Limits and Fits:

- Precision mating fits between “shaft” (outer cylindrical surface) and “hole” (inner surface).
- Assembly examples are
  - driven shaft and cone of ball or roller bearing
  - bearing cup (housing) and casting in which it is mounted
  - bronze bushing and casting in which it is mounted
  - hole in gear or pulley sheave and driving shaft

Limits and Fits:

- Limit dimensions define a range of “acceptable” sizes for each mating component.
- The dimensions are often given as a stacked pair of values which correspond to the upper and lower bound of the range.
- When each part falls within their respective range, their assembly defines a “fit”.

Fits may involve:

- material clearance (free fit)
- material interference (force fit)
- or an overlap of the two (transitional fit)

Basic manufacturing approaches

- Interchangeable assembly
- Fitted assembly
- Selective assembly

Interchangeable assembly

- All parts are toleranced to permit them to be assembled and function without the need for machining or fitting at assembly.
- Parts are therefore interchangeable.

Fitted assembly

- Mating parts are fabricated simultaneously or with respect to one another.
- Process can be performed at various stages of assembly.
- Parts are not interchangeable.
Selective assembly

- Parts are mass-produced to specific tolerance and allowance, then sorted manually or through a computer-controlled optic system.
- All parts are inspected and sorted into various size grades according to size.
- Parts are then selectively assembled.

Nominal size:

- The size designation used for general identification.
- The nominal size of a shaft and a hole are the same.
- Value is often expressed as a fraction.

Basic size:

- The exact theoretical size of a part.
  - value from which the limit values will be computed.
  - often a four decimal place equivalent to the nominal size.
  - The number of significant digits imply the accuracy of the dimension.
- example: nominal size = 1 1/4 inch
  basic size = 1.2500

Design size: (MMC)

- The ideal size for each component based upon the desired fit.
  - the sizes the components are “designed” to be.
- The design size of a part corresponds to that part’s Maximum Material Condition (MMC).
  - the largest shaft permitted by the limits and the smallest hole.

Design size:

- The difference between the design size of the shaft and the design size of the hole is equal to the allowance of the fit.
- When limit dimensions are written the emphasis is placed upon the design size.
  - The design size is written as the “top” value of the limit dimension pair, regardless of whether is is the “largest” or “smallest” of the pair.

Tolerance

- The total amount by which a dimension is allowed to vary. For the fit of a shaft/hole combination, the tolerance is considered to be unilateral, that is, it is only applied in one direction from the design size of the part.
- Standards for limits and fits state that tolerances are applied such that the hole size can only vary larger from the design size and the shaft size small.
Allowance

- The allowance is the intended difference in the sizes of mating parts.

\[ \text{design size}_{\text{hole}} - \text{design size}_{\text{shaft}} = \text{allowance} \]

This allowance may be

- positive (indicated with a “+” symbol),
  - intended clearance between parts
- negative (“-“)
  - intended interference
- zero allowance, used if the parts are intended to be the “same size”.
  - This is also used in an assemble technique known as selective assembly.

Basic hole system

- Most common system of computing limit dimensions.
  - the design size of the hole is taken to be equivalent to the basic size for the pair.
- This means that the smaller limit value of the of hole dimension pair is equal to the basic size of the assembly.

Basic hole system

- The basic hole system is more frequently used since most hole manufacturing devices are of fixed size (for example, drills, reams, etc.)
- A complimentary technique (basic shaft system) may be used when designing using purchased components with fixed outer diameters (bearings, etc.).

Calculation of limits

- Limit values are computed using one of a set of ANSI defined standard fits.
- A similar system (ISO Standard Fits) exists for metric assemblies.

ANSI fit classes

- RC running and sliding fits
- LC locational clearance fits
- LT locational transition fits
- LN locational interference fits
- FN force or heat and shrink fits
ANSI fit classes
• Fits also include a numerical designation of class, for example, RC3 or FN2.
• The higher the number, the greater the allowance value with the type of fit. (an RC7 fit is looser than an RC1)
• A table of these standard fits provides arithmetic modifiers which when applied to the basic size for the assembly provide the limit dimensions required for the fit.

Calculation of limit dimensions
• Given:
  – nominal dia. of assembly
• Choose:
  – desired fit based upon function
• From table:
  – cross reference diameter and fit to obtain modifiers for shaft and hole
  – apply modifiers to basic size of system to obtain limits

ISO Standard Fits, symbology includes:
• A preferred basic size
• A letter designation of Fundamental Deviation (uppercase for internal, lowercase for external)
• A numerical value indicating the International Tolerance grade (IT grade)

Basic Size
• Similar to Basic Size in the decimal inch system, this is the size from which limits or deviation are derived.
• The Basic Size should be selected from a list of preferred sizes.

Deviation and IT Grade
• Deviation
  – The variance in the part size from Basic Size.
• International tolerance grade (IT grade)
  – Establishes the amount of part size variation allowed for internal and external dimensions

Metric fits
• Grade and deviation chosen as a pair from description table.
• Limits calculated from table information in same fashion as ANSI fits.
Unilateral tolerance

• An alternative format for the writing of fit dimensions.
• Provides the same information as limit dimensions in a different form.
• In the unilateral tolerance format, the design size of each component is specified and the tolerance on each is given explicitly.