Basic Dimensioning and Tolerancing

Dr. Hodge Jenkins
MAE 205
Important Elements of Dimensioning
Dimension locations

Dimensions and all text are ALWAYS horizontal

A

B

C

D

E

F

G

H

2.000

.500

.375

.125

.500

.375

2.000
Size and Location of Features

Dimension features in the view best seen.
Dimension Examples
**Figure 4.9** Minimum Dimension Line Spacing

Standard practice for the spacing of dimensions is 10 mm from the view and 6 mm between dimension lines.
Dimension Locations

Dimension out part boundary

Dimensions and all text are ALWAYS horizontal

Unidirectional Current standard

Aligned Old standard
Figure 4.10  Group Dimensions
In standard practice, dimensions are grouped on a drawing. Do not use object lines as extension lines for a dimension.
Grouped dimension

Figure 4.11  Stagger Dimension Text
The general practice is to stagger the dimension text on parallel dimensions.

Figure 4.12  Extension Line Practice
Extension lines should not cross dimension lines, are not broken when crossing object or other extension lines, and are broken when crossing arrows.
Diameter Features

Figure 4.17 Radial Leader Lines
Leader lines used to dimension holes must be radial.
Figure 4.21  Dimensioning Concentric Circles
Concentric circles are dimensioned in the longitudinal view.
Dimensioning Slots

Figure 4.20 Dimensioning Slots
Several methods are appropriate for dimensioning slots.
**Dimensioning Consideration**

**Figure 4.22** Dimensioning Arcs
Arcs of less than half a circle are dimensioned as radii, with the R symbol preceding the dimension value.

**Figure 4.23** Avoid Overdimensioning
Double dimensioning can cause problems because of tolerancing.

**Figure 4.24** Dimension the Most Descriptive View
Dimensions are placed in the most descriptive or contour view.
4.5.4 Single Limit Dimensions

When other elements of a feature will determine one limit dimension, MIN or MAX is placed after the other limit dimension. Items such as depth of holes, length of

![Diagram of tolerancing examples]

(A) Unilateral tolerancing  
(B) Bilateral tolerancing

**Figure 4.28** Plus and Minus Tolerance System Applied to Various Dimensioning Conditions
Figure 4.29 Toleranced Parts and the Important Terms
Figure 4.30 Clearance and Interference Fits between Two Shafts and a Hole
Shaft A is a clearance fit, and shaft B is an interference fit.
Figure 4.25
A system is two or more mating parts.

Figure 4.26
Representing Tolerance Values
Tolerances are represented as direct limits or as tolerance values.

Figure 4.27
Geometric Tolerance System Used to Dimension Parts
Thread Standards and Definitions

- **Pitch** – distance between adjacent threads. Reciprocal of threads per inch
- **Major diameter** – largest diameter of thread
- **Minor diameter** – smallest diameter of thread
- **Pitch diameter** – theoretical diameter between major and minor diameters, where tooth and gap are same width
Standardization

• The *American National (Unified)* thread standard defines basic thread geometry for uniformity and interchangeability

• American *National (Unified)* thread
  - UN  normal thread
  - UNR  greater root radius for fatigue applications

• **Metric thread**
  - M series  (normal thread)
  - MJ series  (greater root radius)
Thread Standardization

• **Coarse series UNC**
  • General assembly
  • Frequent disassembly
  • Not good for vibrations
  • The “normal” thread to specify

• **Fine series UNF**
  • Good for vibrations
  • Good for adjustments
  • Automotive and aircraft

• **Extra Fine series UNEF**
  • Good for shock and large vibrations
  • High grade alloy
  • Instrumentation
  • Aircraft
Thread Standardization

• Basic profile for metric M and MJ threads shown
Bolt Specification

1/4-20 x 3/4 in UNC-2 Grade 5 Hex Head bolt

Nominal diameter

Material grade

Thread series

Class fit

Head type

Material class

Metric

Pitch

M12 x 1.75 ISO 4.8 Hex head bolt

Nominal diameter
# Diameters and Areas for Metric Threads

<table>
<thead>
<tr>
<th>Nominal Major Diameter $d$ mm</th>
<th>Coarse-Pitch Series</th>
<th>Fine-Pitch Series</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pitch $p$ mm</td>
<td>Tensile-Stress Area $A_t$ mm$^2$</td>
</tr>
<tr>
<td>1.6</td>
<td>0.35</td>
<td>1.27</td>
</tr>
<tr>
<td>2</td>
<td>0.40</td>
<td>2.07</td>
</tr>
<tr>
<td>2.5</td>
<td>0.45</td>
<td>3.39</td>
</tr>
<tr>
<td>3</td>
<td>0.5</td>
<td>5.03</td>
</tr>
<tr>
<td>3.5</td>
<td>0.6</td>
<td>6.78</td>
</tr>
<tr>
<td>4</td>
<td>0.7</td>
<td>8.78</td>
</tr>
<tr>
<td>5</td>
<td>0.8</td>
<td>14.2</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>20.1</td>
</tr>
<tr>
<td>8</td>
<td>1.25</td>
<td>36.6</td>
</tr>
<tr>
<td>10</td>
<td>1.5</td>
<td>58.0</td>
</tr>
<tr>
<td>12</td>
<td>1.75</td>
<td>84.3</td>
</tr>
<tr>
<td>14</td>
<td>2</td>
<td>115</td>
</tr>
<tr>
<td>16</td>
<td>2</td>
<td>157</td>
</tr>
<tr>
<td>20</td>
<td>2.5</td>
<td>245</td>
</tr>
<tr>
<td>24</td>
<td>3</td>
<td>353</td>
</tr>
<tr>
<td>30</td>
<td>3.5</td>
<td>561</td>
</tr>
<tr>
<td>36</td>
<td>4</td>
<td>817</td>
</tr>
<tr>
<td>42</td>
<td>4.5</td>
<td>1120</td>
</tr>
<tr>
<td>48</td>
<td>5</td>
<td>1470</td>
</tr>
<tr>
<td>56</td>
<td>5.5</td>
<td>2030</td>
</tr>
<tr>
<td>64</td>
<td>6</td>
<td>2680</td>
</tr>
</tbody>
</table>
Diameters and Areas for Unified Screw Threads

Table 8–2

<table>
<thead>
<tr>
<th>Size Designation</th>
<th>Nominal Major Diameter in</th>
<th>Threads per Inch N</th>
<th>Tensile-Stress Area $A_t$, in²</th>
<th>Minor-Diameter Area $A_r$, in²</th>
<th>Threads per Inch N</th>
<th>Tensile-Stress Area $A_t$, in²</th>
<th>Minor-Diameter Area $A_r$, in²</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.0600</td>
<td>80</td>
<td>0.001 80</td>
<td>0.001 51</td>
<td>72</td>
<td>0.002 78</td>
<td>0.002 37</td>
</tr>
<tr>
<td>1</td>
<td>0.0730</td>
<td>64</td>
<td>0.002 63</td>
<td>0.002 18</td>
<td>64</td>
<td>0.003 94</td>
<td>0.003 39</td>
</tr>
<tr>
<td>2</td>
<td>0.0860</td>
<td>56</td>
<td>0.003 70</td>
<td>0.003 10</td>
<td>56</td>
<td>0.005 33</td>
<td>0.004 51</td>
</tr>
<tr>
<td>3</td>
<td>0.0990</td>
<td>48</td>
<td>0.004 87</td>
<td>0.004 06</td>
<td>48</td>
<td>0.006 61</td>
<td>0.005 66</td>
</tr>
<tr>
<td>4</td>
<td>0.1120</td>
<td>40</td>
<td>0.006 04</td>
<td>0.004 96</td>
<td>40</td>
<td>0.007 96</td>
<td>0.006 72</td>
</tr>
<tr>
<td>5</td>
<td>0.1250</td>
<td>40</td>
<td>0.007 96</td>
<td>0.006 72</td>
<td>40</td>
<td>0.008 80</td>
<td>0.007 16</td>
</tr>
<tr>
<td>6</td>
<td>0.1380</td>
<td>32</td>
<td>0.009 09</td>
<td>0.007 45</td>
<td>36</td>
<td>0.010 15</td>
<td>0.008 74</td>
</tr>
<tr>
<td>8</td>
<td>0.1640</td>
<td>32</td>
<td>0.014 07</td>
<td>0.011 96</td>
<td>32</td>
<td>0.014 74</td>
<td>0.012 85</td>
</tr>
<tr>
<td>10</td>
<td>0.1900</td>
<td>24</td>
<td>0.017 5</td>
<td>0.014 50</td>
<td>24</td>
<td>0.020 0</td>
<td>0.017 5</td>
</tr>
<tr>
<td>12</td>
<td>0.2160</td>
<td>24</td>
<td>0.024 2</td>
<td>0.020 6</td>
<td>24</td>
<td>0.025 8</td>
<td>0.022 6</td>
</tr>
<tr>
<td>$\frac{1}{4}$</td>
<td>0.2500</td>
<td>20</td>
<td>0.031 8</td>
<td>0.026 9</td>
<td>20</td>
<td>0.036 4</td>
<td>0.032 6</td>
</tr>
<tr>
<td>$\frac{5}{16}$</td>
<td>0.3125</td>
<td>18</td>
<td>0.052 4</td>
<td>0.045 4</td>
<td>18</td>
<td>0.058 0</td>
<td>0.052 4</td>
</tr>
<tr>
<td>$\frac{3}{8}$</td>
<td>0.3750</td>
<td>16</td>
<td>0.077 5</td>
<td>0.067 8</td>
<td>16</td>
<td>0.087 8</td>
<td>0.080 9</td>
</tr>
<tr>
<td>$\frac{7}{16}$</td>
<td>0.4375</td>
<td>14</td>
<td>0.106 3</td>
<td>0.093 3</td>
<td>14</td>
<td>0.118 7</td>
<td>0.109 0</td>
</tr>
<tr>
<td>$\frac{1}{2}$</td>
<td>0.5000</td>
<td>13</td>
<td>0.141 9</td>
<td>0.125 7</td>
<td>13</td>
<td>0.159 9</td>
<td>0.148 6</td>
</tr>
<tr>
<td>$\frac{5}{16}$</td>
<td>0.5625</td>
<td>12</td>
<td>0.182</td>
<td>0.162</td>
<td>12</td>
<td>0.203</td>
<td>0.189</td>
</tr>
<tr>
<td>0.6250</td>
<td></td>
<td>11</td>
<td>0.226</td>
<td>0.202</td>
<td>11</td>
<td>0.256</td>
<td>0.240</td>
</tr>
<tr>
<td>0.7500</td>
<td></td>
<td>10</td>
<td>0.334</td>
<td>0.302</td>
<td>10</td>
<td>0.373</td>
<td>0.351</td>
</tr>
<tr>
<td>0.8750</td>
<td></td>
<td>9</td>
<td>0.462</td>
<td>0.419</td>
<td>9</td>
<td>0.509</td>
<td>0.480</td>
</tr>
<tr>
<td>1.0000</td>
<td></td>
<td>8</td>
<td>0.606</td>
<td>0.551</td>
<td>8</td>
<td>0.663</td>
<td>0.625</td>
</tr>
<tr>
<td>1.2500</td>
<td></td>
<td>7</td>
<td>0.969</td>
<td>0.890</td>
<td>7</td>
<td>1.073</td>
<td>1.024</td>
</tr>
<tr>
<td>1.5000</td>
<td></td>
<td>6</td>
<td>1.405</td>
<td>1.294</td>
<td>6</td>
<td>1.581</td>
<td>1.521</td>
</tr>
</tbody>
</table>
Head Type of Bolts

- **Hexagon head bolt**
  - Usually uses nut
  - Heavy duty

- **Socket head cap screw**
  - Usually more precision applications
  - Access from the top

- **Machine screws**
  - Usually smaller sizes
  - **Slotted** or **Philips** head common
  - Threaded all the way
Machine Screws: Types of Heads

(a) Round head

(b) Flat head

(c) Fillister head

(d) Oval head

(e) Truss head

(f) Binding head

(g) Hex head (trimmed)

(h) Hex head (upset)
Threads and threaded fasteners

Figure 4.36 Standard Thread Note for English Dimension Fasteners

- UNC: Unified National Coarse
- UNF: Unified National Fine
- UNEF: Unified Extra Fine
- UN: Uniform Pitch
- UNM: Unified Miniature
- NC: National Coarse
- NF: National Fine
- UNR: Unified National Round
4.37 Standard Thread Note for Specifying Tap Drill Size