8400 ANGULAR GRIPPER

<table>
<thead>
<tr>
<th>SPECIFICATIONS</th>
<th>SERIES 8400 ANGULAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPERATING PRESSURE</td>
<td>40 psi min to 150 psi max [2.8 bar min to 10 bar max] air</td>
</tr>
<tr>
<td>STANDARD UNIT</td>
<td>-20° to +180°F [-28° to +82°C]</td>
</tr>
<tr>
<td>OPERATING TEMPERATURE</td>
<td>5 million cycles minimum with standard seals</td>
</tr>
<tr>
<td>RATED LIFE</td>
<td>Within 1° per jaw</td>
</tr>
<tr>
<td>GRIP BACKLASH</td>
<td>Factory lubricated for rated life</td>
</tr>
<tr>
<td>LUBRICATION</td>
<td>Field repairable</td>
</tr>
<tr>
<td>MAINTENANCE</td>
<td></td>
</tr>
</tbody>
</table>

**GRIP FORCE FACTOR Gf**

$$\text{Gripper: 8410}$$

- Operating Pressure = 87 psi
- Distance from Jaw Pivot = 1.5 in

1. **Determine Grip Force Factor Gf** = .068 (from table above)
2. **Total Grip Force Calculations**:
   - For Standard Unit: 8410-02-001
   - Total Grip Force = \( \frac{87 \text{ psi} \times .068}{1.5 \text{ in}} \) = 3.95 lb

**NOTE:** Maximum load that grippers can handle will vary based on size of part being picked up, shape of part, texture of part, speed at which part is transferred, working pressure, shape of finger pads, etc. PHD recommends that the fingers or jaws be tooled or machined to conform to the shape of the part being gripped.

**GRIP FORCE CALCULATION EQUATION:**

$$\text{TOTAL GRIP FORCE (lb)} = \frac{(\text{Pressure [psi]} \times Gf)}{\text{Distance from Jaw Pivot (in)}}$$

**NOTE:** Gripping force is defined as the maximum value at which the jaws will not move from their gripping position. The above figures are based on calculations and will vary slightly due to friction. Gripping force is proportional to input pressure.

**GRIP FORCE CALCULATION EXAMPLE:**

Gripper: 8410
- Operating Pressure = 87 psi
- Distance from Jaw Pivot = 1.5 in

1. Determine Grip Force Factor Gf = .068 (from table above)
2. Total Grip Force Calculations:
   - For Standard Unit: 8410-02-001
   - Total Grip Force = \( \frac{87 \text{ psi} \times .068}{1.5 \text{ in}} \) = 3.95 lb
### Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Series GRB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Pressure</td>
<td>30 psi min to 100 psi max [2 bar min to 7 bar max] air</td>
</tr>
<tr>
<td>Standard Unit</td>
<td>-20° to +180°F [-28° to +82°C]</td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>5 million cycles minimum with standard seals</td>
</tr>
<tr>
<td>Rated Life</td>
<td>See table below</td>
</tr>
<tr>
<td>Cycle Time</td>
<td>Factory lubricated for rated life</td>
</tr>
<tr>
<td>Lubrication</td>
<td>Field repairable</td>
</tr>
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</table>

### GRIP Force Factor Gr

<table>
<thead>
<tr>
<th>Size</th>
<th>Nominal Jaw Rotation</th>
<th>External Force Factor</th>
<th>Internal Force Factor</th>
<th>Grripper Weight</th>
<th>Close Time [87 psi (6 bar)]</th>
<th>Open Time [87 psi (6 bar)]</th>
<th>Displacement</th>
</tr>
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<tbody>
<tr>
<td>12</td>
<td>180°</td>
<td>0.065</td>
<td>106</td>
<td>0.083</td>
<td>0.28</td>
<td>0.12</td>
<td>0.09</td>
</tr>
<tr>
<td>16</td>
<td>180°</td>
<td>0.18</td>
<td>299</td>
<td>0.21</td>
<td>0.55</td>
<td>0.25</td>
<td>0.07</td>
</tr>
<tr>
<td>20</td>
<td>180°</td>
<td>0.61</td>
<td>994</td>
<td>0.75</td>
<td>0.98</td>
<td>0.45</td>
<td>0.26</td>
</tr>
<tr>
<td>32</td>
<td>180°</td>
<td>1.9</td>
<td>3170</td>
<td>2.4</td>
<td>2.2</td>
<td>0.98</td>
<td>0.41</td>
</tr>
<tr>
<td>40</td>
<td>180°</td>
<td>3.7</td>
<td>6089</td>
<td>4.3</td>
<td>4.3</td>
<td>2.0</td>
<td>0.55</td>
</tr>
<tr>
<td>50</td>
<td>180°</td>
<td>12</td>
<td>19964</td>
<td>14</td>
<td>11.5</td>
<td>5.2</td>
<td>0.56</td>
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### Maximum Allowable Forces & Moments on Gripper Jaws

<table>
<thead>
<tr>
<th>Size</th>
<th>Max Tooling Length</th>
<th>Fa (Tension or Compression)</th>
<th>My</th>
<th>Mz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>in</td>
<td>mm</td>
<td>lb</td>
<td>N</td>
</tr>
<tr>
<td>12</td>
<td>3</td>
<td>75</td>
<td>20</td>
<td>90</td>
</tr>
<tr>
<td>16</td>
<td>4</td>
<td>100</td>
<td>40</td>
<td>180</td>
</tr>
<tr>
<td>20</td>
<td>4.5</td>
<td>115</td>
<td>80</td>
<td>355</td>
</tr>
<tr>
<td>32</td>
<td>5</td>
<td>125</td>
<td>175</td>
<td>780</td>
</tr>
<tr>
<td>40</td>
<td>6</td>
<td>150</td>
<td>380</td>
<td>1690</td>
</tr>
<tr>
<td>50</td>
<td>8</td>
<td>200</td>
<td>700</td>
<td>3110</td>
</tr>
</tbody>
</table>

My, Mz: Allowable moments per jaw. Moments measured from the jaw pivot.
Fa: Allowable total force
Max Tooling Length: Measured from jaw pivot.

**NOTE:** When calculating values for My, Mz, and Fa, include the grip force per jaw, tooling weight, part weight, external forces, and acceleration, as applicable.

### Force Multiplier Graph

- Force multiplier is a function of the jaw position at point of grip.
- Force multiplier with the jaws parallel (0°) is 1.

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See Productivity Solutions (CAT-08) for ordering, dimensional, and options data.

www.phdinc.com/apps/sizing • (800) 624-8511
GRIP FORCE GRAPHS

SIZE 12

TOTAL GRIP FORCE lb [N]

OPEN, 87 psi [6 bar]

CLOSED, 87 psi [6 bar]

MAXIMUM TOOLING LENGTH

TOOLING LENGTH in [mm]

SIZE 16

TOTAL GRIP FORCE lb [N]

OPEN, 87 psi [6 bar]

CLOSED, 87 psi [6 bar]

MAXIMUM TOOLING LENGTH

TOOLING LENGTH in [mm]

SIZE 20

TOTAL GRIP FORCE lb [N]

OPEN, 87 psi [6 bar]

CLOSED, 87 psi [6 bar]

MAXIMUM TOOLING LENGTH

TOOLING LENGTH in [mm]

SIZE 32

TOTAL GRIP FORCE lb [N]

OPEN, 87 psi [6 bar]

CLOSED, 87 psi [6 bar]

MAXIMUM TOOLING LENGTH

TOOLING LENGTH in [mm]

SIZE 40

TOTAL GRIP FORCE lb [N]

OPEN, 87 psi [6 bar]

CLOSED, 87 psi [6 bar]

MAXIMUM TOOLING LENGTH

TOOLING LENGTH in [mm]

SIZE 50

TOTAL GRIP FORCE lb [N]

OPEN, 87 psi [6 bar]

CLOSED, 87 psi [6 bar]

MAXIMUM TOOLING LENGTH

TOOLING LENGTH in [mm]

GRIP FORCE

Total gripping force relative to tooling length is shown below at
the stated actuating pressure. Grip force per jaw equals the total grip
force divided by two. The graphs also indicate the maximum tooling
length for each gripper size.

F = Total Grip Force

See Productivity Solutions (CAT-08) for ordering, dimensional, and options data.

www.phdinc.com/apps/sizing  •  (800) 624-8511

SOLUTIONS FOR INDUSTRIAL AUTOMATION
JAW TOOLING INERTIA GRAPHS (PER JAW)

SIZE 12

SIZE 16

SIZE 20

SIZE 32

SIZE 40

SIZE 50

JAW TOOLING

Jaw tooling must be sized in such a manner as to keep the total jaw tooling inertia (per jaw) in the shaded areas of the charts below. Use the calculation example on page 177 as a template for your tooling design.

See Productivity Solutions (CAT-08) for ordering, dimensional, and options data.

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**JAW TOOLING INERTIA CALCULATION (PER JAW)**

**STEP 1:**
Determine the Gripper Size, Jaw Tooling Dimensions, and Gripper Opening Time.

**STEP 2:**
Calculate the moments of inertia for the Jaw Tooling.

**PART A**

Calculation of Jaw Tooling Mass:
\[ M_A = L_A \times H_A \times W_A \times \text{Mass Density of Jaw Tooling Material} \]

Moment of Inertia Calculation for the Jaw Tooling about Axis Z1:
\[ I_{Z1} = (1/12) \times (M_A \times (H_A^2 + L_A^2)) \]

Moment of Inertia Calculation for the Jaw Tooling about Axis Z:
\[ I_A = I_{Z1} + (M_A \times R_1^2) \]

**PART B**

Calculation of Jaw Tooling Mass:
\[ M_B = L_B \times H_B \times W_B \times \text{Mass Density of Jaw Tooling Material} \]

Moment of Inertia Calculation for the Jaw Tooling about Axis Z2:
\[ I_{Z2} = (1/12) \times (M_B \times (H_B^2 + L_B^2)) \]

Moment of Inertia Calculation for the Jaw Tooling about Axis Z:
\[ I_B = I_{Z2} + (M_B \times R_2^2) \]

**TOTAL JAW TOOLING INERTIA:**
\[ I_{\text{TOTAL}} = I_A + I_B \]

**STEP 3:**
Verify Jaw Tooling Inertia by comparing \( I_{\text{TOTAL}} \) with Jaw Tooling Inertia graph.

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**EXAMPLE:**

**STEP 1:**
Gripper Size: 20, Jaw Tooling Dimensions: see graphic, Gripper Opening Time: 130 ms

**STEP 2:**

**PART A**

- \( L_A = 0.500 \text{ in}. \) [0.013 m]
- \( H_A = 0.625 \text{ in}. \) [0.016 m]
- \( W_A = 0.750 \text{ in}. \) [0.019 m]
- Mass Density of Aluminum = 0.098 lb/in\(^3\) [2712.6 kg/m\(^3\)]
- \( R_1 = 3.000 \text{ in}. \) [0.075 m]

Calculation of Jaw Tooling Mass:
\[ M_A = 0.500 \text{ in} \times 0.625 \text{ in} \times 0.750 \text{ in} \times 0.098 \text{ lb/in}^3 \times 0.013 \text{ m} \times 0.016 \text{ m} \times 2712.6 \text{ kg/m}^3 \]
\[ M_A = 0.023 \text{ lb} \times 0.011 \text{ kg} \]

Moment of Inertia Calculation for the Jaw Tooling about Axis Z1:
\[ I_{Z1} = (1/12) \times (0.023 \text{ lb} \times (0.625 \text{ in}^3 + 0.500 \text{ in}^3)) \]
\[ I_{Z1} = (1/12) \times (0.011 \text{ kg} \times (0.166 \text{ m} \times 0.013 \text{ m})) \]
\[ I_{Z1} = 0.0013 \text{ lb-in}^2 \times [3.9 \times 10^{-3} \text{ kg-m}^2] \]

Moment of Inertia Calculation for the Jaw Tooling about Axis Z2:
\[ I_{Z2} = (1/12) \times (0.051 \text{ lb} \times (0.350 \text{ in}^3 + 0.500 \text{ in}^3)) \]
\[ I_{Z2} = (1/12) \times (0.023 \text{ kg} \times (0.009 \text{ m} \times 0.064 \text{ m})) \]
\[ I_{Z2} = 0.027 \text{ lb-in}^2 \times [8.0 \times 10^{-3} \text{ kg-m}^2] \]

Moment of Inertia Calculation for the Jaw Tooling about Axis Z:
\[ I_A = 0.027 \text{ lb-in}^2 + (0.051 \text{ lb} \times 2.000 \text{ in}) \]
\[ I_A = 0.027 \text{ lb-in}^2 \times [8.0 \times 10^{-3} \text{ kg-m}^2] \]
\[ I_A = 0.023 \text{ lb-in}^2 \times [6.8 \times 10^{-3} \text{ kg-m}^2] \]

**TOTAL JAW TOOLING INERTIA:**
\[ I_{\text{TOTAL}} = 0.208 \text{ lb-in}^2 + 0.231 \text{ lb-in}^2 \]
\[ I_{\text{TOTAL}} = 0.439 \text{ lb-in}^2 \times [1.3 \times 10^{-3} \text{ kg-m}^2] \]

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See Productivity Solutions (CAT-08) for ordering, dimensional, and options data.
GRIP FORCE CALCULATION EQUATIONS:

**IMPERIAL:** \[
\text{PRESSURE (psi)} \times \frac{G_F}{\text{DISTANCE FROM JAW PIVOT (in)}} \times \text{FORCE MULTIPLIER} = \text{TOTAL GRIP FORCE (lb)}
\]

**METRIC:** \[
\text{PRESSURE [bar]} \times \frac{G_F}{\text{DISTANCE FROM JAW PIVOT [mm]}} \times \text{FORCE MULTIPLIER} = \text{TOTAL GRIP FORCE [N]}
\]

**GRIP FORCE CALCULATION EXAMPLE:**

**Gripper:** GRB11-2-20 x 180, [GRB11-6-20 x 180]
**Operating Pressure** = 87 psi [6 bar]
**Find Tooling Length (Distance Between Jaw Pivot and Gripping Point):** Desired tooling length is 1.75 in [44.5 mm].
**Find Jaw Angle at Point of Grip:** Jaws will be parallel (0°) at point of grip.
**Determine Force Multiplier Based on Jaw Angle at Point of Grip:** Because jaws are parallel (0°) at point of grip, force multiplier = 1 (from Force Multiplier Graph on page 173).
**Find Grip Factor** \((G_F) = .61 \ [99.4]\) (from table on page 173)
**Total Grip Force** = \(((87 \text{ psi} \times .61) / 1.75) \times 1 = 30.3 \text{ lb} \ [((6 \text{ bar} \times 99.4) / 44.5) \times 1 = 134 \text{ N}] \)
5300 ANGULAR GRIPPER

<table>
<thead>
<tr>
<th>SPECIFICATIONS</th>
<th>SERIES 5300 ANGULAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPERATING PRESSURE</td>
<td></td>
</tr>
<tr>
<td>STANDARD UNIT</td>
<td>25 psi min to 150 psi max [1.7 bar min to 10 bar max] air</td>
</tr>
<tr>
<td>LIGHT SPRING ASSIST UNIT</td>
<td>35 psi min to 150 psi max [2.4 bar min to 10 bar max] air</td>
</tr>
<tr>
<td>HEAVY SPRING ASSIST UNIT</td>
<td>65 psi min to 150 psi max [4.5 bar min to 10 bar max] air</td>
</tr>
<tr>
<td>OPERATING TEMPERATURE</td>
<td>-20° to +180°F [-28° to +82°C]</td>
</tr>
<tr>
<td>RATED LIFE</td>
<td>5 million cycles minimum with standard seals</td>
</tr>
<tr>
<td>GRIP BACKLASH</td>
<td>Within .2° per jaw</td>
</tr>
<tr>
<td>GRIP REPEATABILITY</td>
<td>Within 0.002 in [±0.05 mm] of original centered position</td>
</tr>
<tr>
<td>LUBRICATION</td>
<td>Field lubricated for rated life</td>
</tr>
<tr>
<td>MAINTENANCE</td>
<td>Field repairable</td>
</tr>
</tbody>
</table>

NOTE: Maximum load that grippers can handle will vary based on size of part being picked up, shape of part, texture of part, speed at which part is transferred, working pressure, shape of fingers, etc. PHD recommends that the fingers of jaws be tooled or machined to conform to the shape of the part being gripped.

<table>
<thead>
<tr>
<th>GRIPPER NO.</th>
<th>DISPLACEMENT</th>
<th>EXTERNAL GRIP</th>
<th>INTERNAL GRIP</th>
<th>SPRING GRIP FORCE Sf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>in²</td>
<td>cm²</td>
<td>IMPERIAL</td>
<td>METRIC</td>
</tr>
<tr>
<td>1532x</td>
<td>.59</td>
<td>9.6</td>
<td>1.87</td>
<td>3058.0</td>
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<tr>
<td>1533x</td>
<td>1.78</td>
<td>29.2</td>
<td>5.56</td>
<td>9085.0</td>
</tr>
<tr>
<td>1534x</td>
<td>4.29</td>
<td>70.3</td>
<td>14.14</td>
<td>23109.0</td>
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<tr>
<td>1535x</td>
<td>12.66</td>
<td>207.5</td>
<td>41.85</td>
<td>68355.0</td>
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<table>
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<tr>
<th>GRIPPER WEIGHT</th>
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<tbody>
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</tr>
<tr>
<td>STANDARD</td>
</tr>
<tr>
<td>lb</td>
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<tr>
<td>1532x</td>
</tr>
<tr>
<td>1533x</td>
</tr>
<tr>
<td>1534x</td>
</tr>
<tr>
<td>1535x</td>
</tr>
</tbody>
</table>

NOTE: Guards against failure due to unforeseen pneumatic pressure loss.

NOTE: Provides up to four times the gripping force of conventional grippers of the same size.
GRIP FORCE CALCULATION EQUATIONS:

IMPERIAL:

\[
\text{TOTAL GRIP FORCE \([lb]\) = \frac{(\text{Pressure \([psi]\) x G}_r)}{\text{Distance from jaw pivot (in)}}
\]

\[
\text{TOTAL GRIP FORCE WITH SPRINGS \([lb]\) = \frac{((\text{Pressure \([psi]\) x G}_r) \pm S_r \([lb]\))}{\text{Distance from jaw pivot (in)}}
\]

METRIC:

\[
\text{TOTAL GRIP FORCE \([N]\) = \frac{(\text{Pressure \([bar]\) x G}_r)}{\text{Distance from jaw pivot (mm)}}
\]

\[
\text{TOTAL GRIP FORCE WITH SPRINGS \([N]\) = \frac{((\text{Pressure \([bar]\) x G}_r) \pm S_r \([N]\))}{\text{Distance from jaw pivot (mm)}}
\]

GRIP FORCE CALCULATION EXAMPLE:

Gripper: Series 5300 Angular bore size 2.56 in [65 mm]
Operating Pressure = 87 psi [6 bar]
Distance from Jaw Pivot = 3 in [75 mm]

1. Determine Grip Force Factor G\(_r\) = 5.56 [9085] (from table on page 178)

2. Determine Distance from Jaw Pivot = 3 in [75 mm]

3. Total Grip Force Calculations:
   For Standard Unit: 15330-1-0000 [15332-1-0000]
   \[
   \text{Total Grip Force} = \frac{87 \text{ psi} \times 5.56}{3 \text{ in}} = 161 \text{ lb} \quad \left[6 \text{ bar} \times 9085 \frac{\text{ N}}{75 \text{ mm}} = 726 \text{ N}\right]
   \]