Tolerances - Information Sheet 2

The Need for Dimensional Tolerances

In the manufacturing or construction industries it is never possible to make an item to a precise dimension with absolute accuracy due to errors introduced through the manufacturing and construction process. This would not be a problem if:

(a) components did not interface and interact with any other parts, think about the parts of a car engine or the wheels and gears of your mountain bike.
(b) there was enough time and resources to work on each part until it was the perfect size or to make sure each component fitted perfectly with each other.

In reality it is very difficult to make sure the above conditions (a) and (b) are ever met. Modern technological advancement, mass production and the drive towards higher levels of productivity has led to an increased demand for manufacturing accuracy. Consumers expect products they buy to be well made, be durable and to perform the function for which they are intended. This can only be achieved through the use of tolerances. The following examples help to illustrate this point:

1. The accuracy with which a door hinge is manufactured will affect the ease of movement of the hinge - in other words it can be too tight or too slack. By specifying the appropriate dimensional tolerances for the hinge the "feel" of the hinge can be controlled. This avoids the need to fit and adjust the hinge, which would be a time consuming job. Any parts not made to the required tolerances either being reworked or rejected as scrap.

2. The European aerospace industry demonstrates how technological and political progress has dictated an ever increasing need for accuracy. The European jet fighter, a £32bn joint project was developed by a consortium of British Aerospace Defence, Dasa in Germany, Alenia in Italy and Casa in Spain. Britain produces part of the fuselage and the cockpit, Germany the mid section fuselage, Italy the left wing and two other parts of the fuselage finally the right wing and leading edge slats are produced in Spain.
The parts are shipped to Germany where the aircraft is assembled. Without tolerances the successful assembly of such a complex piece of machinery would not be possible.

3. There is a similar need for tolerances in the construction industry, for example large power station cooling towers 100m or so in diameter, may have a shell thickness of between 100 - 120mm. Careful attention must be paid to tolerances to ensure successful construction. On the other hand building tolerances are sometimes specified to allow for adjustment during construction. This happens when the precise size of a mating part is not known, for example when a new building is being erected against the party wall of an existing building which has had years to move and settled into position and may not be plumb or square.

The Use of Dimensional Tolerances

Tolerances are used in both the construction and engineering industries, to specify limits on sizes and location, on products as diverse as motorway flyovers, oil tankers, motor cars, digital watches and cameras. Tolerancing information is normally provided on manufacturing and construction drawings. It may be applied to:

(a) Dimensions on a single part specifying the permissible variation of:-

  (i) the size of an item or features on it.
  (ii) the location of features, such as hole centres or supporting columns in a building.

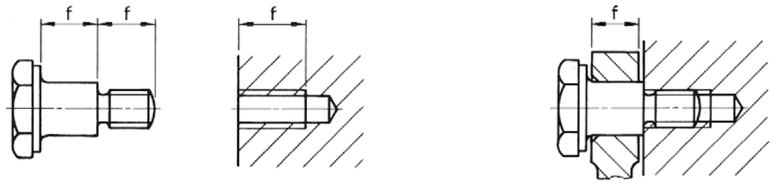
(b) Dimensions on assembly drawings giving the maximum permissible variation of dimensions of assembled components. However only dimensions **crucial** to the assembly and functionality of the assembled item are normally shown on the drawings.

(c) Dimensions on site and floor plans giving the maximum permissible variation in size and location of features.

In reality, all dimensions on manufacturing and construction drawings are subject to tolerances. A distinction must be made between **functional** and **non-functional** dimensions which will affect how and whether the tolerances are shown on a drawing.

Functional Dimensions:

Those dimensions which affect directly the functionality and interchange ability of parts. For example, the diameter of a bicycle seat pin which must fit into the bicycle frame. These dimensions are also referred to as *critical dimensions*. The dimensions indicated on the threaded hole and bolt below show the sizes which directly affect the assembly of the components.



Functional Dimensioning

Non-functional Dimensions:

These are dimensions which do not directly affect either of the above conditions, but may be selected to meet other criteria such as appearance or strength. For example, the internal diameter of a bicycle seat pin or the exterior of a computer casing.

Much greater emphasis is paid to the selection of tolerances on functional dimensions as they have a far greater effect on the assembly and final performance of the product. This distinction can affect the way that tolerancing information is provided. Normally the tolerance for a functional dimension is less than that of a non-functional dimension.