Limit Dimensioning

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Tolerances

The technique of dimensioning parts within a required range of variation to ensure interchangeability is called tolerancing.

A tolerance should be as large as possible without interfering with the function of the part to minimize production costs.

Manufacturing cost increases as tolerances become smaller.
Three methods of specifying tolerances

**UNILATERAL, BILATERAL, AND LIMIT TOLERANCES**

**UNILATERAL TOLERANCE** (Variation in one dir.)
- \[ \pm 0.005 \] General space
- \[ +0.003 -0.000 \] Tight Space
- \[ \phi 0.500 +0.000 -0.005 \] DIA Form

**BILATERAL TOLERANCE** (Variation in two dir.)
- \[ \pm 0.003 \] General space
- \[ +0.002 -0.001 \] Tight Space
- \[ \phi 14.000 +0.004 \] DIA Form

**LIMIT FORM**
- Large on top
  - \[ 2.250 \] General space
  - \[ 2.245 \] Tight Space
- Small to large
  - \[ \phi 14.00 - 14.20 \] DIA Form

**Figure 14.2** These methods properly position and indicate tolerances in unilateral, bilateral, and limit forms for both general and tight spaces.
Order of Numbers

ORDER OF NUMBERS

Large limit on top

22.20
22.00

A. LIMITS

Plus tolerance on top

46.00
+0.40
-0.20

B. PLUS–MINUS

Small limit first

Ø26.00 – 26.40

C. LIMITS

Ø76.0 ± 0.2

D. PLUS–MINUS

Figure 14.3 Place upper limits either above or to the right of lower limits. In plus-and-minus tolerancing, place the plus limits above the minus limits.
Positioning of Numbers

**POSITIONING OF NUMBERS**

\[ H = \frac{1}{8} \]

Same no. of decimal places

\[ \frac{2.0000 + 0.0040}{0.0020} \]

**A. PLUS–MINUS TOLERANCES**

\[ H = \frac{1}{16} \]

\[ \frac{2.0400}{1.9980} \]

**B. LIMIT–FORM TOLERANCES**

*Figure 14.4* This drawing shows the spacing and ratios of numerals used to specify tolerances on dimensions.
Figure 14.5 These mating parts have tolerances (variations in size) of 0.003” and 0.002”, respectively. The allowance (tightest fit) between the assembled parts is 0.002”.

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Cylindrical Fits

Figure 14.6 These parts must be assembled with cylindrical fits that give a clearance and an interference fit.
Terminology of Tolerances

Tolerance: Maximum allowable variation
Limits of Tolerance: Maximum and Minimum dimension of a part
Allowance: Tightest fit between the two mating parts
Nominal Size: Approximate size of shaft or hole
Basic Size: The exact theoretical size from which limits are derived by application of tolerances

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Terminology of Tolerances

**TERMINOLOGY OF TOLERANCES**

- **Shaft**
  - TOL. = .0025
  - 1.4950
  - 1.4925
- **Hole**
  - TOL. = .0040
  - 1.5040
  - 1.5000

**A. LIMIT FORM**
- **Largest Shaft**
  - 1.5000
  - 1.4950
- **Smallest Hole**
  - 1.4925
  - 1.4950

**B. MEANING**
- **Smallest Shaft**
  - 1.5040
  - 1.5000
- **Largest Hole**
  - 1.4925
  - 1.5040

**Allowance**
- **Tightest Fit**
  - 1.5000
  - -1.4950
  - +0.0050

**Max Clearance**
- **Loosest Fit**
  - 1.5040
  - -1.4925
  - +0.0115

**Figure 14.7** The allowance (tightest fit) between these assembled parts is +0.005”. The maximum clearance is +0.0115”.

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Types of Fit

- **Clearance Fit:**
  - Clearance between two assembled mating parts

- **Interference Fit:**
  - Results in an interference between two assembled parts

- **Transition Fit:**
  - May result in either interference or a clearance

- **Line Fit:**
  - May result in surface contact or clearance
Types of Fit

Figure 14.8 This drawing shows three types of fits between mating parts in addition to the clearance fit shown in the Fig. 14.7.
Figure 14.9 Single tolerances can be given in applications of this type in maximum (MAX) or minimum (MIN) form.
Methods of Calculation

♦ BASIC HOLE SYSTEM
  - Utilizes the smallest hole size as the basic diameter for calculating tolerances and allowances.

♦ BASIC SHAFT SYSTEM
  - Applicable when the shafts are available in precise standard sizes.
  - Utilizes the largest diameter of the shaft as the basic diameter.
Cylindrical Fits

- **RC**: Running and Sliding Clearance Fits
- **LC, LT, LN**: Locational Fits
- **FN**: Force & Shrink Fits

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Calculation of Limits

**CALCULATION OF LIMITS: INCH TABLES**

CLASS RC9 FIT See Appendix
(1.97–3.15 DIA)

<table>
<thead>
<tr>
<th>Clearance</th>
<th>Hole</th>
<th>Shaft</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.0</td>
<td>7.0</td>
<td>-9.0</td>
</tr>
<tr>
<td>20.5</td>
<td>0</td>
<td>-13.5</td>
</tr>
</tbody>
</table>

HOLE: 2.5000 BASIC DIA

<table>
<thead>
<tr>
<th>Upper Limit</th>
<th>Lower Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5000</td>
<td>2.5000</td>
</tr>
<tr>
<td>.0070</td>
<td>0</td>
</tr>
<tr>
<td>2.5070</td>
<td>2.5000</td>
</tr>
</tbody>
</table>

SHAFT: 2.5000 BASIC DIA

<table>
<thead>
<tr>
<th>Upper Limit</th>
<th>Lower Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5000</td>
<td>2.5000</td>
</tr>
<tr>
<td>-.0090</td>
<td>-.0135</td>
</tr>
<tr>
<td>2.4910</td>
<td>2.4865</td>
</tr>
</tbody>
</table>

Limits of Clearance

| 2.5000      | 2.5070      |
| 2.4910      | 2.4865      |
| .0090       | .0205       |

Since basic DIA appears on hole, this is a Basic Hole System.

**Figure 14.10** This example shows how to calculate limits and allowances for an RC9 fit between a shaft and hole with a basic diameter of 2.5000 inches. Refer to Appendix 32.
### Calculation Chart

**CLASS RC9 Running & Clearance Fit (From Appendix)**

<table>
<thead>
<tr>
<th>Nominal Size Range Inches</th>
<th>Limits of Clearance</th>
<th>Limits Hole</th>
<th>Limits Shaft</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.97 - 3.15</td>
<td>9.0</td>
<td>+7.0</td>
<td>-9.0</td>
</tr>
<tr>
<td></td>
<td>20.5</td>
<td>0</td>
<td>-13.5</td>
</tr>
</tbody>
</table>

Complete chart below by using table above:

- **Class of fit:** RC9 Basic Hole System
- **Basic Diameter:** 2.5000
- **Hole Limits:**
  - Max Hole: 2.5000
  - Min Hole: 2.5000
- **Shaft Limits:**
  - Max Shaft: 2.5000
  - Min Shaft: 2.5000
- **Hole Tolerance:** .0070
- **Shaft Tolerance:** .0045
- **Max Clearance**
  - Largest Hole: 2.5070
  - Smallest Hole: 2.4910
  - Largest Shaft: 2.4865
  - Smallest Shaft: 2.4865
- **Min Clearance (Allowance)**
  - Largest Hole: 2.5070
  - Smallest Hole: 2.4910
  - Largest Shaft: 2.4865
  - Smallest Shaft: 2.4865
  - .0205

Figure 14.11 Cylindrical fit information may be calculated in an organized manner as this chart demonstrates. (Thanks to Steve Horton.)