three parallel lines engraved over each plug. **One yard is taken as 36 inches distance between the central lines on the two golden plugs.**



The Imperial Standard Yar

Fig. 1.1

(b) The international prototype metre : Just like Imperical standard yard, it is also a line standard. It is made of an alloy consisting of 10 percent irridium and the rest platinum. It is provided with a very rigid section of the shape shown in **fig. 1.2.**

The upper surface of the web is highly polished and has two fine lines engraved over it. The distance between these two lines when measured at a temperature of

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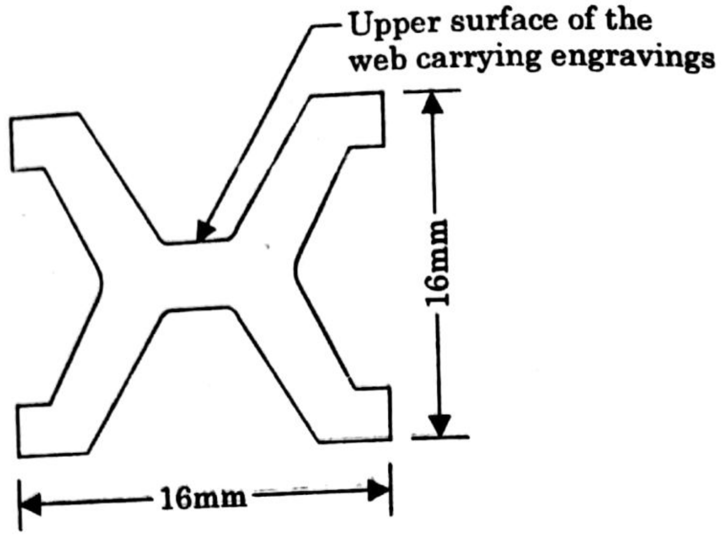
0°C has been taken as one meter. The International standard meter is maintained by the International Bureau of weights and measures in France.



Section of a prototype metre
Fig. 1.2

(ii) End Standard : These standards are developed in two basic forms :

(a) Small block or slip gauges : These are used for short lengths, say, normally up to a maximum of 150 mm.

(b) Cylindrical end bars : These are used for larger lengths, these bars may have flat or spherical end faces, but it is reckoned that the latter type can be manufactured with a greater accuracy and, hence, is more popular.

(iii) Wave length standards : The lengths of the metallic standards such as the meter and the yard may be changed with the passage of time. In order to overcome such a difficulty wave length of red radiation of cadmium has been internationally accepted as the **'Standard of measurement'.**

It is more reliable and could be adopted any where without the risk of being in error. The wave length of red radiation from cadmium is 6438.4696 Angstrom. Unit (1 Angstrom unit = 10^{-10} m or 10^{-8} cm.) under standard conditions of 20°C temperature, 760 mm atmospheric pressure, and 10 mm of vapour pressure.

LIMITS FITS AND TOLERANCES

1.11 TERMINOLOGY

The following terms are used in limit system.

1. Nomimal size : It is the size of a part specified in the drawing as a matter of convenience.

2. Basic size : It is the size of a part to which all limits of variations are determined. The nominal or basic size of a part is often the same.

3. Actual size : It is the actual measured dimension of the part.

4. Limits of sizes : There are two extreme permissible sizes for a dimension

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as shown in fig. 1.3. The largest permissible size for a dimension is called upper or high limit whereas the smallest size is known as lower limit.

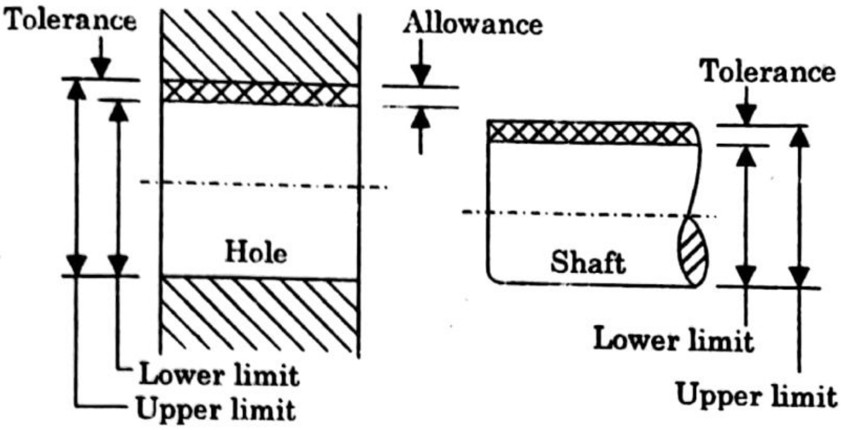

Fig. 1.3

5. Maximum limits or size : The greater of the two limits of size is called the maximum limit of size.

6. Minimum limits of size : The smaller of the two limits of size is termed as the minimum limit of size.

7. Deviation : It is the algebraic difference between a size (actual, maximum, etc.) and the corresponding basic size.

8. Actual deviation : It is the algebraic difference between the actual size and the corresponding basic size.

9. Lower deviation : It is the algebraic difference between the minimum limit of size and the corresponding basic size.

10. Upper deviation : It is the algebraic difference between the maximum limit of size and the corresponding basic size.

11. Zero line : It is a straight line corresponding to the basic size. The deviations are measured from this line. The positive and negative deviations are shown above and below the zero line respectively as in **fig. 1.4**

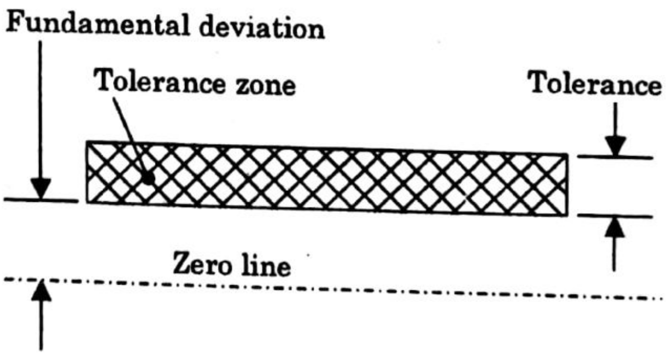

Fig. 1.4

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12. The tolerance is equal to the algebraic difference between Tolerance the upper and lower deviations and has an absolute value without sign.

13. Tolerance Zone : The zone between the maximum and minimum limit sizes is called tolerance zone as shown in **fig. 1.5**

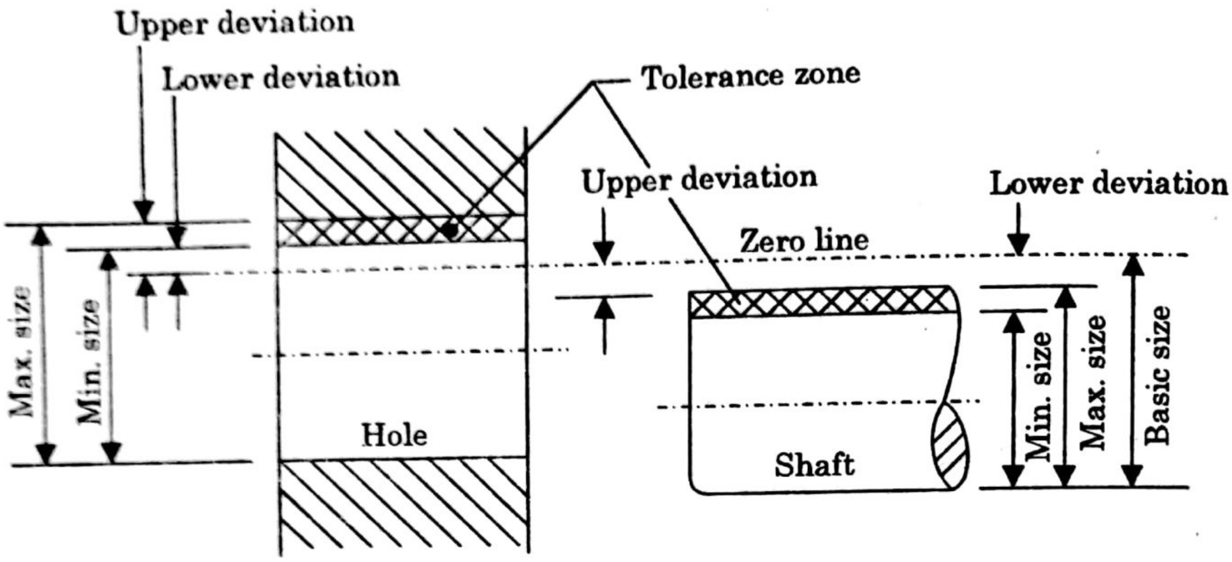

Fig. 1.5

14. Fundamental deviation : It is that one of the two deviations which is conventionally chosen to define the position of the tolerance zone in relation to the zero line. **(Fig. 1.4)**

1.12 TOLERANCE

The permissible variation of a size is called tolerance. The dimension 12.35 ± 0.15 is referred to as Plus-minus dimensioning. The tolerance of this dimension is {(12.35 + 0.15) – (12.35 – 0.15)} = 12.50 – 12.20 = 0.30. It is equal to the algebraic difference between upper and lower deviations and has an absolute value without sign **(Fig. 1.6)**. A tolerance is not given to dimension values that are identified as reference, maximum, minimum, or stock sizes.

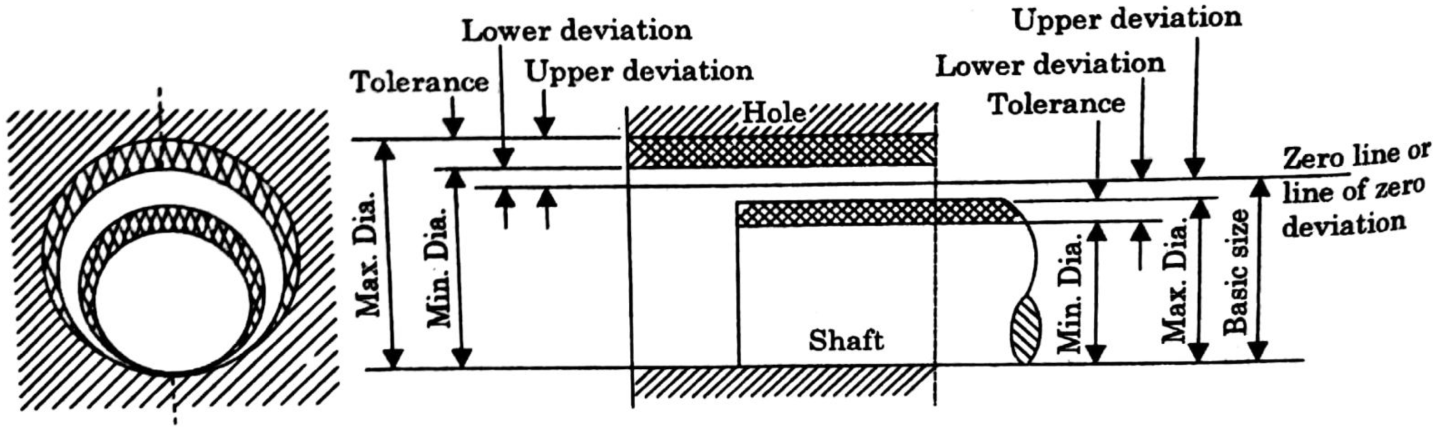

Fig. 1.6

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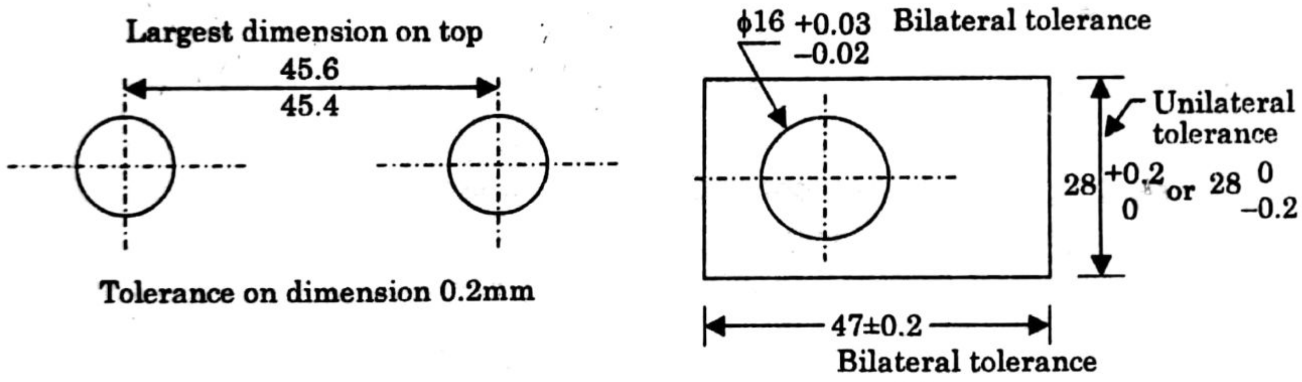
1.13 NATURAL VARIABILITY OF PROCESS

Natural variability is an unavaoidable process. Variation due to this is difficult to trace and control even under best conditions of production. Natural variabitities can happen due to many causes such as limits of control, variations in materials, environmental fluctuations, vibrations, human variability in adjusting the production machine, etc. These are of two types, one comprises of the natural elasticities, resonances, vibrations, hysteresis, and so on in manufacturing machines. This cause can produce some variation between one item and the other. The next type consists of many small causes of variation which may or may not be present all the time, but when combined with previous one, it may result into random results. It has been established that if the variations are due to chance factors alone, the observations will follow a 'normal curve'. Knowledge of the behaviour of chance variation is the foundation on which control chart analysis rests.

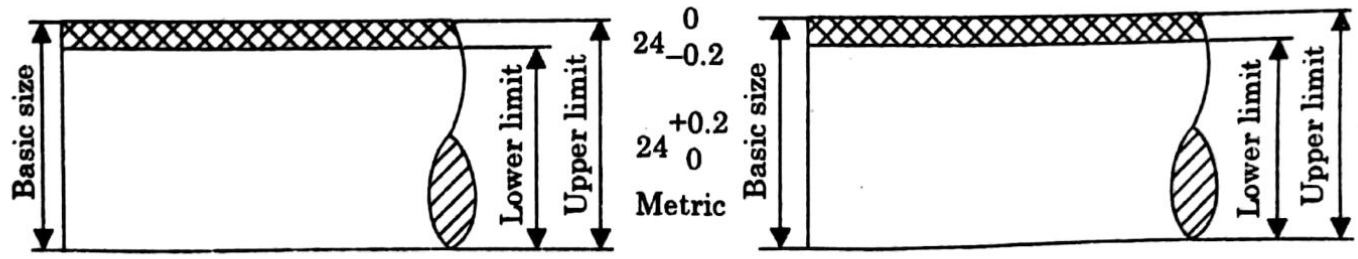
1.14 POSITIONAL TOLERANCES

Two types of positional tolerances are used and these are (a) **Unilateral tolerance** (b) **Bilateral tolerance.**

When tolerance distribution is on only one side of basic size, it is referred to as unilateral tolerance.If permissible variation is both plus and minus, it is referred to as a bilateral tolerance. These are shown in **fig. 1.7**



Dimensions with tolerance



(a) Unilateral Limits **(b) Bilateral Limits**

Fig. 1.7

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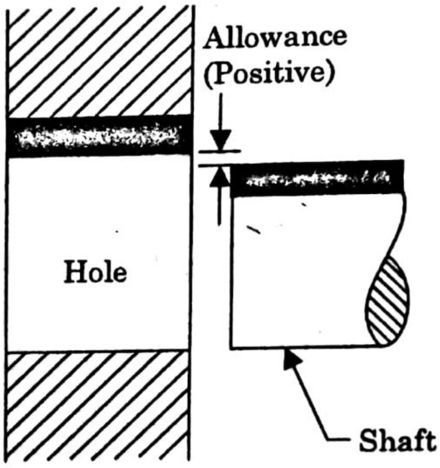
1.15 FITS

The degree of tightness or looseness between the two mating parts is known as a fit of the parts.

1.15.1 Types of fits : According to Indian Standards, the fits are classified into the following three groups :

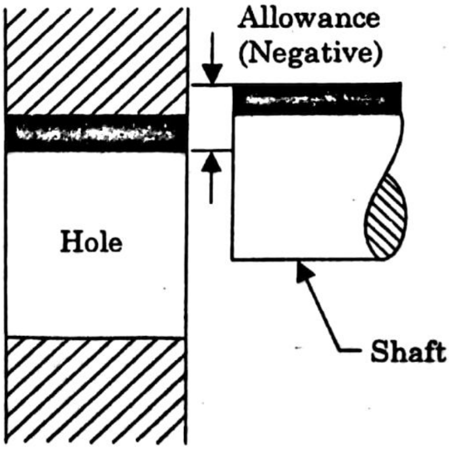
1. Clearance fit
2. Interference fit
3. Transition fit.

1. Clearance fits : In this type of fit, the size limits for mating parts are so selected that clearance between them always occur, as shown in fig. The clearance fits may be slide fit, easy sliding fit, running fit, slack running fit and loose running fit. **Fig. 1.8**



Clearance fit
Fig. 1.8

2. Interference fit : It denotes that condition of assembly of two mating parts in which the limits of sizes of these parts are so selected that interference will always occur, showing a negative allowance, between the mating surfaces of these parts (**fig. 1.9**). The interference fits may be shrink fit, heavy drive fit and light drive fit etc.



Interference Fit
Fig. 1.9

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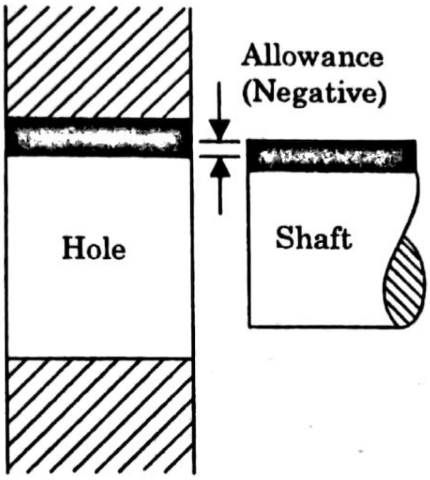
3. Transition fit : In this type of fit, the size limits for the mating parts are so selected that either a clearance or interference may occur depending upon the actual size of the mating parts **(Fig. 1.10)**. The transition fits may be force fit, tight fit or push fit. **Fig. 1.10** shows one such arrangement. In transition fits, the allowance may be negative or positive and any condition between clearance fit and interference fit may occur.



Transition Fit
Fig. 1.10

1.16 BASIS OF LIMIT SYSTEM

The following are two basis of limit system.

(i) Hole basis system : In this system the hole is kept as a constant member and different fits are obtained by varying the shaft size as shown in **fig. 1.1.**

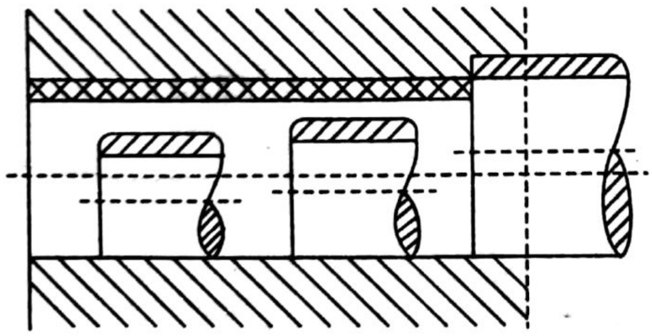


Fig. 1.11

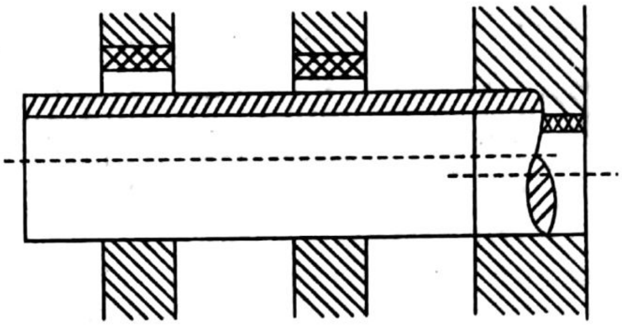


Fig. 1.12

2. Shaft basis system : In this system the shaft is kept as a constant member and different fits are obtained by varying the hole size, as shown in **fig. 1.12**

1.17 DIFFERENT LIMIT SYSTEMS

There are several limit systems prevailing but the main systems very widely used are:

1. The Newall system.

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2. British Standard System.

3. International Federation of National Standardization Associations (ISA) System.

4. I.S.O. System (International organisation for standardisation).

5. I.S.I. System.

1.18 INDIAN STANDARDS ON LIMITS AND FITS

According to Indian standards (I.S : 919 – 1963), the system of limits and fits comprises 18 grades of fundamental tolerance i.e. grades of accuracy for manufacturing and 25 types of fundamental deviations indicated by letter symbols, for holes they are designated by capital letters : A, B, C, D, E, F, G, H, JS, J, K, M, N, P, R, S, T, U, V, X, Y, Z, ZA, ZB and ZC. The corresponding shafts are designated in the same way by small letters from a to zc.

The 18 grades of tolerances are designated by IT01, IT0, IT1, IT2, IT3, IT4, IT5, IT6, IT7, IT8, IT9, IT10, IT11, IT12, IT13, IT14, IT15 and IT16. These are called **'standard tolerances'**. The standards tolerances are determined in terms of standard tolerance unit (i) in microns. There are 7 finer grades of tolerances from IT01 to IT5 and eleven coarser grades from IT6 to IT16. The finer grades associated with the 25 fundamental deviations cover holes and shafts sizes upto 500 mm and the coarser grades associated with these deviations to cover sizes upto 3150 mm. The magnitudes of standard tolerances corresponding to grades IT01, IT0 and IT1 are as follows

$$\text{IT01} = 0.3 + 0.008\,D$$
$$\text{IT0} = 0.5 + 0.012\,D$$
$$\text{IT1} = 0.8 + 0.020\,D$$

where, D is in mm, and IT in microns.

The magnitude of IT2, IT3 and IT4 are derived through geomaterical approximation between the values of IT1 and IT5.

For coarser grades, the magnitude of each grade is a multiple of the fundamental tolerance unit i, where i (μm) = $0.45\sqrt[3]{D} + 0.001\,D$ (D in mm). The relative magnitudes of coarser grades are given in **table 1.2** to 1.5

Table 1.2

Tolerance Grade	IT5	IT6	IT7	IT8	IT9	IT10	IT11	IT12	IT13	IT14	IT15	IT16
Magnitude	7i	10i	16i	25i	40i	64i	100i	160i	250i	400i	640i	1000i

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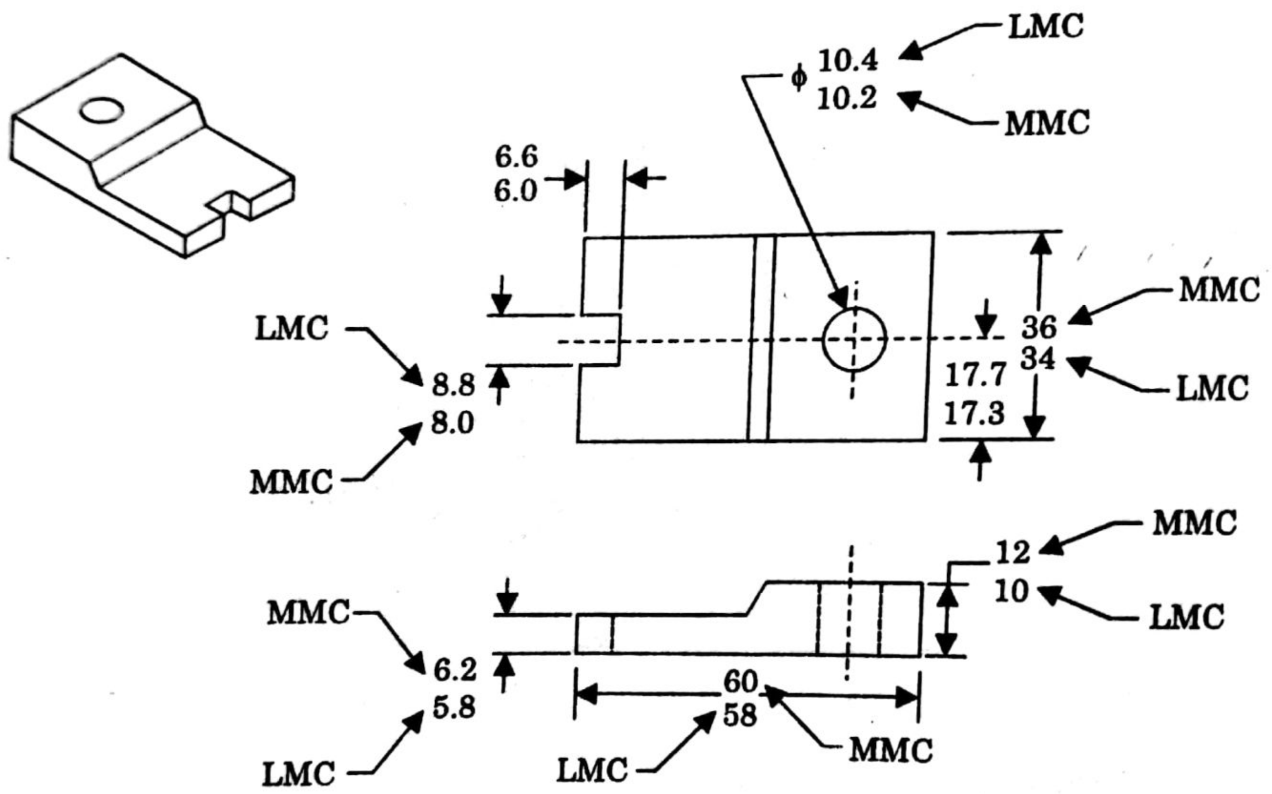
1.19 LEAST MATERIAL CONDITION (LMC)

When a feature or part is at the limit of size that results in the part containing the minimum amount of material it is said to be at least material condition. It is the minimum limit of size for an external feature, such as a shaft, or the maximum limit of size for an internal feature, such as e.g. a hole.

1.20 MAXIMUM MATERIAL CONDITION (MMC)

Maximum material condition is that condition of a part or feature, which contains the maximum amount of material everywhere within the stated limits of size, e.g. minimum size hole, or a maximum size shaft.

Some examples of maximum material condition are given in **fig. 1.13**



Maximum and Minimum Material Conditions of Size

Fig. 1.13

The indication that the value applies at the maximum material condition is shown by the symbol 'M' placed after the tolerance value, the datum letter or both.

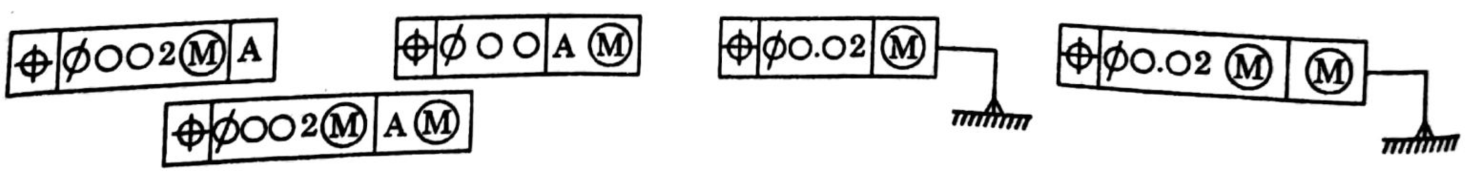


Fig. 1.14

The position of the symbol 'M' decides whether the maximum material principle

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is to be applied to the toleranced feature, the datum feature or both of these items. If a letter does not identify the datum, the maximum material Principle applied to the datum is indicated in the third compartment of the tolerance frame, **(Fig. 1.14 (a), 1.14 (b))**

1.21 USAGE OF STANDARDS FOR DECIDING TOLERANCES :

Standards play a very vital role in deciding tolerances. Some uses of standars are :

(i) They are helpful in improvement of communication, at all levels, by providing a common language to design, manufacturing, and quality control.

(ii) For the selection of tolerances standard tables have been prepared to show grades that can be held by various manufacturing processes for work in metals.

(iii) They are helpful in deciding the positional tolerances.

(iv) With standards it becomes convenient to find right tolerances.

(v) They open many opportunities for an engineer to decide what kind of tolerances should be provided.

1.22 GUIDE FOR SELECTION OF FITS

Guide for selection of fits provide many useful informations, viz.

(i) This guide gives recommendations in engineering problems concerned with the mating of a shaft and a hole. The recommendations are also applicable to noncylindrical fits.

(ii) This guide also gives the representative usage of various classes and grades of fit.

(iii) Much experience is necessary to select the appropriate tolerance for a particular application. This guide make it very easy.

(iv) This guide provides the information about the behaviour of mating parts i.e. length of contract, effect of temperature, effect of humidity etc.

1.23 PLANNING OF INSPECTION

Inspection can be broadly defined as "An essential tool for controlling the quality of a product and assess its acceptability in conformity to the laid quality standards".

In to-days tough competition, the quality of the product plays a vital role. The success of a product in capturing a market share largely depends upon it's quality. Every industry strives to ensure continued maintenance of its product quality. As such it becomes necessary that the product should be properly inspected at every step of its manufacturing stage, right from the raw material to the finishing and final assembly, strictly in accordance with the inspection plan and the prescribed standards of the quality control department inspection, thus classifies the material and products as either 'accepted' or 'reject'.

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1.23.1 Objectives of inspection : The main objectives of inspection are :

1. Inspection separates defective components from non-defective ones and thus ensures the adequate quality of products.
2. By doing so, it prevents the defective or sub-quality products from reaching the assembly stage and, hence, the customer.
3. Inspection prevents further work being done on semi-finished products already detected as **'spoiled'.**
4. It helps the companies in enhancing their reputation by maintaining quality standards.
5. To help the engineering and other depths, concerned with production, by compiling information regarding the performance of the product.
6. To find out defects in raw materials and errors in workmanship to enable the production people to take corrective steps and to prevent manufacture of poor quality products.
7. To protect the consumer from receiving a product of sub standard quality by adopting inspection at various levels of manufacturing.

1.23.2 Functions of inspection : The following are some of the important functions of inspection :

1. Inspection of incoming materials : Whenever any raw material or other purchased components or parts enter the industry, a proper inspection should be carried out to ensure that the materials/items are in accordance with prescribed specifications.

2. Inspection during manufacturing : This type of inspection is done to find out whether the products are being manufactured as per specifications or not.

3. Mechanical and metallurgical inspection : This type of inspection is done to ensure that the input materials possess required mechanical and metallurgical characteristics e.g. hardness, strength, metallurgical structure and composition etc.

4. Tool inspection : This is done to ensure that all the tools being used in various work stations are as per design specifications.

5. Purchased parts inspection : The parts manufactured by the ancillary units of the industry or purchased from the market are sujected to Inspection to determine the quality and to ensure that they are conforming to specifications laid down.

6. Finished goods inspection : The final inspection of the manufactured products is carried out to ensure that the products reaching the consumer are of specified quality levels.

1.24 DECISIONS ABOUT INSPECTION

Some defects do occur during the manufacturing process inspite of careful planning and adequate precautions during actual production. Therefore, the objective and function of inspection is to determine as to whether the product and process characteristics conform to the design specifications or not. If not, then detect the errors and report back so that corrective measure can be taken. As such, in order

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that the end product conforms to the design requirements, some vital decisions are required to be taken in respect of the inspection activities to be performed. These decisions are :

1. Why to inpect ?

In this step we findout the necessity of doing inspection. The purpose for which the inspection is to be done should be clearly laid-down.

2. What to inspect ?

In this step, the product, tool, raw material or finished product is selected upon which the inspection is to be done. In other words, in this step the thing is selected which is to be inspected.

3. When to inspect ?

Under this step, after selection of article upon which inspection is to be done, the time is decided when it is to be done. Date and time is decided when it will to be carried out.

4. Where to inspect :

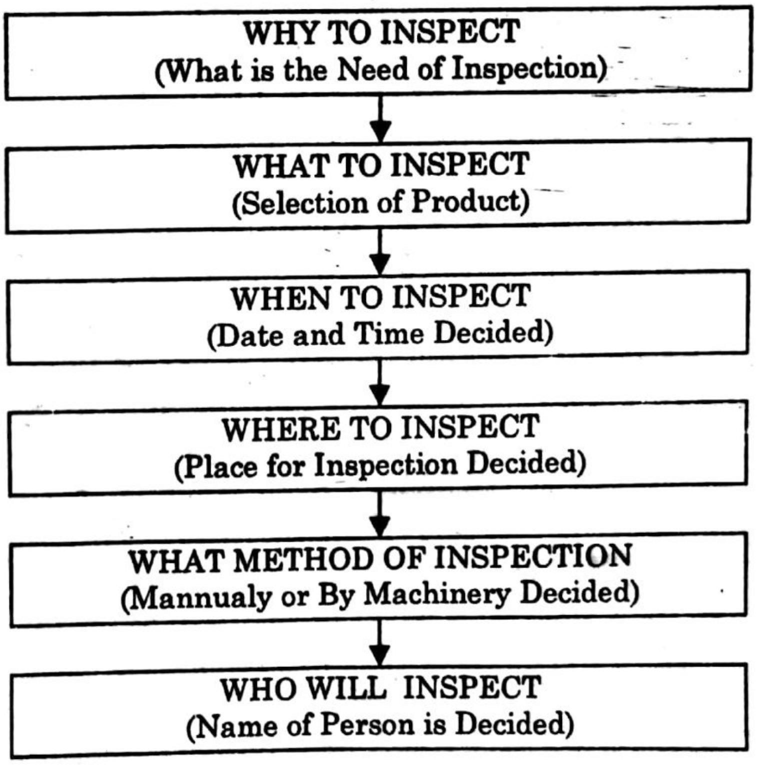
After selection the product and deciding the time when to inspect, the next step is to decide the place or venue where the inspection is to be done (i.e. in factory or outside the factory, in inspection room etc.)

5. What method of inspection :

In this step, the decision is taken that how the inspection will be done. Whether it is to be done mannually by machines or with the special purpose equipments.

6. Who will inspect ?

Finally, the name of person who will do the inspection is decided upon.



Flow Diagram of Decision about Inspection

Fig. 1.15

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1.25 TYPES OF INSPECTION

Depending upon the method of production and location of the work generally the inspection may be of the following kinds :

1. **Based upon method of inspection :**
   - (i) Remedial Inspection
   - (ii) First-Off Inspection
   - (iii) In-Process Inspection
   - (iv) Operation Inspection
   - (v) Sampling Inspection
   - (vi) Final Inspection
   - (vii) Pilot-Piece Inspection
   - (viii) Key-Operation Inspection
   - (ix) Preventive Inspection
   - (x) Final Assembly Inspection
   - (xi) Endurance Inspection
2. **Based upon location :**
   - (i) Centralized or Crib Inspection
   - (ii) Decentralized or Floor Inspection

1. Based upon method of inspection :

(i) Remedial Inspection : In this type of Inspection the tools, jigs, fixtures and machines are checked in advance, according to specifications, before the commencement of operation. A trial is attempted with a single piece and if this piece conforms with the specifications then the production is allowed to be carried out otherwise remedial steps are taken.

(ii) First-Off Inspection : The products manufactured in the first production run are inspected with respect to specifications thoroughly. This type of inspection is normally followed in case where automatic machines are used for production and if the first production run is found satisfactory, it is assumed that afterward production will also be upto the mark.

(iii) In-process inspection : This is also known as **working inspection** and in this inspection products should be inspected while they are in process, to see, that they are being produced according to specifications.

(iv) Operation Inspection : This kind of Inspection is also known as **operative Inspection.** This is used at the completion of an operation before the component passes to next operation/machine or Department.

(v) Sampling inspection : This type of Inspection may be required to be done at several stages of manufacturing, such as for inspection of some types of incoming raw materials, purchased standard components, Inspection of finished parts, etc. By inspecting certain percentage from a lot, the entire lot can be judged.

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(vi) Final inpection : This type of Inspection is employed when the manufacturing process is complete and the article is to be sent to store.

(vii) Pilot-Piece Inspection : This type of Inspection is used in product type of layout. When the first piece is manufactured, the Inspection is done according to specifications and if the piece passes Inspection, the production line is allowed to work for actual production.

(viii) Key operation Inspection : There are certain operations in manufacturing a product which are costly and difficult, and operators often commit mistakes in those operations. Such operations are known as key operations. If Inspection is done prior to and immediately after these key operations, it is called key operation inspection.

(ix) Preventive Inspection : This inspection has many aspects :

(a) This is done upon the incoming raw material to prevent the wrong purchasing of material.

(b) After some time the machine parts, tools used meet wear and tear. Therefore, it effects the quality of product. By Preventive Inspection all these things can be avoided to happen.

(c) After completion of product and before it is sent to the market, once again inspection is done to prevent the bad products entering the market.

(x) Final Assembly Inspection : This is also known as Functional Inspection and it is carried out after the completion of the product assembly to check the accuracy of the assembly and its functioning.

(xi) Endurance Inspection : This type of Inspection is meant for determining how much time the assembly can withstand while working.

2. Based upon location :

(i) Centralised Inspection : In this inspection the product to be checked or inspected are moved to special rooms where precision measuring devices are located. The inspection staff in such situation is likely to be more experienced and skilled in their work.

The main idea in centralized inspection is to separate inspection from manufacturing. Centralised inspection does not mean inspection in one room but a number of cribs may be installed, each located centrally with respect to machines in the shop.

Advantages of Centralized Inspection :

1. The worker and the Inspector do not come in contact with each other ; thus it eliminates any chances of passing a doubtful product.
2. Inspection priorities may be planned according to loads on production sections.
3. Inspection at lower cost is possible with the help of automatic devices.
4. In view of better working conditions, inspectors can check products with higher speed.

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5. Less number of gauges and instruments are required.

Disadvantages of centralised Inspection

1. Material Handling is more.
2. Delay at inspection cribs causes wastage of time.
3. Due to non detection of errors during machining in time, there may be more spoilage of material work.
4. The work of production planning and control department increases as the routing, scheduling and dispatching include inspection cribs.
5. Workers will come to know their mistakes much after the completion of jobs.

(ii) Decentralized/Floor Inspection : In this type of inspection the semi finished items are inspected either on the machine or an the production line. So, in this case inspection work ranges from mere patrolling supervision and in keeping an eye on work at machine to careful testing and measurement of products by means of measuring appliances at its place of manufacture.

Advantages of Decentralized Inspection :

(i) By this production delays, scrap and defectives may be reduced.
(ii) Due to less material handling required the indirect labour cost is reduced.
(iii) By this type of inspection Product Layout and thus mass production can be well achieved.
(iv) It is best suitable for large and heavy jobs.

Disadvantages of decentralized Inspection :

(i) Highly skilled inspectors are required.
(ii) Sufficient space is not available for inspection work.
(iii) Advanced and latest inspection equipment cannot be used.
(iv) It is not suitable for close inspection due to dust, noise and vibrations produced by working machines.

1.26 STUDY OF FACTORS INFLUENCING THE QUALITY OF MANUFACTURE

There are many factors which influence the quality of manufacture. Some of these are as follows :

1. Raw Material : The quality of finished product basically depends upon the incoming raw material. For a quality product the raw material should be of fine quality.

2. Skilled Manpower : Skilled manpower is needed to produce a quality work.

3. Machinery and Equipment : Modern machineries Like C.N.C Automatic, semi-automatic etc. are required for the best quality of manufactured product.

4. Process : The process adopted should be right and according to the requirement.

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