The maximum limit of size is the greater of the two limits of size, whereas the minimum limit of size is the smaller of the two.

Tolerance

This is the total permissible variation in the size of a dimension, that is, the difference between the maximum and minimum limits of size. It is always positive.

Allowance

It is the intentional difference between the LLH and HLS. An allowance may be either positive or negative.

$$\text{Allowance} = \text{LLH} - \text{HLS}$$

Grade

This is an indication of the tolerance magnitude; the lower the grade, the finer the tolerance.

Deviation

It is the algebraic difference between a size and its corresponding basic size. It may be positive, negative, or zero.

Upper deviation

It is the algebraic difference between the maximum limit of size and its corresponding basic size. This is designated as 'ES' for a hole and as 'es' for a shaft.

Lower deviation

It is the algebraic difference between the minimum limit of size and its corresponding basic size. This is designated as 'EI' for a hole and as 'ei' for a shaft.

Actual deviation

It is the algebraic difference between the actual size and its corresponding basic size.

Fundamental deviation

It is the minimum difference between the size of a component and its basic size. This is identical to the upper deviation for shafts and lower deviation for holes. It is the closest deviation to the basic size. The fundamental deviation for holes are designated by capital letters, that is, A, B, C, …, H, …, ZC, whereas those for shafts are designated by small letters, that is, a, b, c…, h…, zc. The relationship between fundamental, upper, and lower deviations is schematically represented in Figure.

Zero line

This line is also known as the line of zero deviation. The convention is to draw the zero line horizontally with positive deviations represented above and negative deviations indicated below. The zero line represents the basic size in the graphical representation.

Shaft and hole

These terms are used to designate all the external and internal features of any shape and not necessarily cylindrical.

Fit

It is the relationship that exists between two mating parts, a hole and a shaft, with respect to their dimensional difference before assembly.

Maximum metal condition

This is the maximum limit of an external feature; for example, a shaft manufactured to its high limits will contain the maximum amount of metal. It is also the minimum limit of an internal feature; for example, a component that has a hole bored in it to its lower limit of size will have the minimum amount of metal removed and remain in its maximum metal condition, (i.e., this condition corresponds to either the largest shaft or the smallest hole). This is also referred to as the GO limit.

Least metal condition

This is the minimum limit of an external feature; for example, a shaft will contain minimum amount of material, when manufactured to its low limits. It is also the maximum limit of an internal feature; for example, a component will have the maximum amount of metal removed when a hole is bored in it to its higher limit of size, this condition corresponds to either the smallest shaft or the largest hole. This is also referred to as the NO GO limit.

Tolerance zone

The tolerance that is bound by the two limits of size of the component is called the tolerance zone. It refers to the relationship of tolerance to basic size.

International tolerance grade (IT)

Tolerance grades are an indication of the degree of accuracy of the manufacture. Standard tolerance grades are designated by the letter IT followed by a number, for example, IT7. These are a set of tolerances that varies according to the basic size and provides a uniform level of accuracy within the grade.

Tolerance class

It is designated by the letter(s) representing the fundamental deviation followed by the number representing the standard tolerance grade. When the tolerance grade is associated with letter(s) representing a fundamental deviation to form a tolerance class, the letters IT are omitted and the class is represented as H8, f7, etc.

Tolerance symbols

These are used to specify the tolerance and fits for mating components. For example, in 40 H8f7, the number 40 indicates the basic size in millimetres; capital letter H indicates the fundamental deviation for the hole; and lower-case letter f indicates the shaft. The numbers following the letters indicate corresponding IT grades.

2.6.6 Taylor’s Principle

In 1905, William Taylor developed a concept relating to the gauging of components, which has been widely used since then. Since World War II, the term Taylor’s principle has generally been applied to the principle of limit gauging and extensively used in the design of limit gauges. Prior to 1905, simple GO gauges were used. The components were carefully manufactured to fit the gauges. Since NOT GO gauges were not used, these components were without tolerance on their dimensions.

The theory proposed by Taylor, which is extensively used in the design of limit gauges, not only defines the function, but also defines the form of most limit gauges.

Taylor's principle states that the GO gauge is designed to check maximum metal conditions, that is, LLH and HLS. It should also simultaneously check as many related dimensions, such as roundness, size, and location, as possible.

The NOT GO gauge is designed to check minimum metal conditions, that is, HLH and LLS. It should check only one dimension at a time. Thus, a separate NOT GO gauge is required for each individual dimension.

During inspection, the GO side of the gauge should enter the hole or just pass over the shaft under the weight of the gauge without using undue force. The NOT GO side should not enter or pass.

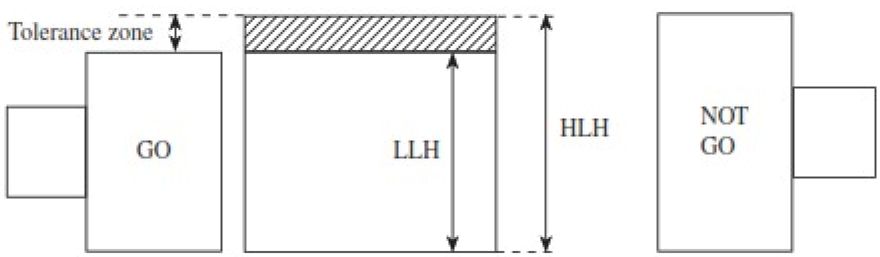

Fig. 2.66 GO and NOT GO limits of plug gauge

[source: "Engineering Metrology & Measurements", N.V. Raghavendra., page-66]

The basic or nominal size of the GO side of the gauge conforms to the LLH or HLS, since it is designed to check maximum metal conditions. In contrast, the basic or nominal size of the NOT GO gauge corresponds to HLH or LLS, as it is designed to check minimum metal conditions.

It can be seen that the size of the GO plug gauge corresponds to the LLH and the NOT GO plug gauge to the HLH. Conversely, it can be observed that the GO snap gauge represents the HLS, whereas the NOT GO snap gauge represents the LLS.

It is pertinent to discuss here that since the GO plug is used to check more than one dimension of the hole simultaneously, the GO plug gauge must have a full circular section and must be of full length of the hole so that straightness of the hole can also be checked.

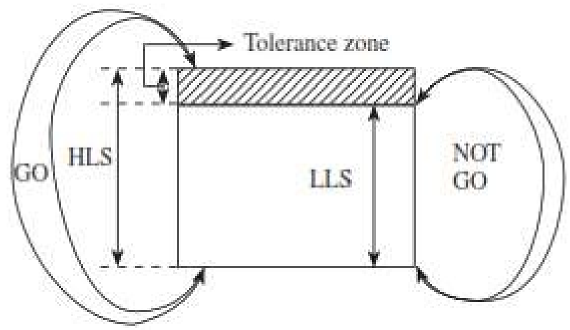

Fig. 2.67 GO and NOT GO limits of snap gauge

[source: "Engineering Metrology & Measurements", N.V. Raghavendra., page-67]

During inspection, it can be ensured that if there is any lack of straightness or roundness of the hole a full entry of the GO plug gauge will not be allowed. Thus, it not only controls the diameter in any given cross-section but also ensures better bore alignment. However, it should be mentioned here that the GO plug gauge cannot check the degree of ovality.

The short GO plug gauge, if used in inspection, will pass through all the curves and is hence not possible to identify defective parts. Therefore, in order to get good results, this condition has to be fulfilled during the inspection of the parts. The length of the plug should normally be more than 1.5 times the diameter of the hole to be checked. Compared to GO plug gauges, the NOT GO plug gauges are relatively shorter.

2.6.7 Important Points for Gauge Design

The following points must be kept in mind while designing gauges:

1. The form of GO gauges should be a replica of the form of the opposed (mating) parts.

2. GO gauges enable several related dimensions to be checked simultaneously and hence are termed complex gauges.

3. During inspection, GO gauges must always be put into conditions of maximum impassability.

4. NOT GO gauges check a single element of feature at a time.

5. In inspection, NOT GO gauges must always be put into conditions of maximum possibility.