7 Fits Between the Shaft and the Hub and Fits Between the Hub and the Shaft

7.1 ISO System Concerning Tolerances

The productions of shafts and hubs cannot strictly be made to a precise dimension without causing a rise in the production costs; therefore any variations in the indicated dimension, must be taken into account. The indicated dimension, which acts as a reference dimension, is the nominal dimension. The higher the required degree of accuracy, the smaller are the deviations relative to such dimension, even if a considerable price rise is involved. Another reason where the deviations from the nominal dimension are acceptable is that it is possible to produce connections made up of a shaft and a hub which can be mounted or dismounted or not. There is not a question of accepting tolerances on one of the components, but rather of producing tightened or clearance that can be mounted or dismounted according to working requirements. The tolerances have been standardized in system ISO based on the following principles:

(1) The qualities are classified on the basis of numbers ranging from 1 to 16; the lowest degree of quality corresponds to the highest number. The qualities worth values of 0 and 01 have been produced in case an extremely high degree of accuracy is required.

(2) Diameters are classified according to different intervals. The diameter calculated by the geometrical average of the interval is characterized by the calculation of the tolerances.

(3) For each quality and each interval of the diameters a tolerance interval is established. This interval is given by the difference between the maximum and the minimum dimensions tolerated for each interval of diameter and for each quality. The base of the calculation is represented by the tolerance unit expressed by the following formula:
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\[ i = 0.45 \sqrt[3]{d_{\text{ref}}} + 0.001 d_{\text{ref}}. \]  

(7.001)

For qualities, the interval of tolerance is a multiple of \( i \) (Table 7.1).

**Table 7.1. Intervals of tolerance ISO**

<table>
<thead>
<tr>
<th>IT5</th>
<th>IT6</th>
<th>IT7</th>
<th>IT8</th>
<th>IT9</th>
<th>IT10</th>
</tr>
</thead>
<tbody>
<tr>
<td>7i</td>
<td>10i</td>
<td>16i</td>
<td>25i</td>
<td>40i</td>
<td>64i</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IT11</th>
<th>IT12</th>
<th>IT13</th>
<th>IT14</th>
<th>IT15</th>
<th>IT16</th>
</tr>
</thead>
<tbody>
<tr>
<td>100i</td>
<td>160i</td>
<td>250i</td>
<td>400i</td>
<td>640i</td>
<td>1000i</td>
</tr>
</tbody>
</table>

The lower deviations are respectively \( ei \) and \( Ei \) for the shaft and the holes. The upper deviations are respectively \( es \) and \( Es \) for the shaft and the holes. Deviations are given by the difference between the real and the nominal dimensions.

(4) Lower and upper deviations are placed in relation to a line called line 0, which corresponds to the nominal diameter. The position of such deviations can vary for each quality from an extremely negative position to an extremely positive position. The position of the deviations is indicated by a letter of the alphabet ranging from \( a \) to \( z \) for shafts, from \( A \) to \( Z \) for the holes. For borings the deviations indicated by \( A \) are in the extreme positive position. The different positions to which precise letters correspond are usually expressed by formula. Nevertheless some peculiarities are observed. The deviation indicated by \( h \) for the shaft is positioned in order to make the upper deviation null. The lower deviation is therefore equal to -IT. For borings the position \( H \) corresponds to a null lower deviation and to an upper deviation equal to +IT. A particular deviation is that indicated by \( js \). The upper deviation is equal to +0.5 IT and the lower deviation is equal to -0.5 IT.

The rule, however, provides detailed tables for all the deviations. The reference for a given dimension is of type 100 s6 for shafts and 100 H7 for holes. The result is: nominal diameter 100, position s for the shaft or position H for the hole and quality 6 for the shaft or quality 7 for the hole. These references are found in the tables of the standard for all the values of the upper and lower deviations which are (in the example provided):

For the shaft

- Lower deviation \( (ei) = +71 \mu m \)
- Upper deviation \( (es) = +93 \mu m \)
- \( \text{IT 6} \quad = 22 \mu m \)

For the hole

- Lower deviation \( (Ei) = 0 \mu m \)
- Upper deviation \( (Es) = +35 \mu m \)
- \( \text{IT7} \quad = 35 \mu m \)